# EVALUATING ECONOMIC POLICIES FOR PROMOTING RAINFOREST CONSERVATION IN DEVELOPING COUNTRIES

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# ABSTRACT

Economic policies are often suggested as mechanisms for promoting rainforest conservation in developing countries. To help decide whether international resources should be used to protect specific rainforests, the calculation of a "rainforest supply price" (RSP) is proposed. If protection is warranted, then empirical analyses explore the conditions under which selected policies within developing countries might be effective in protecting rainforests.

Korup National Park in Cameroon contains the oldest rainforest in Africa and – as a haven for important endangered species – it is the subject of active international conservation efforts. A cost-benefit analysis of a conservation project to protect Korup from increased land-use pressures suggests that it is not in Cameroon's interest unless a 5.4 million ECU inducement is transferred to Cameroon. Given the protection afforded, the transfer is equivalent to a RSP of 1060 ECU per $km^2$ per year. Evaluations of six other tropical rainforest projects suggests that international donors made transfers having values ranging from 15 to 1575 ECU per $km^2$ per year. It is thus concluded that the inducements required are within a range which conservation interests are apparently willing to mobilise.

To target inducements, the provision of incentives in a "buffer zone" around a park is often believed to promote conservation. This is based on the hypothesis that increased incomes will draw individuals out of the park and will give them something better to do than exploit the park. A survey of 341 households around Korup was analysed in detail to test this hypothesis. Evidence suggests that economic development in the buffer zone would increase pressures on the park because: a) higher incomes would reduce emigration from the region and would thus cause greater population pressure on the Park; and, b) hunting effort increases as non-hunting income increases.

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## DEDICATION

To my mother
Tricia Ruitenbeek
and
to the memory of my father
Gus Ruitenbeek.

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# ACKNOWLEDGEMENTS

When I commenced this work, I had become quite accustomed to working – usually under someone else's behest – on five or more projects at one time. It was thus quite a luxury to be able to dedicate myself completely to a single project of my choosing. Such indulgences can only be pursued successfully with financial, intellectual and moral support. For the financial support, I would like to thank the United Kingdom Overseas Research Award Scheme, the Social Sciences and Humanities Research Council of Canada, and the Government of Alberta Heritage Fund.

On the intellectual front, I have had the pleasure of working beside a number of individuals who both assisted and inspired me during the period over which this research has been conducted. In particular, I appreciate the guidance and comments which I received from my supervisor, Professor Nicholas Stern, whose insights often focussed my thoughts and prevented me from pursuing fruitless avenues of research. I am no less indebted to Dr. Jean Drèze, who provided comments on earlier drafts of portions of this work, and to Dr. Joanna Gomulka, who patiently wrestled my data through her double hurdle econometric models. Also, I would like to thank Mr. Richard Labelle of the International Council for Research in Agroforestry (ICRAF) in Nairobi for valuable guidance with the literature searches, and to numerous individuals in the Government of Cameroon for assisting me in gathering relevant data in their archives.

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Last, and most, I thank everyone in my family for their unfaltering moral support.

As is customary, however, the reader is reminded that any opinions and conclusions expressed herein are my own and I take full responsibility for any errors of commission or omission.

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# CHAPTER 1
# INTRODUCTION

## § 1.1 Background

Increasing attention is being paid today to the conservation of tropical rainforests as the developed world is becoming aware that they are a source of both amenity and significant economic potential. The popular literature is replete with assertions that these forests are important havens of genetic resources which can contribute to the discovery of important foodstuffs and pharmaceutical products. Furthermore, it is often asserted that tropical rainforests provide important environmental functions, whether in maintaining a balance in global climates, or in providing more localised benefits through the prevention of soil erosion and flooding. Tragically, many of the world's rainforests are being decimated by their very owners as the immediate needs of the developing world overshadow the often uncertain future benefits which the rainforests have to offer. In response to this need, however, major conservation groups and international organisations – the World Bank among them – have recently committed themselves to transfers to the developing world to ensure that the rainforests are exploited 'properly'. The current vogue is to promote rainforest conservation as an integral part of economic development initiatives.

In certain respects, the current attitude of conservationists is to look towards the economics discipline to provide a justification for rainforest conservation in developing countries (LDCs). This poses interesting analytical challenges which include elements of environmental economics, development economics and public policy. Issues dealing with production and consumption externalities play a prominent role, as do issues dealing with feasible policy reforms in LDCs. Many of the problems which would be tractable in a well-developed modern economy do not lend themselves to obvious solutions under the circumstances imposed in developing countries.

Because tropical deforestation is occurring at a relatively rapid rate, pressure is being placed on all concerned parties to act quickly. Some of this pressure is applied directly to economic planners, who are finding themselves suddenly responsible for devising or designing policies which will promote rainforest conservation. Frequently they must also then provide an economic rationale for the policy which has been so devised.

The planner's job in this case is encumbered by two very real constraints: time and data. Even if optimal policies could be designed given enough time and information to analyse the implications of implementing various policies, the time constraints, coupled with a paucity of data typically found in LDCs, impede the decision-making process. As is often the case in such situations, rules-of-thumb and the planners' own judgment are the primary tools available for designing policies.

In many cases the rules-of-thumb have generated policies which would apparently promote rainforest conservation. Simple models can be constructed to argue, for example, that kerosene subsidies will dissuade fuelwood cutting. Similarly, if local populations are overexploiting a forest, there is an intuitive appeal to promoting conservation by "giving them something better to do" through increasing economic opportunities elsewhere. Such policies have an added appeal because they can often be readily incorporated into existing taxation reform programmes or rural development programmes.

But the acid test of the theory behind any of these policies is ultimately whether they will *indeed* promote conservation. The costs of erring may be particularly high. If in 50 years we look back and find that we have used the wrong policies, it will probably be easy to rewrite the theories, but the rainforests may not have a second chance. It is hence imperative that we carefully evaluate economic policies which are meant to promote rainforest conservation in LDCs. That theme is the focus of this thesis.

In evaluating policies, the practical problem reduces to identifying some of the major linkages between the economy and the environment. Pearce and Turner (1990) note, for example, that much of economic science has been concerned with analysing what goes on *within* an economy, while the natural sciences have been concerned with analysing the interactions and relationships which occur within what we commonly call the natural environment. They note further that – as a research priority – one current challenge to the economics profession is to gain a better understanding of the actual interactions and relationships between the economy and the environment. The empirical work in this thesis is conducted in that spirit: in the process of evaluating selected policy options, some important insights can be gained into how the economy and the environment interacts. In original empirical work, I investigate how the policies do, or do not, in practice contribute to rainforest conservation.

## § 1.2 Scope and Objectives

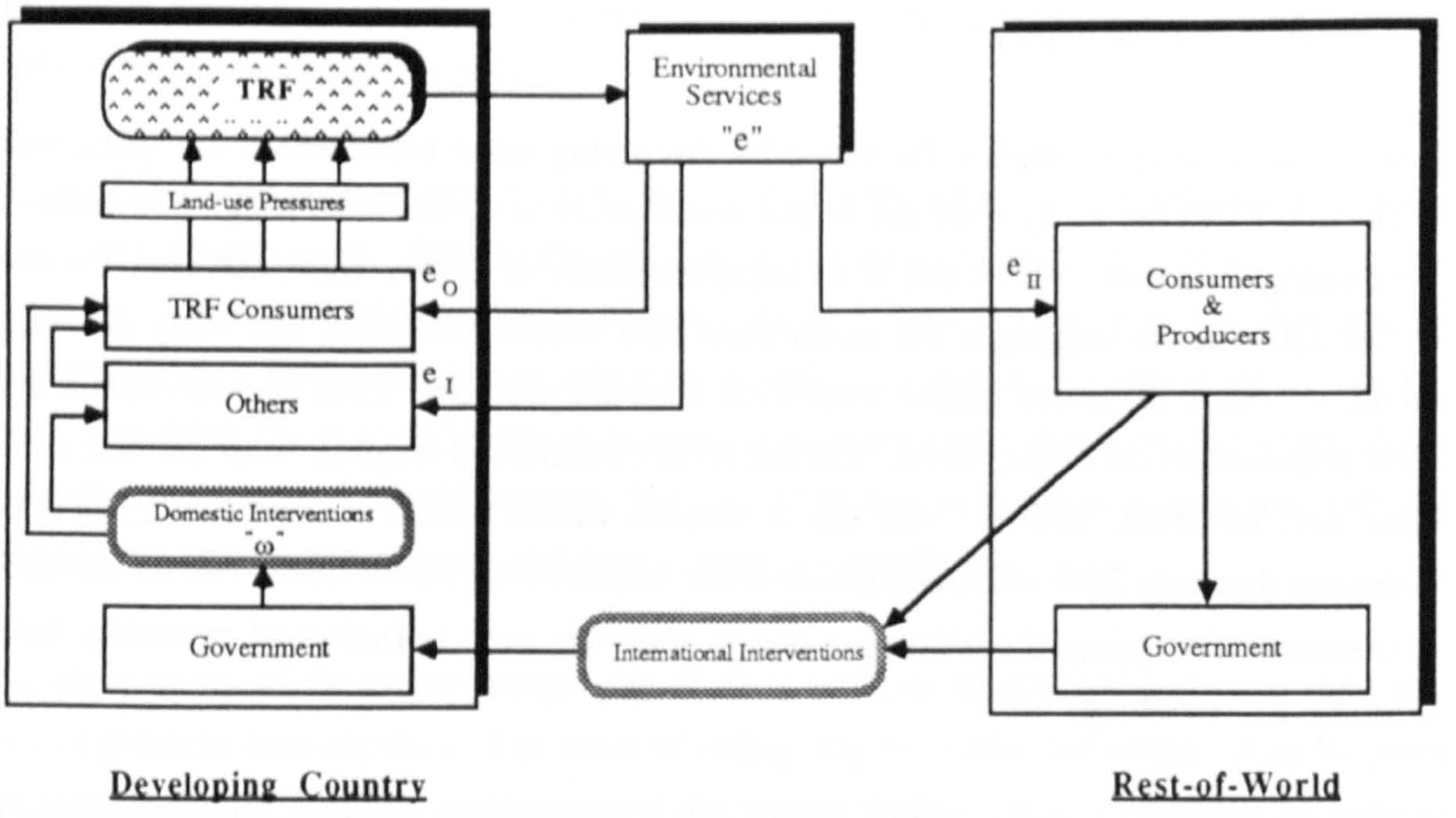
The range of issues which must be addressed in rainforest conservation and management is both complex and vast. It extends from specific technical silvicultural practices to more general concerns associated with land-use conflicts in a country. Given this diversity of potential areas for study, it is important to define the scope of this thesis in a manner which will generate testable hypotheses.

It is useful initially to narrow the scope by discussing some areas which are specifically excluded. First, the study does not in any detail relate to commercial logging practises in developing countries. While this is an important issue in its own right, and contributes to deforestation if the logging is not undertaken on a sustainable basis, this study will focus on deforestation pressures arising from local land-use pressures from the encroachment of rural populations on forest zones. Exclusion of commercial logging from our discussion does not, however, unduly limit the relevance of the work. Indeed, Myers (1986) estimates that only 22% of deforestation of the world's total forest stocks can be attributed to commercial logging; the balance is due to activities such as fuelwood gathering, forest farming, and ranching.

Second, the study does not attempt to provide a quantification of the global benefits of conserving forests. Although such a quantification would be of interest, I shall direct the analyses to a local level to determine ultimately what directions should be pursued.

Third, we shall take a fairly limited view of conservation. It is useful to note that the term 'conservation' has received various definitions and, indeed, it can have completely different and inconsistent meanings in the economic and environmental literature. Barnett and Morse (1963; p. 72) give an interesting historical account of what "conservation" has meant through the ages, including a description of the conservation movement of 1890-1920 for whom "Conservation ranged all the way from abstract metaphysics to practical everyday activity of the individual – it concerned all the various natural sciences, economics, political science, public administration, sociology, engineering, art, and public health." The economic literature often ascribes some idea of 'efficiency' to conservation and, in this regard, it is not unusual to see accounts such as those by McKie and McDonald (1962), in which conservation could be consistent with complete consumption of the available resource over very short time horizons. In contrast, the ecological and environmental literature often provides a much broader scope, an example of which includes the definition provided by the International Union for the Conservation of Nature and Natural Resources (in McNeely [1988]; p. 10): "The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration, and

Figure 1.1
Conceptual Framework for Evaluating Policies Affecting Tropical Rainforests (TRF)




enhancement of the natural environment." In this thesis, the term 'conservation' should be construed in its more common connotation meaning 'preservation'.

The scope of this thesis can best be understood with reference to Figure 1.1. Although the nuances and details of the problem are pursued in greater depth throughout the thesis, Figure 1.1 provides a useful stylised description of the broad issues. Also, it illustrates in simplified terms the conceptual framework which underlies the work in this thesis.

Considering first the flows inside the developing country, note that some subset of individuals – the "TRF Consumers" – assert various pressures on the tropical rainforest. Further, the actual stock of TRF is postulated to provide some flow of environmental services "e", which can normally be characterised as public goods. These services are available for consumption by the TRF Consumers ($e_o$), others in the developing country ($e_I$), as well as individuals in the rest of the world ($e_{II}$). To the extent that the consumption of the TRF affects the availability of environmental services, externalities might be generated both within the developing country and in the rest of the world.

The process of "internalising" these externalities requires, in principle, the existence of appropriate institutions (such as property rights, compensation structures, or regulations) which somehow insinuate themselves into the decision process of the TRF Consumers. A government in a developing country has a number of mechanisms "ω" at its disposal (which we call "Domestic Interventions"), for trying to mitigate the impacts of TRF consumption on others within the economy. These measures range from blatant control or regulation of the TRF Consumers, to more subtle strategies such as taxing the TRF Consumers while compensating those who rely to some degree on the environmental services.

But the problem becomes more complex when individuals in the rest of the world are considered. These may range from nature enthusiasts in the developed world who derive some pleasure from knowing that there are rainforests in the world, to neighbouring countries which rely on the TRF to protect their own watersheds, fisheries, or lowland agricultural areas. In any such cases, depletion of the TRF affects their level of well-being and those affected should, theoretically, be willing to pay some amount for rainforest conservation. For a variety of reasons, however, it is typically not feasible for them to negotiate this conservation directly with the TRF Consumers, and pressures can only be placed on the sovereign government in the particular LDC. The negotiations between the rest of the world and the LDC government can be characterised as "International Interventions". These interventions might range from mild political pressure, to economic sanctions, to direct funding or cash transfers to assist rainforest conservation. But at this juncture, in spite of the perhaps very generous transfers from the rest of the world, it is important to note that the developing country still has *only* the "$\omega$" mechanisms at its disposal for actually controlling the land-use pressures on the TRF.

Finally, we note that this formulation abstracts from the difficult philosophical and practical problem of how to accommodate the needs of future generations. Conceptually, we might consider that each of the service flows $e_0$, $e_I$, and $e_{II}$ has a time dimension which extends to infinity. In that event it is relevant to ask whether any of the agents (TRF consumers, others, or governments) somehow act in the interests of future generations.

In this overall context there are a number of issues which can be addressed in deciding, ultimately, how much rainforest conservation should be promoted. We need to know how the stock of TRF actually affects the level of environmental services available. We need to know the available policies and interventions. We need to know the motivating forces behind those agents which are the actual "TRF Consumers", and, finally, we need to know how the interests of future generations might be best served. Addressing any of these problems poses a considerable task, and it is certainly beyond the scope of this thesis to pursue all of them. The problem of actually measuring the amount that individuals are willing to pay for rainforest conservation is not addressed in detail in this thesis, nor shall I examine in more than a cursory fashion the more technical linkage between the stock of TRF and the environmental services which it provides. Instead, I shall concentrate on the problem of evaluating the effectiveness of various interventions in promoting rainforest conservation.

In doing this, I shall concentrate on how typical interventions can influence the production of environmental services. More formally, if $d\omega$ represents some reform, and $de$ represents the incremental production of some environmental service $e$ as a result of $d\omega$, then in selecting policies which promote conservation we must first ask ourselves what the sign is of $de/d\omega$. In practice, this involves modelling not so much the interventions but rather the actual behaviour of the TRF Consumers – which is far from a trivial task in the context of an LDC. More generally, we might suppose that our policy intervention influences behaviour, which in turn influences the stock of TRF, which in turn influences the environmental functions. That is,

$$de = \left(\frac{\partial e}{\partial TRF}\right)\left(\frac{\partial TRF}{\partial behaviour}\right)\left(\frac{\partial behaviour}{\partial \omega}\right) d\omega \qquad ...(1.1).$$

In brief, the objective of this thesis is to apply a number of economic tools to identify the sign and magnitude of $de/d\omega$. In practice, this will be done by concentrating on the second and third terms on the right hand side of Equation (1.1).

## § 1.3 General Approach

As there is both an international as well as a domestic dimension to the policy interventions, the empirical work in this thesis essentially addresses the following questions:

a) Is some international intervention, through direct transfers or otherwise, justified for promoting conservation in developing countries?

b) If the developed world is willing to transfer resources to LDCs in exchange for their commitment to conserve tropical forests, what domestic interventions are available to ensure that conservation occurs?

It is recognised that, in principle, these two questions must normally be answered concurrently: before international funds are committed we might reasonably want to know whether effective policies might be mobilised within the countries. While the theoretical model which is developed in this paper reflects this interdependence, the actual empirical work is simplified by treating the issues separately.

In addressing the first question, I shall define a concept called the "rainforest supply price" (RSP) which reflects the amount which the world would have to transfer to a particular LDC to induce it to conserve a particular rainforest. The RSP can be calculated as a relatively straightforward extension to cost-benefit analysis, although it is important in empirical work to estimate the value of some of the environmental services of the TRF to the LDC itself. Such a cost-benefit analysis is conducted for a rainforest conservation project in West Africa – Korup National Park – and the rainforest supply price is calculated and then compared to a number of other projects to determine whether the amount which must be transferred is an efficient use of international conservation resources.

While the first question can be addressed at a fairly general level, the second question dealing with domestic policy interventions requires more detailed specification of how individuals behave in response to specific policies. In addressing this, I concentrate on situations in which local populations are consuming the forest non-sustainably, and investigate selected alternatives to achieve sustainable consumption levels through two broad categories of policy reform:

(i) targeted 'economic development' incentives; and,
(ii) indirect taxation mechanisms.

A third alternative – direct control – is not evaluated but is often regarded as the default policy if others are ineffective.

While these alternatives are not meant to be an exhaustive list of government policy, they subsume many of the major 'strategies' currently being promoted in conservation circles. For example, the targeted 'economic development' incentives normally attempt to entice people out of the forest by giving them something better (individually more profitable) to do in the area outside of the forest. The incentives are targeted by defining a 'buffer zone' around critical conservation areas, and this buffer zone then becomes the subject of specific policy efforts to improve incomes. Reform of indirect taxation mechanisms is often regarded as an effective and feasible measure in LDCs for modifying the behaviour of individuals in a manner which is perceived to be more consistent with government goals. If income or taxation incentives are ineffective, then the default strategy – direct control – often entails forced transmigration and policing. The direct control strategy is, for a variety of reasons, not normally favoured; hence actual efforts often concentrate on decentralising the control through incentives or taxation.

Furthermore, the use of incentives or taxes can often be rationalised using what are apparently sound and unambiguous rules of thumb. Increasing farm incomes should, it might seem, discourage hunting. Subsidising kerosene should, it might seem, discourage fuelwood use. But economic theory itself is more ambiguous than this, and arguments can be marshalled for asserting that an increase in farm incomes might increase hunting pressures (if hunting is a leisure activity) or that kerosene subsidies will increase fuelwood use (if there is a strong income effect). Given that the results of theoretical constructs can be ambiguous, it is therefore important to test these rules of thumb with empirical research.

In the empirical work, I shall focus on three specific policy–behaviour interactions:

a) the impacts of targeted economic development incentives on migration;
b) the impacts of targeted economic development incentives on forest-use; and,
c) the impacts of untargeted indirect taxes on forest-use.

For the evaluation of targeted incentives, a theoretical model suggests that development incentives may not be effective at promoting conservation if there is full migratory adjustment. Intuitively, what occurs is that increased development in the buffer zone may attract people out of the forest, but it will also attract people from the rest of the country (via urban-rural and rural-rural migration) into that area and thus potentially assert additional pressures on the forest. Ironically, the required strategy (if conservation is the only objective) in that event would be to *depress* conditions in the buffer zone area. Empirically, the answer to whether such policies are effective depends upon the nature of the migratory adjustment process and the nature of forest-use activities in and around the park. Modelling of the migratory adjustment and forest-use process is conducted for Korup National Park based on household survey results.

The argument for using indirect taxes suggests that, to reduce negative externalities arising from consumption, one must tax the consumption activity. If taxation of this activity is not administratively feasible, as is often the case with fuelwood gathering, for example, then such taxation might be ineffective. One might then revert to taxing activities complementary to fuelwood consumption or to subsidising its substitutes. In this thesis, empirical work is undertaken to illustrate how this problem might be approached. The specific analysis deals with the nature of fuelwood demand in India, and investigates whether subsidising kerosene would be an effective mechanism for reducing fuelwood consumption and pressures on the forest resource.

As data are often limited in developing countries, a central task of this thesis is to demonstrate that important propositions can be tested using the limited data which are available. To this end, the empirical studies rely both on highly aggregated national data as well as microeconomic household data. Because much of the household data are qualitative in nature, econometric models using qualitative dependent variables are developed to analyse the data. In the process, the discussion also sheds some light on the applicability of various practical modelling techniques for evaluating such data.

Finally, it is useful to realise that, when we are dealing with tropical rainforests we are, for the most part, dealing with LDCs. It is impossible to summarise here all of the issues and concerns which are relevant in undertaking economic analyses of policies in LDCs, but there is one recurring feature of these economies which merits mention here: that relating to the identification of *feasible* policies and policy reforms. While much of the literature in resource and environmental economics deals with optimisation theory and finding optimal development paths, such concepts are of limited value in economies which are constrained politically or economically in the strategies which they have available. In practice, therefore, the aspirations of the economic planner should be fairly modest: rather than identifying the optimal state of the world and jumping to it, it is more realistic to try to identify reforms which are somehow both feasible and welfare-improving. As will be shown in this thesis, even the identification of such reforms is far from cut and dried: theory is often ambiguous and data are often limited.

Also, identifying optimal policies – as opposed to evaluating specific policies – requires fairly detailed information on the interactions which exist within the economy as well as between the economy and the environment. As information regarding such interactions is often sporadic for LDCs, the evaluation of specific policies can make an important contribution to the information base which would eventually be required for conducting optimisation studies.

In light of this, the focus of this thesis is generally to evaluate feasible economic policy reforms which promote rainforest conservation. This should not, however, belittle the importance of identifying the optimal state of the world. Indeed, it should not surprise us in the long-term if the policy reforms which we identify through marginal techniques do not necessarily move us towards the optimal state of the world: they may simply move us towards some local optimum; and there is no *a priori* reason for assuming that the applicable set of feasible policies and states of the world is convex. Nonetheless – and without apologies – the appropriate maxim here is that if you want to climb trees, and you cannot see the highest tree in the forest, then climb the highest tree you can see and hope that you will learn something more about the forest in the process.

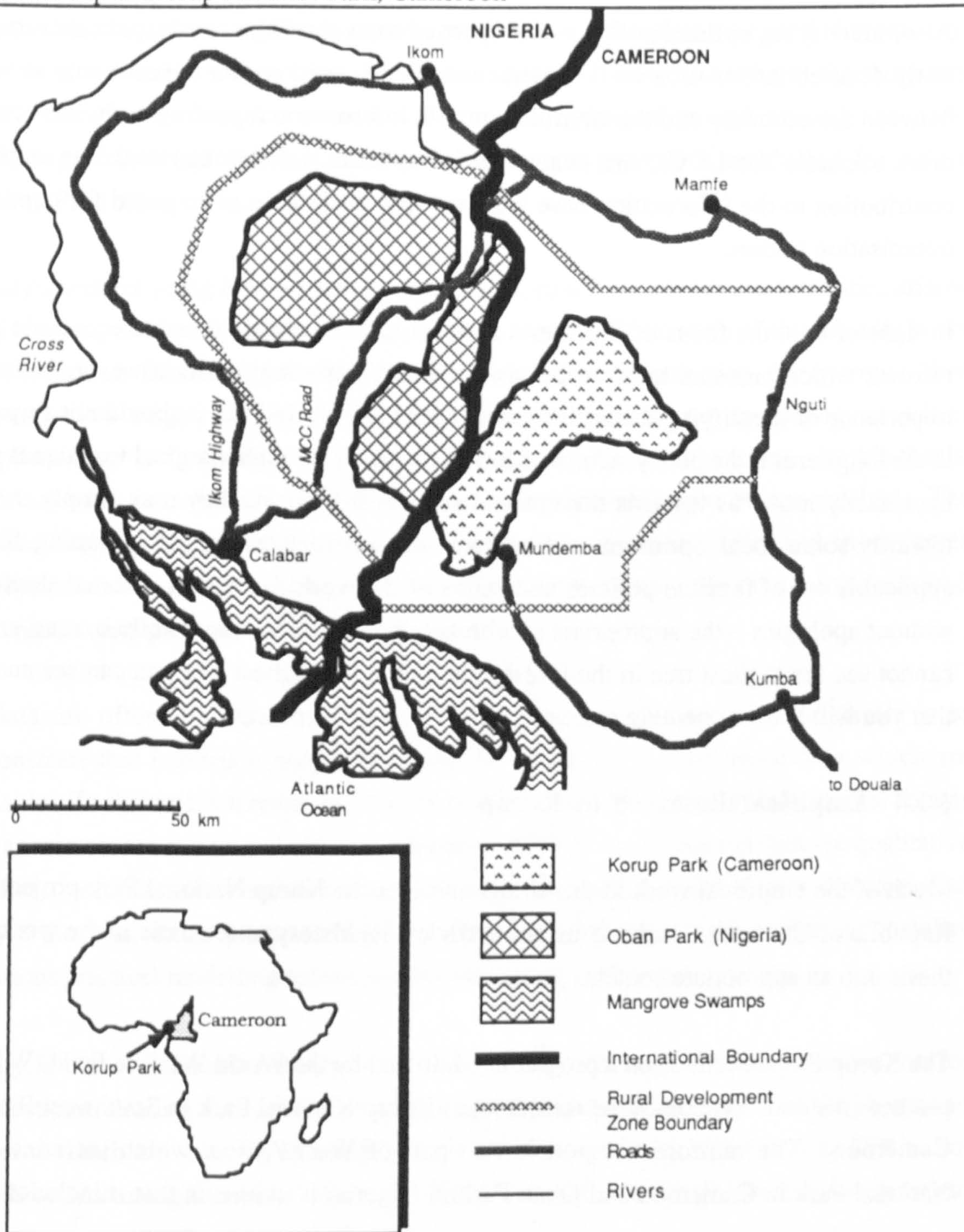
## § 1.4 Empirical Research in Korup

Much of the empirical work in this thesis involves the Korup National Park project in the Republic of Cameroon, and it is useful to review its history to set some of the work in the thesis into an appropriate context.

The Korup Project centres on a programme initiated by the World Wildlife Fund (WWF) to promote the conservation of the rainforest in Korup National Park in Southwest Province, Cameroon. The rainforest region in this part of West Africa, which includes Korup National Park in Cameroon and Oban Park in Nigeria, is unique in that it includes one of the oldest rainforests in the world which displays a high degree of endemism among its indigenous species. Without conservation efforts, the area faces the risk of falling fate to persistent land-use pressures from within both Cameroon and Nigeria.

The Korup Project is equally significant in that, through the efforts of the Government of Cameroon and external funding agencies, an economic development plan is being pursued for the area which is meant to complement the conservation goals of the park. Rather than

Figure 1.2
Location Map of Korup National Park, Cameroon



seeing the various goals as conflicting, the attitude has been that conservation of the biome and its products can promote economic development in the region. To this end, a management area has been defined consisting of 126,000 ha of core park area plus a buffer zone of 300,000 ha around this core.

Figure 1.2 shows a map of the area. Virgin rainforest is found in the areas delineated as Korup National Park and Oban National Park. The international boundary, which follows a river course, divides the forest in two. Although the forest itself differs little between Nigeria and Cameroon, the land-use pressures and economies of the two regions are quite different. While the work in this thesis pertains entirely to Cameroon, circumstances in Nigeria are also of relevance to the extent that land-use pressures in Nigeria threaten the integrity of the forest in Cameroon.

On both sides of the border, a central protected area has been defined which is regarded as the critical ecological zone. The protected area in Oban is uninhabited, whereas that in Korup contains just under 1000 individuals in six villages. A rural development zone (RDZ) has been defined around the protected regions. The RDZ has a population of approximately 37,000 in Nigeria and approximately 12,000 in Cameroon. Access to Oban from Calabar – the capital of Cross River State – is excellent along the MCC Road and the corridor along this road is quite heavily populated. By contrast, the area around Korup has poor access from outside and is relatively sparsely populated. The road from Mundemba (the site of the park headquarters) to the regional trading centre of Kumba is often closed during the rainy season and is a one-day journey at the best of times. Most individuals travel within the park and surrounding buffer zone on foot over an extensive trail system. Similarly, any goods entering or leaving the region are normally head-loaded to the nearest road.

The actual administrative history of the park goes back to 1937, when the Korup Forest Reserve was established. Hunting, trapping and tree felling were prohibited by law in the area in 1980, and the concept for a park was first entertained seriously by the Republic of Cameroon in 1984. Following negotiations with international agencies, Korup National Park was gazetted in October, 1986, giving it the highest protection possible under Cameroon law. In August, 1987, an agreement between WWF and the Republic of Cameroon was executed which called for the development of a management plan for the Park. The planning and implementation period was expected to require 5 years and had a capital budget of about £3.7 million. The funding would come primarily from WWF and the Overseas Development Administration (ODA) of the UK, with a contribution of some £150,000 from the Government of Cameroon, primarily through the secondment of personnel to the project. By 1989, significant contributions had also been made by USAID, the European Community, and the German Technical Assistance Programme (GTZ).

Interest from the international aid and conservation community has centred on Korup and Oban because of its importance as an international reserve for biodiversity. It is the oldest remaining rainforest in Africa – having survived over some 60 million years – and is characterised by very high species richness believed to have arisen as a result of its isolation as a rainforest refuge during Pleistocene glaciation incidents. It is home to over 1000 species of plant and 1300 animal species, including 119 mammals and 15 primates. Of all species in the area, 60 occur nowhere else and 170 are currently listed as endangered or vulnerable. These include the drill, angwantibo, otter shrew, and Preuss' red colobus. The economic significance of this diversity is illustrated by the fact that at least one major international crop originated in the area (the oil palm, *Eleis guineensis*) and endemic co-evolved insects which pollinate this species are currently being used in Southeast Asia to safeguard crop performance. In addition, the forested watersheds of Oban and Korup appear to perform a vital role in sustaining mangrove fishery production downstream of the forests. The region's physiography is such that the two countries exchange major rivers, and the maintenance of forest cover on both sides of the border is believed to be essential to maintaining hydrological stability downstream.

Land-use pressures in the region include timber production, fuelwood gathering, hunting and trapping, and forest farming. Forest farming occurs both from clearing land in a traditional bush-fallow farming manner, as well as direct gathering of forest products for both subsistence and cash. While all of these pressures pervade in Nigeria, land-use pressures in Cameroon are limited primarily to hunting, trapping, and forest product gathering activities.

Timber production pressures are greatest on the Nigerian side of the border. Nigeria has already converted 90% of its primary tropical rainforest and, whereas it was at one time a major exporter of timber products, it currently is a net importer of wood products. The area around Oban has been logged and one timber concession still exists within the current park boundaries. In Cameroon, on the other hand, the rough terrain and poor access makes timber production in the Korup area uneconomic. Cameroon does have a vital timber export industry, but it is currently concentrated in other parts of the country. As such, the major timber pressures on the forest estate in Cameroon come indirectly from the Nigerian side: deforestation in Nigeria would likely decrease the quality of the forest in Korup as well.

Similarly, fuelwood gathering and bush-fallow farming are significant pressures on the forest only in Nigeria. The relative sparseness of population in the Korup area is such that land-intensive activities do not pose a serious threat to the forest. In Nigeria, however, recent deregulation of farm prices and restrictions on food imports has created substantial incentives for farmers to produce at the extensive margins. This has manifested itself in accelerated forest clearing in the Oban area – primarily for the production of cassava. In addition, the problem is exacerbated by a traditional land tenure system which can best be described as 'claim staking': an individual can achieve rights in perpetuity to a plot of land either through inheritance or through clearing primary forest. Again, while such direct pressures do not exist in Cameroon, the land-use pressures in Nigeria would eventually contribute to degradation of the forest estate in Cameroon.

The primary pressure on the Cameroonian forest estate is through direct harvesting of forest products: through both hunting and gathering activities. Forest animals are hunted and trapped as a source of meat: some of it is for subsistence but most is sold. In Cameroon there is an active cross-border trade of 'bushmeat' to Nigeria. In addition, forest products which include fruit, spices, medicinal plants, and materials for small-scale manufacturing are gathered throughout the year. While the gathering activities are largely regarded as sustainable and not detrimental to the forest, hunting activities are of major concern because many of the animals being hunted are endangered and hunters themselves report that the incidence of many species has declined rapidly over the past ten years. As a central purpose of the park is to protect many of these species and their habitat, initiatives are concentrating on mechanisms to protect the park areas.

Because the land-use pressures are quite different in the two countries, different strategies must be adopted. The problems are somewhat more tractable in Cameroon as there is really only one immediate pressure – hunting – which threatens the forest. But in Cameroon – unlike Nigeria – the problem is complicated by the fact that there are individuals living within the National Park. These people, mostly of the Korup tribe, most probably settled in the region about 300 years ago, having been driven inland by European colonists. Land tenure arrangements are informal but well respected. As there has been no land shortage, any individual from within a village could claim land through claim-staking and farm it within an area of control of that village. Outsiders wishing to farm land can do so only upon payment of some consideration to the village chief, or upon marriage into one of the families in the village. The commonness of this practice has made the region somewhat impervious to immigration and most migration which has occurred has been intra-regional or strict emigration.

The challenge in Korup arises because, legally, the 1000 individuals in the Park are not allowed to live there under Cameroonian law (Republic of Cameroon [1983; 1984]). Strictly, they must be resettled and must be compensated for certain costs incurred in the resettlement. But the Government of Cameroon, under its current economic reforms, does not have the funds necessary to resettle them and international aid agencies – largely because of the controversy associated with certain resettlement programmes – is reticent to become involved in the direct compensation and resettlement of these villages. Appropriately, a feasible strategy which has been selected is to commence an active programme of economic development in a buffer zone around the national park area. The idea is that such a programme will both induce individuals out of the park as well as giving them something better to do than hunt.

To provide some basis for eventually assessing the impacts of the development in and around the park, WWF conducted a "socio-economic survey". This consisted of a series of surveys through 1987 and 1988 which were originally supposed to be used both as a baseline for analysing eventual impacts, as well as a basis for recommending the resettlement strategy. In total, three household surveys were administered by WWF covering the following:

a) food consumption;
b) hunting activities; and,
c) household demographic and income characteristics.

In undertaking these surveys, it should be noted that the intent of WWF was never to perform any rigourous statistical analysis of this information. The surveys generally had quite different goals and, consequently, the sample group for each survey was completely different. The goal of the food survey (Malleson [1987]), for example, was primarily to get an idea of what types of food people ate at various times of the year. As a result, there are no income characteristics corresponding to the households for which food consumption data are available.

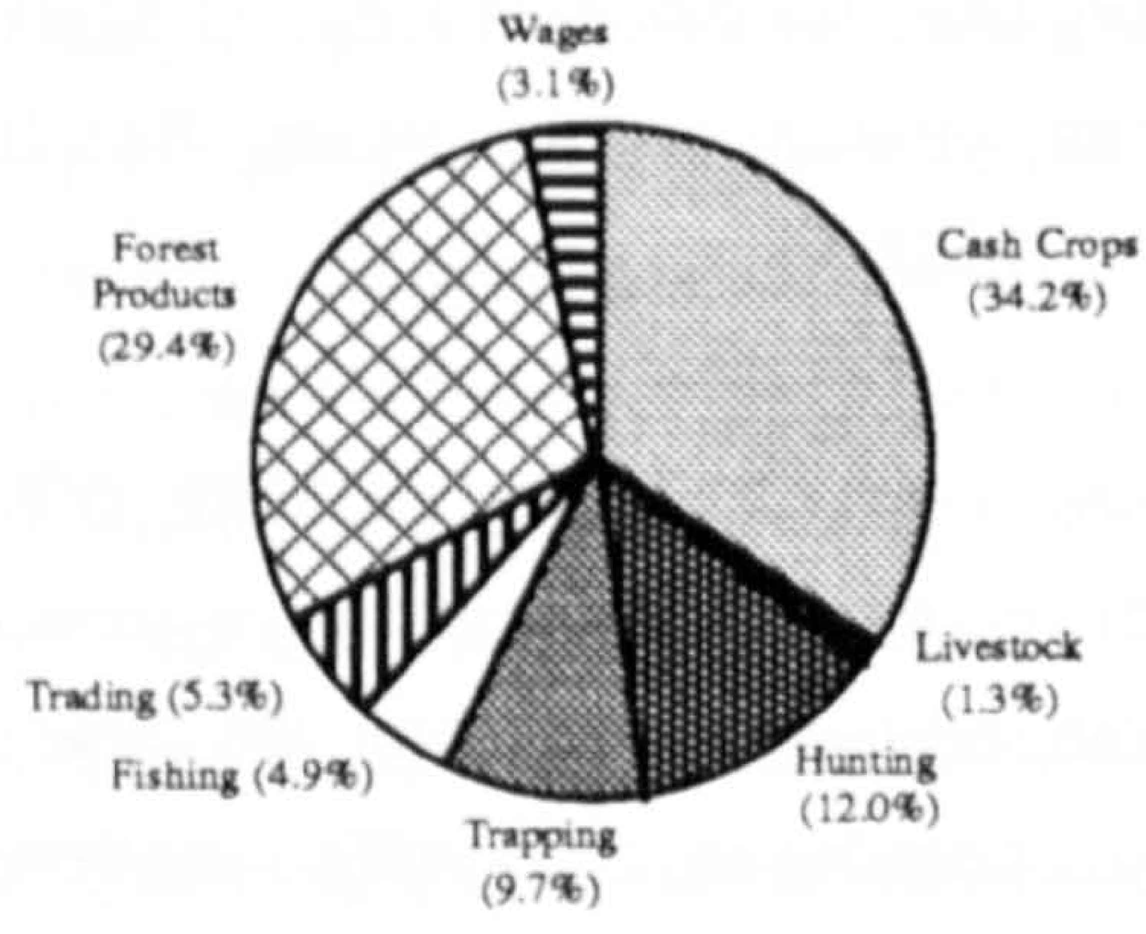
The surveys with applicability to this thesis are the household demographic/income survey and, to a lesser extent, the hunting survey. The demographic survey was conducted by WWF primarily to obtain a count of the people in and around the park, and to identify the activities with which each household in the park was involved. Again, no rigourous statistical analysis of this survey was undertaken by WWF, and some of the results relating to park populations and activities are provided in Devitt (1988). The hunting survey was conducted as a cross-check of the interviews conducted in the household income survey. Because hunting was technically illegal in the park, it was feared that responses to the income survey would be biased, hence a separate hunting survey was conducted which involved placing one researcher in the field for a period of 7 months. The researcher, after gaining the confidence of local villagers, joined hunting parties and recorded the level of hunting activities and successes. Results of this hunting survey are provided in detail in Infield (1988).

In November, 1987, I agreed with WWF to provide an assessment of the development incentive approach if I could have access to the data from the household demographic and income surveys. At that time, the survey instruments had been designed and printed, so it was not possible to add specific questions to the survey which might be particularly helpful to providing such an assessment. Nonetheless, the questions were relatively extensive in scope and they would provide some basis for making an assessment. In February, 1988, a field trip was made to Korup to discuss the conduct of the surveying with the surveyors, and to initiate surveys in the first villages. The surveys were completed by June, 1988, and in July a final field trip was made to discuss the survey results with the surveyors and, in particular, to flag any responses which were suspect. A final field trip was made to Oban National Park in April, 1989, to gain some impressions of how Cameroonian hunting activity might be influenced by conditions in Nigeria.

In total, from February to June, 1988, 357 households were surveyed in 24 villages in and around Korup National Park. Three different individuals were involved in the surveying to allow the completion of the surveys before the start of the July rainy season. The normal routine was that the surveyor would be accompanied by a guide and an interpreter, and would spend up to one week living in each village. The guide was necessary because most of the villages could be reached only by foot through trails in primary or secondary forest. Although English is predominantly spoken in Southwest Cameroon, the lingua franca in the villages is a pidgin English and, often, the presence of a local interpreter both facilitates discourse and allows the interviewee to feel more at ease in the situation. The actual interview would normally last 1 to 2 hours and, in most cases, was with the household head. When the household head was absent, the spouse or other household member would be interviewed. As this was in some instances the third time that interviewers were visiting the villages, they were generally well received and respondents were quite open in providing information.

During the field work, a map of each village was made while walking through the village with the chief or other elder, who was able to indicate where houses had been abandoned due to people moving away. Also, where household heads were temporarily absent and where no-one within the household was available to answer the questions, the chief or elder provided as much information as possible on that particular household. Although the income data in these circumstances was often absent or, at best, suspect, the demographic data are probably fairly accurate. In addition, the map-making process allowed an enumeration of the availability of some basic facilities (schools, churches, and meeting places).

Figure 1.3
Korup Region Income Composition
(341 households)




As one contribution of this thesis research, I transferred all of the demographic and income data from the household surveys into a data management system which would allow summary statistics to be generated, as well as allowing various economic analyses to be undertaken. As considerable effort was dedicated in this research to the generation and analysis of this original data set, a separate appendix to the thesis provides a detailed description of the data gathering and reduction process used for these surveys.

One of the striking descriptive results of the income survey was the importance of the forest to local cash income. For example, Figure 1.3 illustrates that income from forest product gathering and manufacturing was about as important as cash crop production, and that hunting and trapping activity represents almost one-quarter of total income. Wage labour and remittances contribute very little to local incomes. In short, without access to the forest, one might expect economic well-being to decline if the integrity of the forest is threatened or – for that matter – if very restrictive enforcement programmes are required to protect the forest.

## § 1.5 Organisation of Study

The thesis is broadly organised into two parts. Part I consists – in two chapters – of a technical background to the issues involved in rainforest utilisation and an overview of some of the contributions which economic theory might make to these issues. Part II consists of four chapters which present specific empirical evaluations of programmes which are intended to promote rainforest conservation.

In Part I, Chapter 2 sets the context for the thesis, historically and geographically, by introducing a number of the technical issues involved in tropical rainforest development. The chapter relies to a great extent on technical literature in the biological, agricultural, atmospheric, and environmental sciences in an effort to summarise the issues which are of central importance to designing economic policies. In short, the goal of the chapter is to provide an appropriate context in which one can define a number of the policy options for promoting rainforest conservation, highlighting especially the central role which economic policies are anticipated to play. Chapter 3 presents a review of some of the economic literature of relevance to the issue of rainforest conservation, and elaborates on the conceptual framework presented earlier in Figure 1.1. A decision process is outlined which suggests adoption of a two-tier implementation procedure to promoting conservation, corresponding to the international and domestic interventions discussed earlier.

Part II provides selected empirical evaluations. Chapter 4 addresses the question of whether international resources should be allocated to any particular conservation project. A formal derivation of the rainforest supply price is provided to illustrate its relationship to welfare economics and the theory of policy reform. An operational definition of the rainforest supply price is offered which can be calculated as a natural extension of cost-benefit analysis. A cost-benefit analysis of Korup National Park is then conducted which also includes estimates of the values of a number of environmental functions associated with the forest. The rainforest supply price of Korup is computed and then compared to amounts which have been paid elsewhere for rainforest conservation projects. The comparative analysis is based on six recent conservation projects, four of which are associated with "debt-for-nature" swaps.

Chapters 5 and 6 then consider the behaviour of individuals in the Korup area, with the intent of suggesting whether targeted economic development incentives will be effective in promoting conservation. Chapter 5 discusses in more detail the notion of promoting conservation by establishing a buffer zone around a park. Rural development is initiated in the buffer zone in an attempt to draw people away from the park and give them an alternative to exploiting the park. In Chapter 5, I investigate how effective such policies will be if some degree of migratory adjustment occurs within the region. Chapter 6 provides an extension to Chapter 5, although it explicitly attempts to model one of the primary production relationships occurring between man and the tropical rainforest, concentrating in this instance on hunting activity.

In Chapter 7, the effectiveness of indirect taxes as a mechanism for promoting conservation is investigated through an empirical analysis of fuelwood demand in India.

Finally, Chapter 8 summarises the results of the thesis and provides suggestions for further research.

An Appendix provides additional detail on the household surveys conducted in Korup. The information contained in the Appendix is relevant primarily to Chapters 5 and 6 and, to a lesser extent, to Chapter 4.

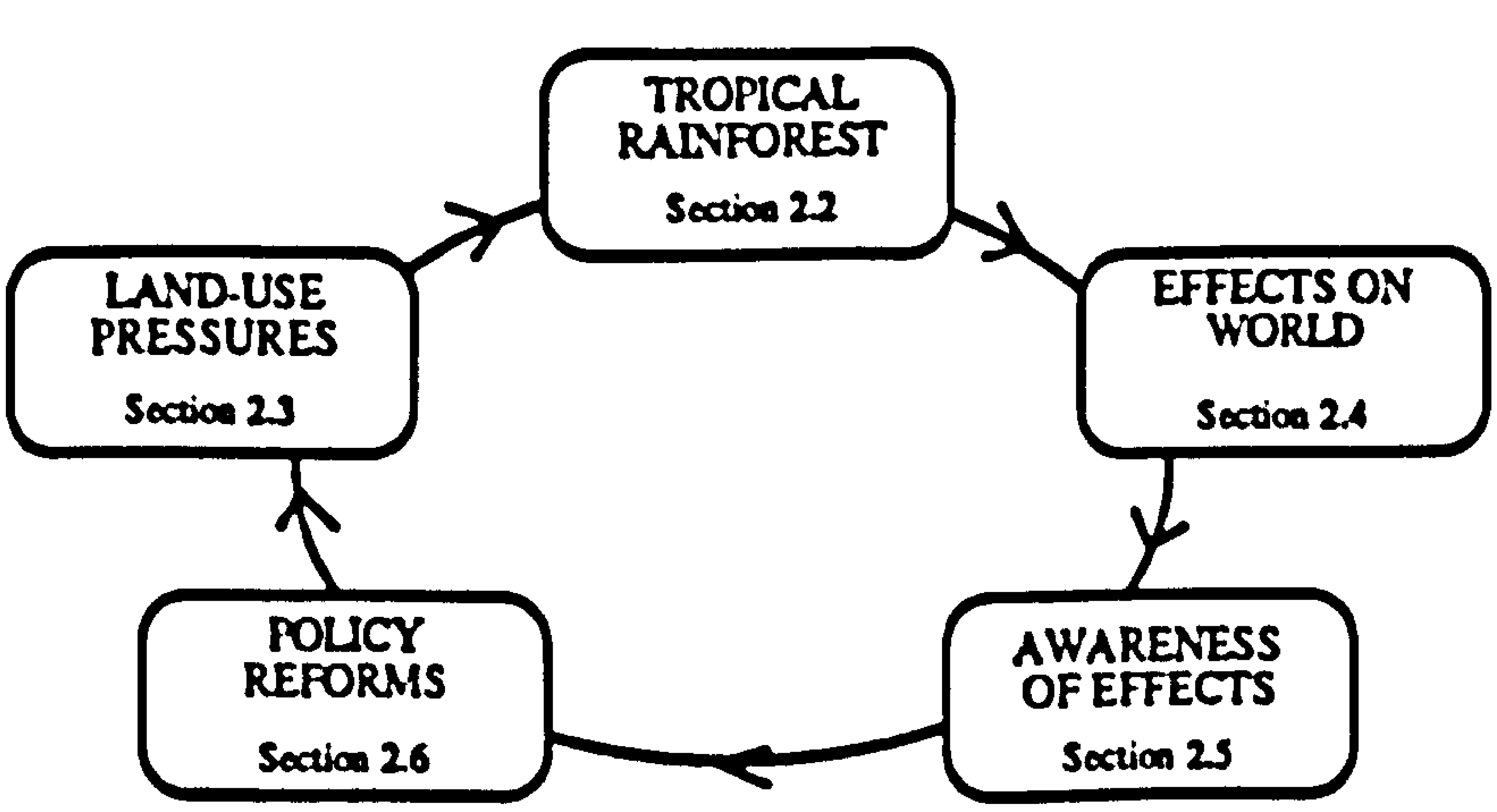
# CHAPTER 2
# TROPICAL RAINFORESTS: BACKGROUND

## § 2.1 Introduction

In both the popular literature as well as academic papers, one finds that authors place no small amount of the blame for tropical deforestation squarely on the shoulders of 'bad' policies. Although numerous factors will often contribute to the implementation of such policies, one recurrent refrain is that policy-makers are simply unaware of how tropical rainforests work. The implication is that before we embark on solving any of the problems associated with deforestation, we should first have a fairly sound understanding of the nature of the problems. Only then will we be in any position to prescribe effective policies. To this end, this chapter concentrates solely on some of the technical and institutional issues which will eventually both define and constrain the economic policies which might be implemented. In the process, the reader unfamiliar with the discipline will also receive a primer on the "non-economic" issues before the economic issues are treated more rigourously in subsequent chapters.

The tropical rainforest "problem" can be characterised most simply as depicted in Figure 2.1. Various land-uses exert pressure on the tropical rainforest biome. This in turn has impacts on the rest of the world. As the world becomes aware of these impacts, there is some desire to offset the pressures by introducing new policies or policy reforms. Although our ultimate interest, from an economic perspective, may be to identify optimal policies or – more modestly – policy reforms which are somehow welfare improving, this can only be done with some understanding of each of the elements in this process.

Figure 2.1
Issues in Tropical Rainforest Conservation



First, in Section 2.2, the physical nature of the biome itself is described, drawing particular attention to how some of the technical literature characterises it as a single living organism. Section 2.3 concentrates on the various land-use pressures exerted on the biome, especially: timber production; ranching; fuelwood gathering; and forest farming. In addition, it outlines the contributions which perverse government policies have made through these pressures. Section 2.4 describes the environmental impacts and effects of rainforest development. It draws extensively from the literature in the environmental sciences and serves to describe the nature of some of the externalities involved with the various land-use pressures on the biome. Section 2.5 concentrates on the international awareness of the rainforest problem which has developed, and how this has led to both political and economic pressures for instituting some policy reforms. Finally, we discuss in Section 2.6 the policy options which are available in light of the growing awareness and the fact that people and countries are willing to dedicate resources to conservation. In particular, this section describes how economic policies have come to the forefront as a promising mechanism for promoting rainforest conservation.

## § 2.2 The Rainforest Biome: Its Nature and Exploitation

In examining the tropical rainforest, it seems natural to ask first what distinguishes it from other forest resources in the world. Prance (1986) alludes to three types of forests in tropical latitudes: deciduous forest, moist forest, and rain forest. Moist forests normally occur in lowland areas which receive amounts of annual rainfall in excess of 2000 mm and rainforests typically receive well in excess of 4000 mm of rain annually.[1] But seasonality is also an important factor, and areas receiving less than 120 mm of monthly rainfall for more than one month typically revert to tropical moist forest. Where there is strong seasonality or low rainfall, deciduous species tend to take over from moist forest species and, as a result of this seasonality, the deciduous forest has fewer species and biomass than does moist forest or rainforest. Although such distinctions can be made between moist forest and rainforest, much of the literature uses the terms interchangeably, as we shall here.

Even within the rainforest biome, there are extremes. Among the wettest are those in Southwest Cameroon in West Africa (Djimde and Raintree [1988]) and in the Chocó area of Colombia (Gentry [1982b]) where annual rainfalls in excess of 10,000 mm are regularly documented while the "driest" are those seasonal rainforests in Central Amazonian Brazil

[1] By comparison, London receives an average annual rainfall of about 600 mm.

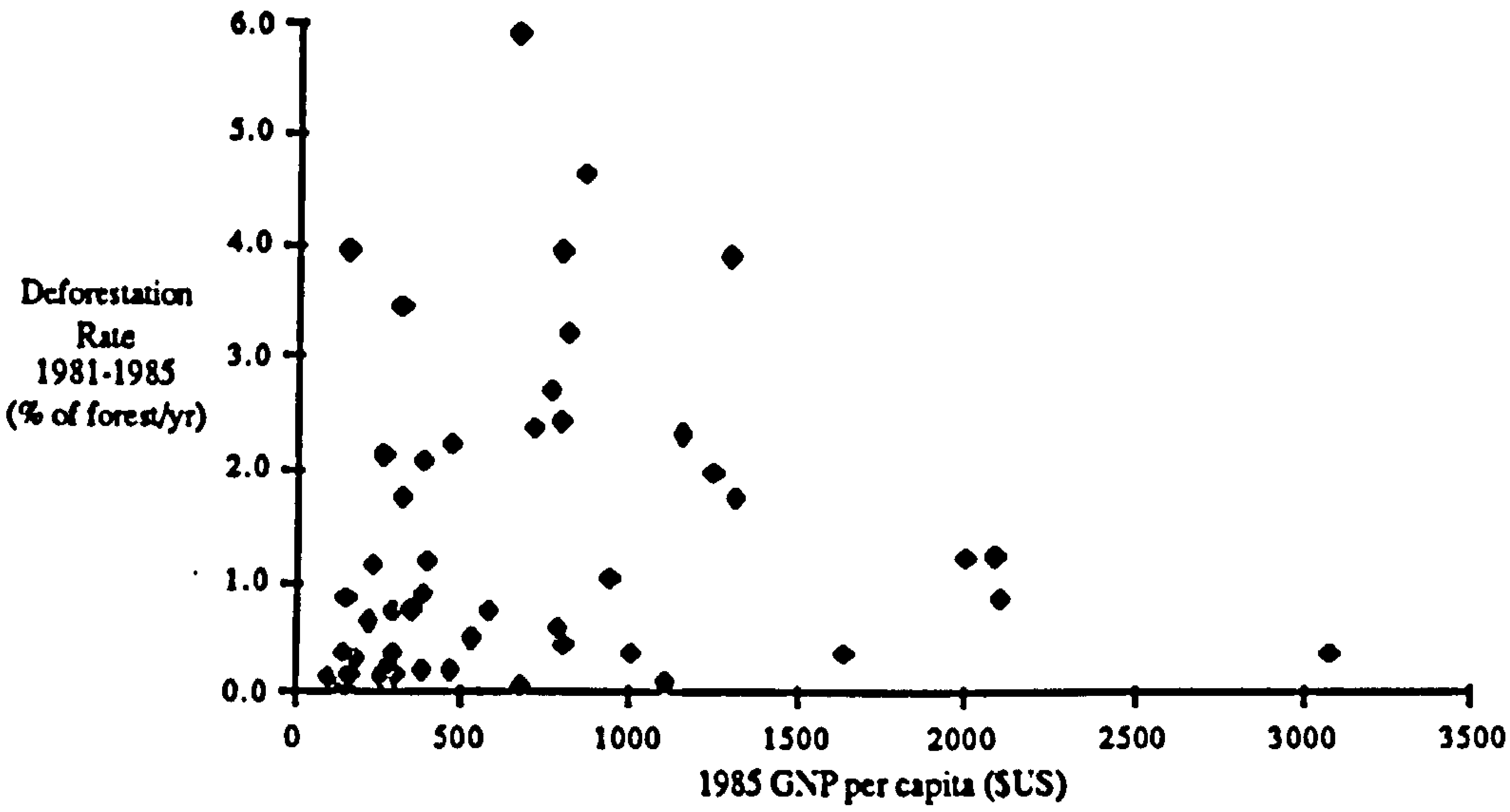
which receive only some 1800 mm of rainfall annually. But tropical rainforests are found all over the world where climate, soil and landscape allow. Perhaps one of the more interesting generalisations made by botanists from cross-sectional studies of rainforest areas is the observation by Gentry (1982a) that there exists a strong correlation between species diversity and rainfall. While many temperate forests can be regarded essentially as monocultures of a single tree crop, rainforests tend to be species rich. Dodson and Gentry (1978) surveyed a 1.7 square kilometre area in a coastal forest in Ecuador and identified 1033 individual tree species.

The species diversity found in rainforests applies not only to tree species but also to plants, animals, and insects. Associated with this rich diversity in the rainforest ecosystem, there have developed complex interactions and interdependencies between the various living parts. The ecological literature is replete with examples of how the survival of some parts of the forest are intricately tied to interactions in other parts. An illuminating example of this interaction involves the survival of the well-known brazil nut. Prance (1985) showed that the brazil nut tree flowers need to be cross-pollinated with pollen from another tree before they would bear fruit. This pollination is performed by local carpenter bees, which feed on the brazil nut flower nectar during a short period of the year, and rely on other trees during the rest of the year when the brazil nut tree is not flowering. The brazil nut could not survive without the bees, the trees for cross-pollination, and the other tree species which support the pollinators. The web gets more intricate when one realises that the bees' mating success depends in turn on the presence of certain epiphytic orchids found in the forest. And the formula becomes more complex still when one realises that the propagation of brazil nut seeds occurs through scatter hoarding by a large forest floor rodent – the agouti. In summary, the brazil nut depends not only on the bees and the trees, but also on the presence of the orchids and animals of the forest. Removing any one element in this mosaic could threaten the survival of the brazil nut.[2] For numerous other examples of such interactions, the interested reader is referred to Mitchell (1986) or Longman and Jeník (1987).

Given the interrelationships and interactions which exist among a rainforest's individual species, some authors prefer to treat the 'rainforest' as a single living organism. This implies that we cannot exploit any single part of it without risking – in some manner – affecting other parts of it as well. A corollary to this view, however, is that the rainforest, as with any single organism, has substantial adaptive mechanisms available to it to survive, albeit in an altered form, any pressures or stresses which it encounters. This adaptivity

[2] Because laws in Brazil recognise the economic importance of the brazil nut, it is illegal to fell them. Ironically, it is not uncommon to see individual trees in areas which have been completely clear-cut.

Figure 2.2
Deforestation Rates and per Capita GNP




Source: Based on Table 2.1

concept is paralleled in an idea which is gaining increased support in the ecological sciences: the Gaia hypothesis. Writers such as Lovelock (1979) assert that the world as a whole is a single organism which can adapt to most any stress which is placed on it. For instance, if the world gets too warm from something that humans happen to be doing, then ice caps will melt, clouds will form, the earth's albedo will increase, and more of the sun's light will be reflected into space: a new equilibrium is eventually established and the earth's ecosystem will continue to flourish. Whether humans can survive in this changed ecosystem is a moot point. The parallel to treating rainforests in this fashion is that minor stresses can perhaps be readily accommodated without causing complete destruction of the rainforest. Unfortunately, our understanding of all of the interactions and adjustments which occur within the rainforest biome is not sufficiently advanced either to defend or refute such a hypothesis.

What is irrefutable, however, is that, when subjected to major land-use pressures, rainforests will eventually succumb. The evidence for this fact is far from fragmentary. Repetto and Gillis (1988) estimate that more than 11 million hectares of forests are cleared annually in the developing world for other uses. In addition, Melillo et.al. (1985) estimate that some 4 million hectares are 'converted' annually from virgin primary forest to lower quality secondary forest. Furthermore, the rates of deforestation appear to be increasing with expanding populations and demands for land. The International Institute for Environment and Development and the World Resources Institute (1986) recently completed a country-by-country inventory which estimated the extent of deforestation of primary forests in developing countries. The results of this study are shown in Table 2.1, along with estimates of the per capita GNP for these countries. An interesting conclusion which arises from comparing deforestation rates to incomes, as illustrated in Figure 2.2, is that there is no particular relationship between GNP and current rates of deforestation. While one must be careful in making and interpreting such broad cross-sectional comparisons, this one is of particular interest because it is often asserted that poor countries are more short-sighted than their richer counterparts and would, therefore, be inclined to consume any capital assets at faster rates. About the only generalisation which can be made is that the countries where deforestation is taking place are poor in comparison to the rest of the world, and this is simply because most of the developing countries are found in the tropical latitudes.

Although deforestation may be occurring at an alarming rate, it is important to note that estimates of deforestation rates vary substantially in the literature. To a large degree, this is because the techniques used to measure deforestation on such a large scale are not 100% reliable. It is only recently that satellite imagery has been used with any degree of success (Woodwell, et.al. [1986]) to measure deforestation, and even then it can only unequivocally identify areas which have been completely clear-cut or have been subject to major conversion. Areas where minor conversion has occurred in the rainforest understory can not be discerned with this technique.

To sum up, this section has provided simply a brief look at some of the physical characteristics of the rainforest biome, highlighting especially the species diversity and interaction which arises. Deforestation pressures have been substantial throughout the developing world, and in the next section we investigate more closely the individual sources of these land-use pressures.

Table 2.1
Deforestation Rates and per Capita GNP in Tropical Countries

| Country | Closed Forest Area 1980 ('000 ha) | Rate of Deforestation 1981-1985 (percent) | Area Deforested Annually ('000 ha) | Per Capita GNP 1985 ($US) |
|---|---|---|---|---|
| **Group I - high rates and large areas affected** | | | | |
| Colombia | 47,351 | 1.7 | 820 | 1,320 |
| Mexico | 47,840 | 1.2 | 595 | 2,080 |
| Ecuador | 14,679 | 2.3 | 340 | 1,160 |
| Paraguay | 4,100 | 4.6 | 190 | 860 |
| Nicaragua | 4,508 | 2.7 | 121 | 770 |
| Guatemala | 4,596 | 2.0 | 90 | 1,250 |
| Honduras | 3,797 | 2.4 | 90 | 720 |
| Costa Rica | 1,664 | 3.9 | 65 | 1,300 |
| Panama | 4,204 | 0.9 | 36 | 2,100 |
| Malaysia | 21,256 | 1.2 | 255 | 2,000 |
| Thailand | 10,375 | 2.4 | 252 | 800 |
| Laos | 8,520 | 1.2 | 100 | n/a |
| Philippines | 12,510 | 0.7 | 91 | 580 |
| Nepal | 2,128 | 3.9 | 84 | 160 |
| Vietnam | 10,810 | 0.6 | 65 | n/a |
| Sri Lanka | 2,782 | 2.1 | 58 | 380 |
| Nigeria | 7,583 | 4.0 | 300 | 800 |
| Ivory Coast | 4,907 | 5.9 | 290 | 660 |
| Madagascar | 12,960 | 1.2 | 150 | 240 |
| Liberia | 2,063 | 2.2 | 46 | 470 |
| Angola | 4,471 | 1.0 | 44 | n/a |
| Zambia | 3,390 | 1.2 | 40 | 390 |
| Guinea | 2,072 | 1.7 | 36 | 320 |
| Ghana | 2,471 | 0.9 | 22 | 380 |
| Total | 241,037 | 1.7 | 4,180 | |
| **Group II - low rates and large areas affected** | | | | |
| Brazil | 396,030 | 0.4 | 1,480 | 1,640 |
| Peru | 70,520 | 0.4 | 270 | 1,010 |
| Venezuela | 33,075 | 0.4 | 125 | 3,080 |
| Bolivia | 44,013 | 0.2 | 87 | 470 |
| Indonesia | 123,235 | 0.5 | 600 | 530 |
| India | 72,521 | 0.2 | 147 | 270 |
| Burma | 32,101 | 0.3 | 105 | 190 |
| Kampuchea | 7,616 | 0.3 | 25 | n/a |
| Papua New Guinea | 34,447 | 0.1 | 22 | 680 |
| Zaire | 105,975 | 0.2 | 182 | 170 |
| Cameroon | 18,105 | 0.4 | 80 | 810 |
| Congo | 21,508 | 0.1 | 22 | 1,110 |
| Gabon | 20,690 | 0.1 | 15 | n/a |
| Total | 979,836 | 0.3 | 3,160 | |

Continued ...

Table 2.1 (continued)
Deforestation Rates and per Capita GNP in Tropical Countries

| Country | Closed Forest Area 1980 ('000 ha) | Rate of Deforestation 1981-1985 (percent) | Area Deforested Annually ('000 ha) | Per Capita GNP 1985 ($US) |
|---|---|---|---|---|
| **Group III** - high rates and small areas remaining | | | | |
| El Salvador | 155 | 3.2 | 5 | 820 |
| Jamaica | 195 | 1.0 | 2 | 940 |
| Haiti | 58 | 3.4 | 2 | 310 |
| Kenya | 2,605 | 0.7 | 19 | 290 |
| Guinea-Bissau | 664 | 2.6 | 17 | n/a |
| Mozambique | 1,189 | 0.8 | 10 | 160 |
| Uganda | 879 | 1.1 | 10 | n/a |
| Brunei | 325 | 2.2 | 7 | n/a |
| Rwanda | 412 | 0.7 | 3 | 280 |
| Benin | 47 | 2.1 | 1 | 260 |
| Total | 6,529 | 1.2 | 76 | |
| **Group IV** - low/moderate rates and small areas affected | | | | |
| Belize | 1,385 | 0.6 | 9 | n/a |
| Dominican Republic | 685 | 0.6 | 4 | 790 |
| Cuba | 3,025 | 0.1 | 2 | n/a |
| Trinidad and Tobago | 368 | 0.3 | 1 | 6,020 |
| Bangladesh | 2,207 | 0.4 | 8 | 150 |
| Pakistan | 3,785 | 0.2 | 7 | 380 |
| Bhutan | 2,170 | 0.1 | 2 | 160 |
| Tanzania | 2,658 | 0.4 | 10 | 290 |
| Ethiopia | 5,332 | 0.2 | 8 | 110 |
| Sierra Leone | 798 | 0.8 | 6 | 350 |
| Central African Republic | 3,595 | 0.1 | 5 | 260 |
| Somalia | 1,650 | 0.2 | 4 | 280 |
| Sudan | 2,532 | 0.2 | 4 | 300 |
| Equatorial Guinea | 1,295 | 0.2 | 3 | n/a |
| Togo | 304 | 0.7 | 2 | 230 |
| Total | 31,789 | 0.2 | 75 | |

Sources: International Institute for Environment and Development and World Resources Institute (1986), World Bank (1986)

## § 2.3 Rainforest Development in Perspective

Land-use pressures in developing countries are often severe where population growth rates are among the highest in the world, arable land is available in limited amounts, and desires for foreign exchange place pressures on local governments to export forest resources or clear forest land for other development objectives. Although there are many contributory factors to deforestation in any given area, the literature normally identifies four principal direct causes:

a) timber production;
b) ranching;
c) fuelwood gathering; and,
d) forest farming.

In addition, two other contributory factors are often cited as exacerbating tropical rainforest deforestation. These are:

e) perverse government policies (operating through [a]-[d]); and,
f) random changes in the global environment.

Each of these factors is discussed in detail in the following sections.

First, the literature on the international timber trade (Burns [1987]; Hyde [1980]; Nectoux and Dudley [1987]; Ross and Donovan [1987]; Repetto [1988]; Repetto and Gillis [1988]; Myers [1983; 1984; 1986]) is virtually unanimous in its assessment that tropical hardwoods are being harvested at non-sustainable rates[3] and that this land-use pressure alone is responsible for the clearing of some 4.5 million hectares annually. For many countries, timber is an important source of export earnings, and government concessions to encourage the timber trade have often resulted in increased deforestation. The deforestation caused by the timber trade will, eventually, lead to degradation of the hardwood assets in LDCs and limit their ability to export or, indeed, meet their own requirements. Nigeria was at one time a major timber exporter but 90% of its native forests have been cleared and it is currently a net importer of timber products. As shown in Table 2.2, a study undertaken by Grainger (1987) suggests that timber exports will start to decline from most developing regions within the next two decades. In the case of Southeast Asia, these exports have already commenced their decline.

In an attempt to preserve the integrity of their forests, many countries require that timber logging companies engage only in selective logging and replant any areas which have been

[3] The issue of "sustainability" is of considerable interest to rainforest deforestation, and it is addressed in detail in the context of the economics literature in the following chapter. In this instance, and throughout this chapter, "non-sustainable" simply means that the physical harvest rate exceeds the natural rate of regeneration.

Table 2.2
Projected Exports of Logs and Processed Wood from Developing Countries (million $m^3$)

| Region | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|---|
| Africa | 7.9 | 7.7 | 11.4 | 15.8 | 32.8 | 33.7 | 21.6 | 25.2 | 8.1 |
| Asia-Pacific | 41.5 | 47.3 | 35.6 | 30.9 | 12.1 | 13.3 | 11.8 | 4.2 | 7.1 |
| Latin America | 1.2 | 8.4 | 32.2 | 51.7 | 77.0 | 104.0 | 55.4 | 33.2 | 20.7 |

Source: Grainger (1987).

cut. In many cases, however, the replanting is not conducted or – if it is conducted – it is not effective because the biome has been damaged to the extent that it can not regenerate (Ledec and Goodland [1988]). Further, selective logging practices which allow cutting of only certain species often leave entire areas damaged and incapable of natural regeneration. Part of the problem is that the very species diversity which exists in rainforests also implies that the density of individual species is very low. Thus if an individual species – such as teak – is exclusively harvested, it may not be capable of re-establishing itself in an area without substantial silvicultural management. While the state of forest management is certainly adequately advanced to conduct these practices, the economic return to such activities tends to be low for individual operators, and the propensity to clear-cut is thus high in the absence of government intervention.[4]

Second, although cattle ranching as an agent of deforestation is confined to Latin America, the best available indication suggests that at least 2 million hectares are cleared annually to support this activity. In this case, timber is not cleared for export but rather the standing forest is clear-cut and then burned in an attempt to return some of the nutrients to otherwise poor quality soil. Browder (1988a) estimates that the amount of cattle pasture in Amazonia would account for as much as 72% of the total deforestation measured by Landsat satellites.

The impetus behind the ranching has been Brazil's attempt at gaining access to the international beef export markets. Massive subsidies (see Binswanger [1987]; Browder [1988b]; Dudley [1985]; Goodland [1980; 1983]) were provided to the livestock sector to attract foreign capital and establish a viable industry. Unfortunately, livestock production is not economically viable at world prices: income covers only some 45% of the costs. But

[4] For examples, see Sartorius and Henle (1968), Hyde (1980), Wyatt-Smith (1987a; 1987b) or McNeely (1988). The usual argument is that the private discount rate exceeds the social discount rate, and that individual operators therefore would not undertake some investments (in replanting) which, from a social perspective, are desirable.

because the land it uses is of such poor quality, continued expansion of pasture lands is necessary even to maintain current herd sizes. In addition, Shane (1986) notes that the clearing often results in substantial displacements of local indigenous peoples – taking away their livelihoods while providing no compensation or employment alternative.

Third, although both timber companies and cattle ranching interests operate on large scales, small scale wood gathering by individual households is estimated to account for as much as 2.5 million hectares of forest clearing annually. As wood is still one of the most predominant energy sources in the developing world, the pressures being exerted by this activity pose a serious threat to existing resources. While the world went through various oil price shocks in the 1970s and 1980s, decreasing wood availability can, in many developing countries, be regarded as the relevant energy crisis.

The extent of this energy crisis is not isolated to any particular area of the globe, although its persistency is concentrated in rural areas. A detailed survey undertaken by the FAO (de Montalembert and Clément [1983]) projected that about one-half of the world population would be facing wood shortages by the year 2000. Of these people, about 80% would be living in rural areas or in towns of less than 100,000 population. As shown in Table 2.3, the estimate for 1980 was that about 100,000 people suffered from "acute scarcity" of fuelwood and that almost 1.3 million were in a "deficit" situation. The FAO defined acute scarcity as a situation in which individuals were harvesting the resource base at rates exceeding its sustainable yield and were – even then – not meeting their subsistence fuel requirements (from all sources). A deficit situation was characterised also by rates of non-sustainable harvesting, yet individuals were meeting current subsistence requirements through an aggregate of the wood use or other fuels.

The fuelwood problem poses special challenges to rainforest management programmes because the agents creating the pressures are often the most disadvantaged in the country: the rural poor. As fuelwood becomes scarce they are forced either to spend more time and effort gathering marginal fuel sources, or to revert to burning agricultural residues which could otherwise serve as fertiliser, or simply to cook their food less. The various aspects of this problem are discussed in considerably more detail in Chapter 7.

Fourth, by far the most substantial impact on tropical rainforests has been the small-scale forest farmer. Forest farming includes the shifting farmer, the migrant squatter, or the landless colonist; and activities associated with forest farming usually include non-sustainable harvesting or gathering of forest resources. Because their impact is not usually to clear-cut the forest but rather to degrade its quality, it is difficult to estimate the exact

Table 2.3
Populations Experiencing a Fuelwood Deficit (millions)

| | 1980 | | | | | | 2000 | |
|---|---|---|---|---|---|---|---|---|
| | Acute Scarcity | | Deficit | | Prospective Deficit | | Acute Scarcity/Deficit | |
| | Total Pop'n | Rural Pop'n | Total Pop'n | Rural Pop'n | Total Pop'n | Rural Pop'n | Total Pop'n | Rural Pop'n |
| Africa | 55 | 49 | 146 | 131 | 112 | 102 | 535 | 464 |
| N.E. & North Africa | | | 104 | 69 | | | 268 | 158 |
| Asia-Pacific | 31 | 29 | 832 | 710 | 161 | 148 | 1,671 | 1,434 |
| Latin America | 26 | 18 | 201 | 143 | 50 | 30 | 512 | 342 |
| TOTAL | 112 | 96 | 1,283 | 1,053 | 323 | 280 | 2,986 | 2,398 |

NOTE: Rural defined as total less that of towns with > 100,000 population

Source: de Montalembert and Clément (1983), FAO.

contribution which the forest farmer has on the biome. Nonetheless, most estimates (Myers [1986]; McNeely [1988]) would confirm that forest farming is responsible for in excess of 10 million hectares of deforestation annually.

Where land is scarce and populations are expanding, the landless will often carve out a niche in the rainforest to practice traditional rotational agriculture or, at times, more modern agroforestry practices which involve the joint production of wood and food crops.[5] While these practices may even be indefinitely sustainable, they do involve permanent conversion of the rainforest biome and increasing population pressure is a persistent threat. It is often argued (see, for example, Dudley [1985]) that the blame for this type of deforestation should be placed not on the individual forest farmers but rather on timber companies and on development projects such as hydroelectric dams. He argues that these projects involve road-building and that – inevitably – people will go where the roads are and try to make a living along such corridors.

Part of the problem with estimating the impacts which forest farming has is distinguishing between sustainable and non-sustainable production and assessing the actual extent of the resulting conversion. A case in point is the harvesting of minor forest products – plants, seeds, and fruit – for minor manufacturing, food or medicinal purposes. Some recent

[5] Examples of this can be found in Brechin (1984), Hoekstra (1987) and Raintree (1986).

surveys indicate that this is an important forest use,[6] and sustainable harvesting in such a manner is likely to add to the well-being of those involved while not unduly threatening the integrity of the forest.

Fifth, while the above discussions may tempt one to start blaming timber companies, cattle ranchers and the rural poor of the world for tropical deforestation, one should recall that in most cases these agents were simply responding to their physical and economic environments at the time. More recent literature recognises that in many cases this economic environment was under the direct influence of local governments which were perhaps in turn corrupted by pressures from local power brokers. Repetto (1986; 1988), Repetto and Gillis (1988), and McNeely (1988) therefore cite 'bad' public policies as instrumental in the deforestation. While the previously described example of giving subsidies to cattle ranchers is a case in point, numerous other examples can be found. Among them are the incentives given by Indonesia and Malaysia to timber companies for harvesting hardwoods.

But the judgment that such policies were somehow 'bad' should be interpreted from the point of view that they did not – for whatever reason – promote rainforest conservation. In hindsight we may be able to see that the deforestation has had detrimental economic effects on the individual countries, but nonetheless – where not driven by corruptive influences – the policies may have seemed both reasonable and desirable at the time they were implemented. Whether the policies were implemented at the time to provide foreign exchange to reduce debt burdens, or to support infrastructure developments, governments at the time implicitly placed a premium on the immediate benefits of deforestation. While attacks on many such policies have been relentless, the encouraging implication is that – if policies have acted as such a strong influence in leading to deforestation – they can presumably be applied with equal vigour and effect in the opposite direction to promote rainforest conservation.

Finally, the last factor which contributes – albeit unpredictably – to deforestation is shifting weather patterns. The basic argument here (see Ledec et.al. [1985], Muscat [1985]) is that carrying capacity of certain areas is being diminished, not necessarily by intensive land-use, but rather by changes in local or global weather patterns. Such changes lead to droughts which in turn lead to deforestation and – in extreme cases – desertification. Gorse and Steeds (1987) acknowledge these effects have been contributory to the deforestation associated with the Sahel droughts of the past ten years, and Starr (1987) argues that much

[6] See Schwartzmann and Allegretti (1987), Prescott-Allen and Prescott-Allen (1983), and Chapter 5 of this thesis.

of the impoverishment and deforestation in Central Niger was linked directly to drought and environmental variability. The problem with actually estimating the direct contribution which droughts have on deforestation is that the impacts may occur indirectly quite far away as individuals leave drought-stricken areas. Refugees from the Sahel droughts, for example, can be found living as far south as the forest zones in Southern Cameroon.

In summary, the direct pressures to which the tropical rainforest biome is subjected are quite varied, ranging from large-scale public timber companies to the small-scale forest farmer who is concerned simply with making a living in a rainforest environment. The pressures have often been exacerbated by public policies which effectively promote deforestation, and environmental variability has contributed in some unquantifiable degree to the overall deforestation.

## § 2.4 Effects of Rainforest Development on the Natural Environment

### 2.4.1 Overview

Whereas the previous section focused on the types of pressures to which the rainforest biome is being subjected, in this section we shall be more concerned with characterising the effects of any degradation on the natural environment. Accordingly, we shall consider the following salient issues which arise in the environmental literature:

a) local climate effects;
b) global climate effects;
c) biological diversity ; and,
d) *in absentia* benefits.

Many of these issues will highlight that there is considerable uncertainty involved in the linkages between deforestation and the natural environment. In this chapter I shall concentrate on the technical aspects of this uncertainty; Chapter 3 will deal in more detail with the potential contributions of economic theory to dealing with this uncertainty.

In addition, to the extent that people are part of the natural environment, it is useful to review briefly the effects of deforestation on indigenous peoples themselves. Although in many cases they are the direct and immediate beneficiaries of any of their activities (at least if they are farming or wood gathering), they will also be the first to experience any degradation in the quality of the environment. Although it is World Bank policy to protect tribal societies from the potentially negative effects of development projects, it acknowledges (see Ledec and Goodland [1988]) that one of the greatest challenges arises when indigenous cultures start to modify their own environment. This can occur due to technological change which makes harvesting easier, to population growth, increased participation in market economies, or simply the breakdown of traditional value systems. Whatever the cause, the effects of non-sustainable harvesting eventually fall back on those individuals who initially relied on it for their livelihoods. Reyes (1983) estimated that 60% of the primary forest had been lost in the Philippines to persistent non-sustainable shifting cultivation over the period 1971-1980. Boado (1988; p. 167) cites population growth and a general lack of conservation ethics among Filipinos as contributory, and notes that it has resulted in "unproductive croplands, degraded soils unsuitable for agriculture, increased erosion and siltation of watersheds, and a growing shortage of forest products." Similar stories can be found throughout the developing world.

### 2.4.2 Local Climate

The major local climatological linkages which could occur with tropical rainforests are associated with precipitation recycling, surface run-off, and soil erosion. Salati et.al. (1986) argue that regional precipitation recycling is an important function of the rainforest. In the Amazon basin for example, only about one-half of the rainfall actually leaves the catchment area through the Amazon River system – the rest is returned to the atmosphere through evapotranspiration. Any decrease in the capacity to recycle this water will have a number of effects. First, there will be less cloud formation and more of the sun's energy will reach the forest zones. But the lower recycling capacity implies that less energy will be required to evaporate the water, and hence an overall heating can be expected in the forest environment. As the survival of many forest species depends on well controlled temperature and humidity bounds, any deforestation is expected eventually to cause weather changes which will themselves threaten the entire biome.

A second associated effect deals with surface run-off. The forest canopy normally protects the forest floor from the sun's intense equatorial rays and from the high volumes of rainfall.[7] But with reduced cloud cover coupled with the removal of the canopy, forest soils are subjected to a dual barrage of sun and rain. This effect on peak flows, coupled with a decrease in low flows due to the lower overall water balance in the system, leads to much larger extremes in surface run-off. In Malaysia, conversion of forests to plantation doubled peak storm flows and halved low flows (Salati, et.al. [1986]). This can have substantial impacts on any fishing or farming operations which are accustomed to and, indeed may depend on, less variability.

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[7]Longman and Jeník (1987) note that as little as 10% of the rainfall falling on a tropical rainforest canopy actually reaches the forest floor directly.

The final effect is closely associated with the surface run-off phenomenon: soil erosion and siltation. With peak floods increasing in volume and the forest floor unprotected by the canopy, soils are removed from the forest and the surrounding catchment area and deposited downstream. This deposition and siltation can have fairly catastrophic impacts on both overall agricultural productivity or on important infrastructure. MacKinnon (1983) estimated that the destruction of a typical catchment area in Indonesia would decrease irrigation efficiency by about 30% to 40%. The Aswan High Dam on the Nile River, for example, has had its useful life expectancy reduced from 100 years to 15 years due to siltation in the reservoir (Blaikie [1985]). In Cameroon, road maintenance costs in deforested areas are typically 10 times higher than normal due to repairs necessitated by erosion. In sloping terrain the problems are compounded because of higher soil erosion, and it has become more widely accepted (WRI [1989]) that the severity of the flooding which occurred in Bangladesh in 1988 was at least partially attributable to deforestation upstream in Nepal. In summary, changes in local weather patterns can affect not only the forest itself, but also economic productivity in the entire catchment area.

### 2.4.3 Global Climate

Connections between rainforest deforestation and global weather systems are less well defined than those involving local climate effects, and the scientific literature is far from unanimous that deforestation will effect global weather. Dickinson (1981) concludes based on atmospheric modelling of energy and water balances that even complete tropical deforestation will lead to variations no greater than those caused by natural fluctuations. His study, however was based simply on the passive functions fulfilled by tropical rainforests, and more recent work has focussed on interactions between the world's oceans, forests, and atmosphere which are influenced by the deforestation *process* – especially the process of burning forest for the purpose of clearing land.

McElroy and Wofsky (1986) stress that an important shift in scientific thought has occurred with respect to interactions between various parts of the biosphere, and that the study of tropical systems is increasing in importance. In part this has come about because of specific concerns such as the ozone layer, but also due to the availability of better data collection and analysis techniques to atmospheric chemists. The short conclusion from the research is that atmospheric chemistry has definitely been changing. Whether this can be correlated as well to climatic changes, and whether tropical deforestation can be held responsible for any part of this change in atmospheric composition are points still very much open to debate.

The first issue relates to how tropical rainforests influence atmospheric chemistry. It is often asserted in popular literature that rainforests are the "lungs of the world" and that they make an important contribution in maintaining oxygen levels in the atmosphere. In fact, however, rainforests play a minor role in this regard as the most significant sources of oxygen are the world's oceans.[8] Similarly, tropical forests appear to play only a minor role in maintaining equilibrium levels of some trace gases. Although ozone is only one of the important trace gases in the atmosphere, it is useful to describe how tropical forests might effect ozone accumulations as some current popular literature draws strong correlations between deforestation and the well-being of the earth's ozone layer. In fact, however, the connection between the two is still tenuous.

Ozone plays an important role in regulating the conditions for life on earth, as it effectively shields organisms from potentially harmful ultraviolet radiation. Concerns for the ozone layer were first expressed in the early 1970s in response to high-flying jet aircraft (Crutzen [1970]; Johnston [1971]) and scientific study has since identified the importance of nitrous oxides and chlorides in the removal of ozone from the earth's atmosphere. Nitrous oxide is produced both by natural decay as well as by burning, and simple forest clearing and burning are estimated to contribute only about 3% of current man-made emissions.[9] The major threat posed by chlorine originates with industrial chlorocarbons used as propellants in aerosols and as refrigerants. A strong natural buffer against these is methane, which is also produced by decay processes and which, when present, effectively intercepts the chlorine molecules before they break down the ozone. McElroy and Wofsky (1986) estimate, however, that the total contribution of tropical forests to the atmospheric methane burden represents about 2% of the total annual supplies.[10]

The most significant contribution which tropical forest clearing makes to atmospheric composition is through the generation of carbon monoxide (CO) and carbon dioxide ($CO_2$). CO and $CO_2$ production arises primarily from combustion and from oxidation of hydrocarbons. While it is not possible to estimate the contribution of man-made $CO_2$ production to the atmosphere,[11] Khalil and Rasmussen (1983) estimated the total man-

[8] For excellent recent references to scientific compendiums on the issue of global and local climate stability the reader is referred to U.S. Environmental Protection Agency (1989), OTA [U.S. Office of Technology Assessment] (1989), National Resources Defense Council (1989), and the Organisation for Economic Cooperation and Development (1989b; 1989c).

[9] The remainder comes from fertilised agricultural lands (48%) and combustion of hydrocarbons (49%). (McElroy and Wofsky [1986])

[10] Cattle are responsible for 30%, rice paddies for 23%, termites for 12%, and the remainder is attributed to various sources including oceans, tundra, biomass burning, natural gas loss, and coal mining.

[11] There is good documentation for increases in atmospheric carbon dioxide of about 10% over the past three decades (McElroy and Wofsky [1986]), but the problem lies in attributing this to any particular

made sources of CO to be 460 million tons annually, of which 200 million tons were directly attributable to forest clearing and the burning of savanna and agricultural land in the tropics. More recent studies (Crutzen, et.al. [1985]; Delaney, et.al. [1985]) attribute a recurring photochemical CO smog over the Brazilian Amazon directly to emissions from agricultural burning and forest clearing. The local effect which this may have is to destroy the regional forests through toxic components in the pollution, although no evidence of this has yet been noted.

This brings us to the second major consideration: what effect does atmospheric chemistry have on the weather? We have seen that tropical forests appear to contribute little to our ability to breathe and it is argued that any degradation in the ozone layer can be corrected more easily by addressing concerns other than tropical rainforests. But through combustion and decay, deforestation does lead to increased production of carbon monoxide and carbon dioxide. A substantial body of literature based on historical scientific records suggests that – over a history extending back 600,000 years – there has existed a high positive correlation between carbon dioxide loads in the atmosphere and global temperatures.[12] Given that tropical systems do appear to play some role in equilibrating trace gases critical to these fluctuations, many believe that massive deforestation will have some effect on global climates. This would in turn cause redistributions in rainfall and changes in ocean currents,[13] and would invariably effect agricultural productivity – perhaps positively or negatively – throughout the world.

In summary, tropical rainforests do have some potentially important contribution to make to the maintenance of global climatological balances. But the scientific community has only begun to understand these contributions and the mechanisms which link the rainforests to the rest of the world ecosystem. There is still considerable scope for interdisciplinary work in the physical sciences before even the direction – let alone the magnitude – of the effects on global climates can be estimated.

source. While burning of vegetation from deforestation could have contributed as much as the burning of fossil fuels, Seiler and Crutzen (1980) suggest that much of the vegetation burned is converted to charcoal and – in this process – would not release the carbon dioxide. In most cases this charcoal is returned to soils or river sediments and does not enter the atmosphere. Even if one argues, however, that the charcoal is eventually used as an energy source, it would simply displace other wood or fossil fuels and the incremental contribution of burning cleared rainforest to carbon dioxide build-up would be relatively minimal.

[12] Delmas, et.al. (1980) and Neftel, et.al. (1982) reconstructed the historical record from ice cores back 60,000 years, and Pisias and Shackleton (1984) extended this record further through measuring carbon composition in marine skeletons.

[13] The effects which major ocean currents have on world weather has been well documented. See, for example, Leighton and Wirawan (1986), who correlated droughts and fires in Borneo to the el Niño event in the South Pacific.

### 2.4.4 Biological Diversity and Extinction

Much of the literature regarding tropical rainforest values asserts that their most important contribution to the world is through their role as a storehouse for biological diversity. In simplest terms, it is implied that – because of their immense diversity and abundance of species – there remain substantial discoveries to be made in the rainforests which can contribute germplasm to the food and pharmaceutical industries of the world. Various estimates suggest that there exist some 5 million to 30 million species of living organisms in the world, of which less than 1.5 million have been described (McNeely [1988]). Many of these are found in tropical rainforests. Mitchell (1986) describes that it is only in the past 5 years that technology has allowed scientists to study the rainforest canopy, and that his investigations alone caused him to revise his estimates of species counts in the rainforest upwards by a factor of 10. With access to the rainforest canopy (provided in fact by modern mountain climbing equipment), new species were discovered, and others which were previously believed to have been endangered were found to be thriving. Given that science has only scratched the surface of what the rainforest has to offer, the destruction of species through deforestation causes inestimable losses to food and pharmaceutical science.

In exploring this further, we shall first outline in more detail what is meant by biodiversity. Second, we shall investigate some of the significant historical contributions which have been made by wild germplasm to the pharmaceutical and food industries. Finally, although they are in a minority in the technical literature, we shall look briefly at some of the dissenting views which, more particularly, focus on the usefulness of laboratory science, gene banks, and the overall 'optimality' of the extinction process.

Biological diversity actually encompasses three distinct concepts which often have conflicting meaning.[14] These three levels include: ecosystem diversity; species diversity; and genetic diversity. Ecosystem diversity is the most general level and relates to the diversity of ecological complexes in which species occur. The functions of the ecosystem include the cycling of nutrients and the storage and transport of minerals, biomass and energy. Species diversity relates quite simply to the number of varieties of living organisms which exist on earth. Genetic diversity relates to the variability of genetic characteristics within a particular species, sub-species, or breed. Genetic diversity is important to the survivability of a species as it determines how adaptable a species can be to changes in its environment. It is also of key concern to genetic scientists as wide genetic diversity effectively broadens the menu of characteristics which can be chosen when

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[14] For a more detailed discussion, see Wilson (1988), OTA (1987), Soulé (1986) or Ricklefs, Naveh and Turner (1984).

developing disease or pest resistant strains of agricultural products.

But although genetic diversity is perhaps the key characteristic, and although genetic diversity can normally be increased by increasing population sizes, other factors must be considered. For example, increasing populations of one species may threaten other species within that ecosystem so – to maintain species diversity – some balance must be struck. Furthermore, in the interests of ecosystem diversity, much of the theoretical literature recognises that a number of small 'island' ecosystems may be better than one large ecosystem. Because there are obvious land constraints, a further balance must be struck between species diversity and ecosystem diversity.

Assuming for the moment that mankind can select which species and ecosystems are going to survive and which are going to perish, then, in theory, one might wish to address biodiversity as an issue which can be solved as a straightforward optimisation problem. In such a formulation, we might ask, for example, what the optimal number of ecosystems, species, and genetic characteristics are given some objective of maximising a biodiversity index which in turn, we suppose, reflects the value of the biodiversity to mankind. The optimisation problem itself would be subject to constraints imposed by species-species interactions, species-ecosystem interactions, and ecosystem-ecosystem interactions, and – presumably – some initial conditions which are themselves a product of natural selection and adjustment mechanisms. While the mathematical constructs are available to address such problems,[15] the nature of the biological interactions within generations – let alone over long time horizons – is not known well enough to conclude what should be done if we are trying to optimise biological diversity.[16]

The importance of having access to wild resources is, however, in little dispute. Wild genetic materials have made considerable contributions in the past to agricultural products, the pharmaceutical industry, and to material sciences. Wild genetic resources have been used – sometimes successfully, sometimes unsuccessfully – to enhance the productivity of most major food and cash crops in the world. A detailed study by Prescott-Allen and Prescott-Allen (1983) covered 29 of the major world crops. A summary of the results of their study are presented in Table 2.4.

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[15] See, for example, Seierstad and Sydsæter (1987), Barrett (1987), Brown and Goldstein (1984), Krautkramer (1985).

[16] Even if one manages to overcome all of the "practical" problems, there still exists an important philosophical question as to what extent mankind's intervention in the process of natural selection is warranted. Some would feel on moral grounds that any such interventions are unethical – that they are paramount to playing the role of a god which mankind has no right to play. Others would assert that such interventions are themselves part of the natural selection process and therefore require no explicit justification.

Table 2.4
Origins of Wild Germplasm Used to Improve Major Crops

| Crop | % of Production Grown in | | Source of Wild Germplasm |
|---|---|---|---|
| | Developed Countries | Developing Countries | Country (Number) |
| Barley | 87 | 13 | Turkey (1) |
| Maize | 65 | 35 | USA (1), Venezuela (1) |
| Oats | 94 | 6 | Israel (1), Portugal (1), Algeria (1), Tunisia (1) |
| Rice | 7 | 93 | India (1) |
| Wheat | 66 | 34 | Turkey (2), Israel (1), Italy (1), Spain (1) |
| Carrot | 74 | 26 | U.S.A. (1-introduced) |
| Cassava | 0 | 100 | Brazil (1) |
| Potato | 83 | 17 | Argentina (3), Bolivia (1), Mexico (2), Peru (1) |
| Sweet Potato | 2 | 98 | Mexico (1) |
| Oil Palm | 0 | 100 | Ivory Coast (1), Nigeria (1), Zaire (1) |
| Sesame | 0 | 100 | India (1) |
| Sunflower | 79 | 21 | U.S.A. (2) |
| Tomato | 60 | 40 | Ecuador (4), Peru (5), Chile (1) |
| Beans | 22 | 78 | None |
| Peas | 61 | 39 | Israel (1), Jordan (1), Lebanon (1), Syria (1), Turkey (1) |
| Soybean | 67 | 33 | None |
| Grapes | 80 | 20 | U.S.A. (6), U.S.S.R. (1) |
| Apple | 77 | 23 | Japan (1), U.S.S.R. (1) |
| Banana | 2 | 98 | None |
| Citrus | 51 | 49 | None |
| Pear | 78 | 22 | U.S.S.R. (1) |
| Strawberry | 90 | 10 | U.S.A. (3), Canada (1), Chile (1) |
| Sugar Beet | 92 | 8 | Italy (1) |
| Sugarcane | 9 | 91 | Papua New Guinea (1), India (1), Indonesia (1) |
| Tobacco | 39 | 61 | Australia (2), Peru (2), Argentine (1), Bolivia (1), Brazil (1), Paraguay (1), Uruguay (1) |
| Cacao | 0 | 100 | Peru (1) |
| Coffee | 0 | 100 | None |
| Cotton | 42 | 58 | Cameroon (1), C.A.R. (1), Chad (1), Ethiopia (1), Niger (1), Nigeria (1), Somalia (1), Sudan (1), Angola (1), Namibia (1), Mexico (1), U.S.A. (1) |
| Rubber | 0 | 100 | Brazil (1) |

Source: Prescott-Allen and Prescott-Allen (1983).

Three general conclusions stand out from their work. First, no country is self-sufficient in its potential for use of genetic resources. Second, although five of the crops have not been improved using wild germplasm (soybeans, beans, banana, citrus, and coffee), developing countries are a major source for wild germplasm for those crops which have been improved. Finally, the flow of benefits has not only been South-North, as it was often characterised, but substantial benefits flow South-South: i.e., the developing world benefits substantially from having access to wild germplasm for improving its domestic crops. In hindsight, this is not surprising as the domestic and wild growing environments are similar, hence desirable characteristics which are sought for domestic crops may be found in wild varieties near at hand.

While specific examples of the contribution of tropical genetic resources abound, the case of maize serves to illustrate the point. Domestic varieties of maize have two major problems: they require sowing annually; and, they are prone to serious diseases. In 1977 the Mexican botanist Rafael Guzman made what has been hailed the "botanical discovery of the century" (Iltis and Doebly [1980]) in a moist forest area which was about to be cleared for development: *Zea diploperennis* – a wild maize variety which hybridises easily, is perennial, and is immune to the four most serious diseases of maize.[17] Although its most desirable traits have not yet been transferred to domestic varieties, it holds tremendous potential as a wild genetic source. Fisher and Hanemann (1985) estimate that the variety may potentially contribute some $6.82 billion in net benefits through decreased planting costs.

Contributions of the rainforest to medicine are not readily subjected to quantification, yet their importance to health both in the developing world and to the developed world is substantial. Prescott-Allen and Prescott-Allen (1982), Myers (1983), Oldfield (1984), and Namkoong (1986) all draw attention to the importance of plant-based drugs in primitive cultures and in local healing in rural and forested areas. In the developing countries, Principe (1988a; 1988b) estimates the retail value of prescription and non-prescription plant-based drugs to have been $43 billion in 1985 in the OECD countries, and that additional social benefits associated with better health (higher productivity, lower health care costs, amenity value of better health) provided an additional benefit of between $150 billion and $1,750 billion annually in those countries. Although it is impossible to estimate the incremental contribution of tropical rainforest plants, a single example can again illustrate the point. The rosy periwinkle (*Vinca rosea*), native to South American

[17] These are chlorotic dwarf virus - the major disease responsible for maize crop losses in the United States; chlorotic mottle virus - significant in South America and parts of the United States; streak virus - responsible for most disease related losses in Africa; and bushy stunt mycoplasma - a serious disease at high elevations in Central and South America. (Nault, L.R. and W.R. Findley [1983])

rainforests and used locally as a hallucinogen and as a treatment for inflammation, was found to have powerful properties against certain forms of cancer. Alkaloids derived from extracts of this plant are now used commonly in the chemical treatment of acute lymphocytic leukemia.[18] Whereas 50 years ago the life expectancy of a sufferer of this disease would have been measured in terms of months, these drugs are now effective in causing remission in all but 2% of cases.

While few would argue that genetic germplasm is important, a position can be taken that there are means of preserving genetic diversity other than *in situ* in the rainforests. Proponents of this view argue that – in practice – local governments have not bothered to catalogue genetic resources in protected areas, or that the amount of land required to effectively protect a biome is impractically large. In such cases, it is argued, *ex situ* gene pools can be maintained in laboratories, zoos, or botanical gardens where scientific access is guaranteed and conditions for the protection of the varieties can be closely monitored. The disadvantage of the *ex situ* gene bank approach, however, is that human error sometimes causes the loss of genetic resources. Hymowitz (1976) documents a case where seed explorers collected 4000 samples of soybean seed from China, Japan and Korea and about two-thirds of the collection was at one point inadvertantly lost or thrown out. Further, maintenance problems still arise, as is documented by (Berding and Koike [1980]) who noted that the wild material in a sugarcane collection was reduced by half after a period of 18 years because of poor maintenance. Quite often the lack of maintenance can not be blamed on any particular human error, but rather is a result of removing the genetic material from its natural environment where it may have established interdependent relationships with other species. This was the case with wild African rices moved to a gene bank in the Philippines. (Harlan [1981]) Also, *in situ* reserves provide a natural laboratory which will often provide the researcher with insights which would not otherwise have developed. Rick (1974) attributes improvements he made in tomato size to observations of how the fruit was developing in natural conditions. Finally, once in an *ex situ* gene bank, varieties will generally stop evolving, whereas *in situ* species can co-evolve with various pests and diseases. To summarise, however, it should most probably be concluded that *in situ* and *ex situ* gene banks should not be regarded as competitive methods for preserving biological diversity: both methods have merits.

The last issue we deal with here concerns extinction as a process. Although the arguments presented above tend to support policies which would slow down the extinction process, we should be reminded that extinction of weak species is a *natural* evolutionary process

[18] Hiatt, Watson and Winsten (1980).

which is critical to the survival of strong species.[19] We should not necessarily be squeamish every time a particular species disappears: varieties mutate, the strong survive, the weak fail. We may more rightfully be concerned, however, if human actions are accelerating the process. McNeely (1988) regards the deforestation in the tropics as an unprecedented destruction of species, and many writers obviously feel that mankind's own long-term survival as a species depends, to some degree, on the well-being of a healthy rainforest biome.

### 2.4.5 *In Absentia* Benefits

Both the environmental and the economic literature is replete with assertions that natural areas provide some *in absentia* benefits to individuals or societies quite apart from those discussed above. Unfortunately, many of these benefits are often lumped into one category loosely referred to as 'option value'. For the sake of clarity, and to discern among the different interpretations of these benefits in the literature, we divide these into the following general categories:

a) basic option value;
b) access option value;
c) quasi-option value;
d) serendipity value;
e) bequest value; and,
f) existence value.

The earliest literature in environmental economics which discusses option value essentially intends to capture the amount which an individual would be willing to pay to preserve their option to have access to an environmental good or service.[20] The essential contribution of this work was that individuals would pay to keep this option open, even if they did not specifically have any intent of visiting the area which might provide the good or service. In addition, society as a whole may be willing to pay to have access to a specific genetic resource at some time in the future, even if it has no immediate consumption or production value. This value, that of being willing to pay for the option of having *certain* access to consumption, we describe as basic option value. It is normally implied that this consumption will be at some future date, although Smith (1983) notes that the passage of time is not essential to the formulation of this type of option value.

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[19] For an excellent discussion of extinction, see Ehrlich and Ehrlich (1981).
[20] These earlier papers include: Weisbrod (1964), Cicchetti, Seneca and Davidson (1969), Cicchetti and Freeman (1971), and Fisher, Krutilla and Cicchetti (1972a; 1972b; 1974).

Gallagher and Smith (1985) subsequently defined "access option value" as the amount that individuals would be willing to pay for increasing the *probability* that they would at one time have access to a given environmental good or service. In essence, this simply recognised that – even once an option was 'purchased' – it might not guarantee the ability to exercise that option. Nonetheless, it seems clear that individuals might be willing to pay for an improvement in their opportunity set, which is essentially what access option value reflects. As with the basic option value, the existence of access option value does not depend on the passage of time.

Freeman (1984), by noting the fact that irreversible decisions were often involved in environmental projects, argued that a "quasi-option value" existed in conservation projects. This argument essentially extended the 'time-dependent' aspects of option value put forward independently by Arrow and Fisher (1974) and Henry (1974b). It requires that, at the outset, the planner does not have complete information on the intrinsic value of the resource. In the case of tropical forests, for example, the argument would be that we do not know everything about the forest's value. If we clear-cut, we will never find out. If we defer clear-cutting the forest and wait, then the opportunity that we have generated for finding out more about the intrinsic value of the forest is our quasi-option value. Fisher and Hanemann (1985) proved that this quasi-option value is positive provided the expected value of the information which might be gained by deferring development is positive. Hanemann (1989) later demonstrated that, under circumstances where a continuum of development levels is available, the quasi-option value might, in fact, be negative for some levels of development.

A further distinction is sometimes made in the popular conservation literature to "serendipity value" (Pearsall [1984], Schultes and Swain [1976]), although it is equivalent to the quasi-option value usually addressed in economics literature. This basically relates to the potential that some species might have a currently unimaginable and undiscovered human use. An example of this would be the role which animals have been found to have as early indicators of ecosystem stress responses to air pollution (Newman and Schereiber [1984]).

An interesting extension to option value is the concept of "bequest value" (Krutilla and Fisher [1975]).[21] This reflects the fact that this generation might vicariously be willing to pay to leave open the options of future generations. It expresses the idea that current generations feel some obligation to future generations, and to some writers (Pearsall

[21] An excellent recent review of the literature relating to this aspect is provided in Chapter 9 of Pearce and Turner (1990).

[1984]; Spash and d'Arge [1989]) it dominates all other benefits of wilderness preservation and environmental integrity.

Finally, we come to "existence value". This reflects that some individuals derive satisfaction from knowing that some species or natural environment exists, even if they never intend to see it, may never want to see it, nor care if anyone else ever derives any economic value from it. They may simply be happy to know that there are gorillas in the rainforests. Ethics and morality are clearly a significant component in establishing any idea of existence value. Many writers[22] would argue that normal valuation procedures should be dropped at this stage, and that certain rules of ethics should be treated as constraints to defining the feasible set of alternatives. To Stone (1972), for example, trees and other natural objects should have legal rights such that we would no sooner eliminate a species of tree than we would murder an individual.

In short, the *in absentia* benefits provided by rainforest conservation often extend well beyond the rainforest biome. While it is difficult to estimate the values which individuals place on these benefits, the interested reader is referred to empirical work by Krutilla and Fisher (1975), Abelson (1979), Cuddington, et.al. (1981), and Harrington and Fisher (1982); or to Eltringham (1984), Redclift (1984) and Usher (1986) for less technical accounts.

## § 2.5 International Awareness

On March 11, 1989, twenty-four member states[23] of the United Nations were signatory to a declaration which stated, in part:

> Today, the very conditions of life on our planet are threatened by the severe attacks to which the earth's atmosphere is subjected. Authoritative scientific studies have shown the existence and scope of considerable dangers linked in particular to the warming of the atmosphere and to the deterioration of the ozone layer.... According to present scientific knowledge, the consequences of these phenomena may well jeopardize ecological systems as well as the most vital interests of mankind at large. Because the problem is planet-wide in scope, solutions can only be devised on a global level. Because of the nature of the dangers involved, remedies to be sought involve not only the fundamental duty to preserve the ecosystem, but also the right to live in dignity in a viable global environment, and the consequent duty of the community of nations vis-à-vis present and future generations to do all that can be done to preserve the quality of the atmosphere....

[22] See, for example, Partridge (1981) and Norton (1988).
[23] These nations include the Federal Republic of Germany, Australia, Brazil, Canada, Ivory Coast, Egypt, Spain, France, Hungary, India, Indonesia, Italy, Japan, Jordan, Kenya, Malta, Norway, New Zealand, Netherlands, Senegal, Sweden, Tunisia, Venezuela, and Zimbabwe. (United Nations [1989])

> What is needed here are regulatory, supportive and adjustment measures that take into account the participation and potential contribution of countries which have reached different levels of development. Most of the emissions that affect the atmosphere at present originate in the industrialized nations. And it is in these same nations that the room for change is greatest, and these nations are also those which have the greatest resources to deal with this problem effectively. The international community and especially the industrialized nations have special obligations to assist developing countries which will be very negatively affected by changes in the atmosphere although the responsibility of many of them for the process may only be marginal today. Financial institutions and development agencies, be they international or domestic, must coordinate their activities in order to promote sustainable development.
>
> Without prejudice to the international obligations of each State, the signatories acknowledge and will promote the following principles:
>
> (a) The principle of developing, within the framework of the United Nations, new institutional authority which ... shall be responsible for combating any further global warming of the atmosphere and shall involve such decision making procedures as may be effective even if, on occasion, unanimous agreement has not been achieved; ...
>
> (d) The principle that countries to which decisions taken to protect the atmosphere shall prove to be an abnormal or special burden, in view, inter alia, of the level of their development and actual responsibility for the deterioration of the atmosphere, shall receive fair and equitable assistance to compensate them for bearing such burden. To this end mechanisms will have to be developed;....

While this declaration specifically mentions the ozone layer, and is partially a follow-up on an earlier resolution made in the General Assembly (United Nations [1988]), it is typical of the growing international resolve to address problems of an environmental nature. From previous sections it is clear that even rainforest conservation would not fall outside of the purview of this declaration. Such awareness and resolve is no longer isolated in small fringe environmental groups in society.

Individual and consumer action has also become a mounting force. Individuals contribute almost $100 million annually to the World Wide Fund for Nature – a non-governmental organisation committed to conserving wildlife and wildlife habitat. Consumer boycotts on large hamburger chains in the United States are largely credited with reducing beef imports from Latin America (Browder [1988b]) over the past three years. Similar campaigns are now being mounted in Europe to respond to a shift in marketing strategy on the part of beef producers in Latin America. Consumer pressure is also being levelled against non-sustainable timber production in developing countries. Purchasers in the United Kingdom are being encouraged to buy temperate softwoods in place of imported tropical hardwood products, and they have access to a *Good Wood Guide* (Friends of the Earth [1988]) to guide their shopping.

While scope for individual expression and action has been growing, most of the large scale efforts are being initiated by international organisations. In 1985, an international task force was convened by the World Resources Institute (WRI) to address tropical forest development. The proceedings of that task force (WRI [1985]) eventually spawned the "Tropical Forest Action Plan" published by the FAO, the World Bank, WRI, and the United Nations Development Program in 1987. It is essentially a framework for coordinated action in the priority areas of forest related land-uses, forest-based industrial development, fuelwood and energy, conservation of tropical forest ecosystems, and institution building. Another product of the work was the proposal (WRI [1988]) to put into place an *International Conservation Funding Project* intended to provide funds for conservation projects in developing countries.

Perhaps most of the clout, however, is being wielded by institutions such as the World Bank. It has more recently accepted that wildland management is an important component of economic development in all countries, and in particular in LDCs where environmental degradation can have severe local consequences (Ledec and Goodland [1988]). International aid agencies such as USAID, CIDA, and the ODA-UK are also starting to integrate environmental concerns with their economic development projects. USAID, for example, has a special budget allocated specifically for projects which promote biodiversity in developing countries which, in 1988, contributed $150,000 to the Korup Project in Cameroon.

In summary, individuals and large organisations have taken notice that the conservation of tropical rainforests is something that they wish to promote. Whatever the basis for these sentiments, there is little dispute that actions are being taken to institute policies and programmes which will fulfill these wishes.

## § 2.6 Defining the Options for Promoting Rainforest Conservation

We have to this point described the tropical rainforest biome and the various pressures exerted on it, and outlined some of the potential effects of deforestation on both a local and global scale. This, coupled with a growing international awareness of the problem and a growing desire to do something about it, now brings us full circle to the very practical problem of whether we can do anything effective about promoting rainforest conservation. In this section we shall highlight the mechanisms which are available for addressing the problem. Broadly speaking, the methods which have been used or suggested fall into the following areas:

a) direct control or regulation;
b) education and training;
c) natural management systems;
d) economic incentives; and,
e) integrated economic/conservation development.

While many programmes will use combinations of strategies from these methods, we shall investigate them individually to highlight the salient advantages and disadvantages of each.

First, the most fundamental option which is available to policy-makers is direct control or regulation. It involves direct physical intervention in a situation by legally restricting the activities which individuals would otherwise want to pursue. Given the inherent simplicity of the approach, it has often been used in developing countries where other policies seem ineffective. Its most immediate advantage is that it can be administered quickly. One disadvantage is that individuals will often feel chagrined by the regulations and thwart them either out of spite or out of economic incentive. For example, Western (1984) notes that in Amboseli National Park, Kenya, Masai deliberately killed rhinoceroses in the park to register their objections to being excluded from land which they regarded as rightfully theirs and which they traditionally required as a grazing area for their cattle. A second disadvantage to direct control is that some international organisations – conservation groups in particular[24] – are reticent about giving money to projects which require massive disruptions to indigenous populations unless the individuals being disrupted are somehow themselves compensated for their losses. A final disadvantage to direct regulation is that the illegal activities (such as poaching) are often so profitable that they can corrupt local enforcement agents or – in the extreme – the governments which oversee them. Despite these disadvantages, however, some form of regulation is often unavoidable when establishing a national park area.

The second strategy which is commonly touted involves education and training of local people. This might involve the instruction of techniques of farming which are more conducive to rainforest conservation, or might simply involve trying to convince native peoples that conservation is in their own self-interest. A striking example of the latter involves the Chipko movement in India. (Dudley [1985]) Although traditionally there had been few constraints on firewood, population growth exerted pressures on fuelwood supplies which spawned the Chipko movement. Supporters of this cause, through

[24] The WWF, for example, will fund park planning or infrastructure but does not contribute funds to resettlement programs.

education by word-of-mouth, attempted to instill into the current generation a sense of moral obligation to future generations. As a practical exercise, it organised tree-planting sessions which, in the end, became as much a symbolic gesture of their commitment to their children as a more immediate fulfillment of their needs for firewood. While education is a useful strategy, its primary disadvantage is that the returns to it are often not realised immediately. In the case of rainforest conservation, where time is of the essence and more immediate remedies are required, education can seem to be too lengthy a process.

The third option involves the use of what has been variously described by Lundgren and Raintree (1983) and Johns (1985) as sustained management or by Leslie (1987) as natural management systems. This approach involves using advanced techniques to increase the productivity of existing rainforest areas as much as ten-fold without materially disturbing the environmental services of the forest. Selective logging, when done properly, falls into this category, as does a wide range of agroforestry systems which involve the joint production of wood crops with food or cash crops. Makeham and Malcolm (1986) point out that practices such as agroforestry can improve the economics of growing traditional crops because of lower losses from pests and diseases, as well as due to higher overall productivity from the available soil. While the advantages of such practices are clear, the disadvantage is that they require significant agricultural extension programmes to support the training and follow-up needed to ensure success. Further, the long-term nature of the techniques are such that they can be applied only to non-pastoral groups: populations which are traditionally pastoral may not be amenable to adopting the suggestions put forward.

The term 'economic incentive' is somewhat of a catchall concept which has grown in the literature of rainforest management to include any policy or programme which uses money, goods or services to influence individual agents. While at the individual or national level the meaning is normally confined to incentives in cash, in kind or through various fiscal mechanisms such as those described in OECD (1989a), at the international level McNeely (1988; p. xiii) extends the term to include "... grants, loans, subsidies, debt swaps, ... food,... commodities agreements, technical assistance, equipment, ... information [,... and] very abstract incentives such as peer pressure and public image." The advantages to using economic incentives are that they are well within the mandates of local governments, they still leave economic choices open to individual agents, and they can be implemented on fairly short time frames – often through existing institutions or reforms.

The greatest disadvantage to economic incentives is that – if one is interested in using them to promote conservation – knowledge is required of how individual agents will act in response to a given economic incentive. While this is not news to any applied economist, it seems to have sometimes slipped the attention of planners. Section 2.3 previously noted that economic policies were at times responsible for accelerated deforestation. These were generally intended to promote some other goal; but even when the intent is to preserve the productivity of a given forest or habitat, economic incentives may backfire. Perrings et.al. (1987) note that, when droughts became more persistent, the Botswana Meat Commission paid farmers elevated prices for cattle in an attempt to still meet farmers' income expectations while allowing reduced stocking rates on arid lands. While incomes were indeed maintained at pre-drought levels, stocking rates went up in response to the higher prices and accelerated degradation of grazing land ensued with an itinerant loss in diversity of both fauna and flora. Although this is a simple example of what might go wrong – even when planners do have conservation in mind – it should serve as a warning that the effect of any given incentive may indeed be the opposite of that which was intended. This is especially true given that many policies – such as those evaluated in Chapters 5 through 7 in this thesis – are based on some rule-of-thumb which appears reasonable on the surface.

To conclude this section we look at the idea of integrating conservation with economic development. It is treated separately because it can perhaps be better described as an approach (if not a philosophy) rather than a specific mechanism. Yet it receives significant attention in the current environmental planning literature as well as in the stated policies of lending institutions such as the World Bank and conservation organisations such as WWF.[25] In a nutshell, it is argued that conservation and economic development should not be regarded *a priori* as conflicting goals. The premise is that, in many cases, they are in fact complementary: economic development initiatives will be more successful if they include a conservation component and, conversely, conservation efforts will be more successful if they include an economic development component.

McNeely (1987) cites an example of the former: the World Bank invested $1 million to establish the Dumoga-Bone National Park to protect a major irrigation project in Indonesia. The project was geographically quite removed from the Park but it nonetheless relied on the rainforests in the park area to keep water levels in the catchment area at the required levels. An example of the latter is Thailand's Khao Yai National Park.[26] The park was established to protect a forest area and the wildlife in it, but it was adjacent to small villages with low incomes, few services, and no land tenure system. Villagers persistently encroached on the park to poach wildlife or to farm. In 1985, a trekking program was established out of one village which gave preferred employment to local villagers as guides and porters at three

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[25] For further discussion of these principles, the interested reader is referred to Ayensu (1987), Casey and Mai (1987), McNeely (1987), Pearce (1988), and Ledec and Goodland (1988).
[26] Praween, Tavatchai, and Dobias (1988).

times the average wage for village labour. The program was complemented by agricultural extension and a subsidised loan fund provided by an environmental group which essentially guaranteed access to the funds as long as the park habitat remained intact. The program, to date, has shown considerable success: incomes have gone up, poaching has stopped, the farmers are reforesting areas of the park where they had previously encroached, and the concept is now being extended to 10 other villages along the park outskirts.

In summary, of all of the mechanisms which have been identified, economic incentives are becoming increasingly popular tools of rainforest conservation management. If these incentives are applied prudently, they may indeed be effective in conserving some rainforest.

## § 2.7 Summary

A pervasive theme throughout the literature dealing with tropical rainforests, is that the tropical rainforest biome is a complex organism. Although some progress has been made in understanding its interactions with the rest of the world, our knowledge is still relatively limited about how humanity influences rainforests, how rainforests influence humanity, and how we can possibly optimise its development for the benefit of humankind. Despite the complexity of the interactions between the rainforest and the rest of the biosphere, there has developed a growing awareness that there may be benefits to conserving rainforests beyond those normally taken into account by those responsible for deforestation. Whatever the impetus behind this awareness, it is clear that steps are being taken to promote tropical rainforest conservation.

The mechanisms for promoting conservation are likely to be as complex as the problem itself; but it is becoming increasingly clear that economic policies will be a part of the overall strategy. One reason for this is the premise that such economic policies are well within the mandate of local governments, and are somehow more desirable and effective than are strategies involving direct control and regulation. A second reason for relying on economic policies involves the critically short time scales involved: while education and the implementation of natural management systems are important elements in conservation promotion, their effectiveness is measured over generations, whereas the response to economic incentives is more immediate. A final reason for placing the onus on economic policies is not necessarily flattering to the economics profession: poor economic policies in the past have been blamed for much of the current deforestation and, if they had such a calamitous effect when they were improperly applied, one might presume that they can act as an equally powerful lever in promoting conservation if they are properly applied. It is thus incumbent upon economists to select policies prudently. This theme serves as an appropriate introduction to the following chapter, wherein we investigate what guidance economic theory can provide in the identification of appropriate policies and strategies.

# CHAPTER 3
# ECONOMIC THEORY AND RAINFORESTS

## § 3.1 Introduction

The previous chapter illustrated that economic policies are becoming increasingly relied upon as a mechanism to promote rainforest conservation. Because of time and information constraints, planners often rely on economic rules-of-thumb to guide their strategies. For example, simple policies such as kerosene subsidies might seem relatively innocuous and, in addition, appear to promote conservation by discouraging fuelwood gathering. But the relevant tests are not only the theory on which these rules-of-thumb are based, but also the empirical evidence of what happens when the policies are actually implemented. Theories must constantly be revised in the light of new evidence and, appropriately, rules-of-thumb should also be adjusted in the wake of new evidence. But before evaluating any specific policies, it is useful to review what general contributions economic theory might make to rainforest management.

In reviewing some of the applicable theory, this chapter first outlines in Section 3.2 the contribution which natural resource economics might make to how we define and attack the rainforest problem. Some central issues in natural resource economics are treated in light of the technical issues discussed in Chapter 2. As many of the problems raised deal with environmental concerns, Section 3.3 reviews the major issues which arise in the environmental economics literature. Third, as noted in Chapter 2, much of the intrinsic value in tropical rainforests supposedly relates to as yet undiscovered products which are of value as genetic material in the agricultural or pharmaceutical industries. Issues discussed in this context are not dissimilar to those addressed in the literature dealing with research, development and invention, hence that is covered in Section 3.4. Fourth, Section 3.5 addresses some of the lessons which can be applied from the economics of contract theory, especially as it relates to devising policies involving 'agreements' between developed countries and LDCs. In all of these cases it should be noted that, in the interests of brevity, I shall primarily be presenting intuitive arguments for the results, making reference to the formal proofs which occur in the literature.

The concluding sections of the chapter provide a conceptual framework for evaluating policies which are intended to promote conservation. In particular, it is argued that, in addition to some of the generalisations which can be made from the economic theory, it is useful to adopt an analytical structure which allows studies on a case by case basis. The central idea is that – although we may want to promote conservation – identifying appropriate reforms relies on knowing who will be affected by such reforms and, ultimately, what their reaction will be to the reforms. To this end, Section 3.6 introduces a two-tier evaluation process for policy design which parallels the two levels – international and domestic – of policy intervention. Finally, Section 3.7 highlights the main points in the chapter and introduces Chapters 4 through 7 which deal with individual empirical problems.

It should be noted that one relevant area of the literature is welfare economics, and many of the issues discussed in this chapter – such as public goods, externalities, and the measurement of benefits – rely extensively on this literature. Applications of welfare economics are also found, however, in cost-benefit analysis, and conservation projects are increasingly being subjected to social cost-benefit analyses which attempt to define and estimate all of the values associated with the environmental services provided by rainforests. If undertaken properly, such analyses can provide useful contributions to identifying beneficial projects and policy reforms. Rather than including the discussion of cost-benefit analysis in this chapter, however, I shall defer it to the following chapter. In Chapter 4, some of the applicable theory of welfare economics and the evaluation of policy reforms is treated more rigourously as an introduction to selected empirical work involving a cost-benefit analysis of the Korup Project.

## § 3.2 Rainforests and Natural Resource Economics

Although there is a vast literature dealing with natural resource economics,[1] little of it specifically addresses the problem of rainforest conservation or management. While this may seem unusual given that tropical rainforests are natural resources, one of the challenges lies in selecting whether the rainforest should be treated as a renewable or a non-renewable resource. To explore the implications of each in the context of the literature, I shall look at the following issues:

a) 'mining' vs 'harvesting' tropical forests;
b) 'population models' of tropical forests; and,
c) the role of open access on deforestation.

Natural resource economics is generally disaggregated into non-renewable resources and renewable resources. Non-renewable resources include those which are available in a fixed

[1] For an overview see Herfindahl and Kneese (1974), Dasgupta and Heal (1974, 1979), Dasgupta (1982), or Heaps and Helliwell (1987).

amount which, once depleted, are gone. Renewable resources are those which either grow or, if harvested, regenerate themselves to some degree. Non-renewable resources normally involve inanimate resources such as oil, gas, or minerals, whereas renewable resources include biological resources.[2] The discipline of natural resource economics primarily addresses the question of how such natural resources can be developed optimally.

The essential results of non-renewable resource depletion were first derived by Hotelling (1931). They say simply that an operator will organise his production plan such that the discounted marginal profits are the same at all points in time. If this were not the case, production could be shifted away from a period of low discounted marginal profit to improve the overall profitability of the extraction plan. While formal proofs of this are relatively standard,[3] the important implication is that if it is expected that the value of a resource will go up at a rate faster than the discount rate, then it pays to hold on to it, whereas if the value is expected to increase at a rate less than the discount rate, it should be consumed immediately. This result is also not unfamiliar in capital theory, and can be readily extended to renewable resource economics. In the case of a natural resource which grows or regenerates, the extraction plan is simply adjusted to reflect the physical rate of growth in the stock of the resource: here the rule would be to leave the asset alone if the sum of the rate of appreciation in its per unit net value and the rate of physical growth are greater than the discount rate. It also results in the well-known conclusion (see, for example Clark [1976] or Johansson and Löfgren [1985)]) that the optimal strategy for a slow-growing forest is to clear-cut it immediately and replant it with a faster growing asset.

There is, however, considerable difficulty in characterising tropical rainforests as either renewable or non-renewable. If it is renewable, then harvesting models can be applied to determine the optimal rate of annual harvesting. If, on the other hand, we assert that it is a non-renewable resource then we must approach the problem from the point of view that the rainforest is essentially a mine. For any individual rainforest, this will normally imply that we either completely clear-cut it or leave it standing. As was intimated in Chapter 2, however, environmental and botanical science suggests that the rainforest unit should be treated as a single complex organism. Because of the great age of the forests, little is known of its regenerative capacity over long time periods. What is known is that a clear-cut forest area can often not be reforested because soil conditions under such circumstances

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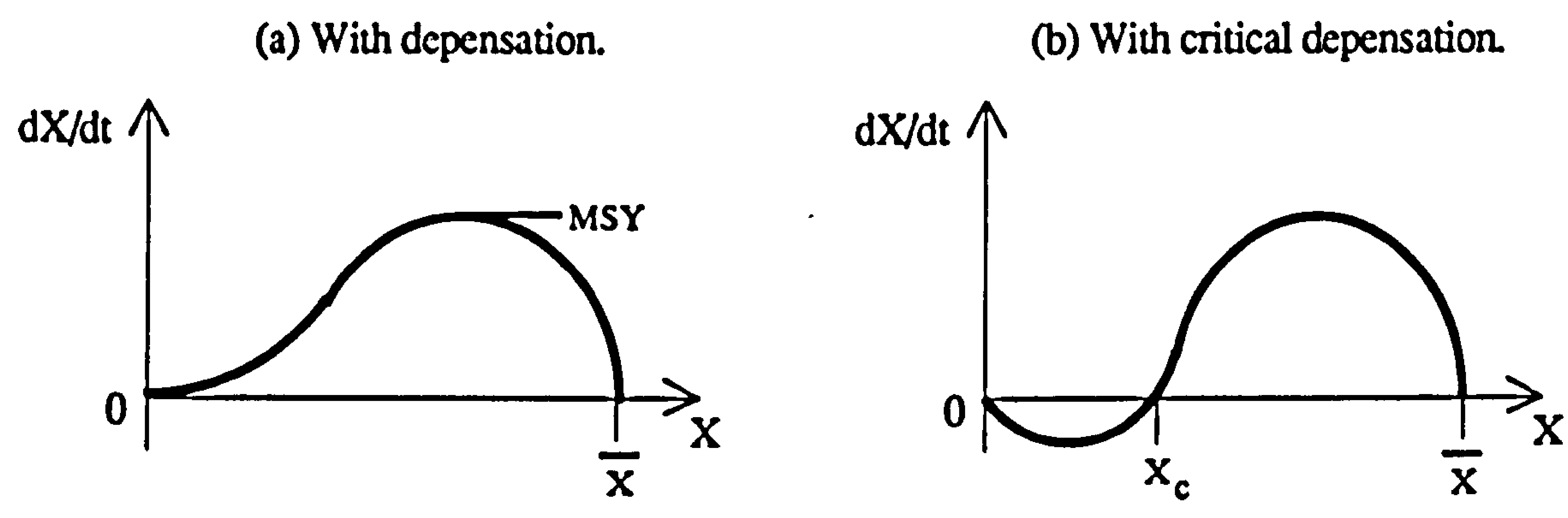
2 It is also useful to make the distinction between "stocks" and "flows". Sunlight and wind, for example, are often referred to as "renewable" to the extent that they keep recurring and consumption in one period does not preclude consumption in another period. In this context, natural resource economics has little to say about the flows of such services, with the exception that they be used in any given period in that application which maximises net benefits.

3 See Kneese and Sweeney (1985) or Scott (1967). Also, see Lecomber (1979) for a derivation using the optimal control approach.

Figure 3.1
Population Models




will not support the same level of life. The 'optimal rotation problem' – on which much of the temperate forestry literature concentrates – is not an appropriate model for the tropical rainforest.

If we choose to treat the forest as a single organism, it is perhaps easiest to characterise the forest in a typical population model. A useful technical model is shown in Figure 3.1. It is commonly used in modelling biological populations, and has been used most extensively in fisheries (Clark [1976]). The simple form of these types of models shows population growth rate dX/dt as a function of stock X.

The first model – Figure 3.1a – illustrates a case where a population will grow asymptotically to a maximum stock size of $\overline{X}$. There are two characteristics of interest in this model. First, the population size is self-limiting because of some external constraints on the system: often food or habitat availability. In the biological literature, this characteristic is known as 'compensation'. Second, a process of 'depensation' occurs at low stocking rates. This reflects the fact that populations often exhibit low initial growth due to higher vulnerability to predation or lower breeding opportunities for sparsely distributed species: here, it generates an inflection in the growth function. In the model, a population can be maintained at any given size X in perpetuity by choosing a harvesting rate h equal to the growth rate at that stock size. The 'maximum sustainable yield' (MSY) is said to occur at a population size at which dX/dt is at a maximum. Depending on the nature of the harvesting cost function, optimal sustainable economic equilibria can be generated anywhere on this function. The practical side of fisheries economics is thus concerned with discovering what the growth function looks like, choosing an optimal harvesting strategy, and then finding policies which achieve this strategy.

Although the above model is often used, Figure 3.1b is often asserted to be a more realistic depiction of certain types of populations. It is characterised by a process referred to as 'critical depensation': once the population falls below a critical size $X_c$, it will eventually become extinct because its natural growth path actually experiences an annual decline. For wildlife resources this may arise due to minimum stocks necessary for breeding to occur viably, or due to increased vulnerability to natural fluctuations in the environment. In the case of tropical rainforests, the model in Figure 3.1b would appear to reflect three of the salient features often encountered in the technical literature. First, it reflects that old-age primary forests appear to be extremely stable in their virgin state: characterised by the equilibrium population $\overline{X}$. Second, it captures the idea that some form of harvesting of the rainforest would be sustainable (between $X_c$ and $\overline{X}$). Finally, in the area of critical depensation, it shows that if the rainforest is over-harvested it will be incapable of regeneration and will continue to decline in quality even if harvesting is halted.

Although an 'organic' model with critical depensation may be the simplest conceptual model which we can devise of the rainforest, the most significant problem which we encounter is that our understanding of tropical rainforest interactions and dynamics is inadequate to provide a basis for devising optimal harvesting strategies. How, for example, does one measure X? Is it cubic metres of wood, tonnes of biomass, numbers of species, area of rainforest, or some index incorporating all of these? And even if we find a useful definition, the task is then one of estimating the growth function. Knowing an approximate value of $X_c$ would be a good start, but even that has not been estimated with our current knowledge and resources. In short, although natural resource economics might have some specific prescriptions to offer if we can provide such information, we are, in practice, far short of describing the technical relationships which exist in the rainforest.

One pervasive theme in the natural resource economics literature is that dealing with intergenerational equity and the selection of optimal extraction strategies. It is largely independent of the type of model used and has usually centred around the discount rates used for evaluating such strategies. While I shall not summarise the vast literature relating to discount rates here[4], and while there is by no means a unanimity of opinion on how to treat intergenerational equity, a common conclusion is that 'social discount rates' (which would be used by society as a whole) are less than 'private discount rates' (which would be used by private agents).[5] If one accepts this, then under many natural resource models,

[4] See Fisher (1989), Spash and d'Arge (1989), Markandya and Pearce (1988) for recent discussions of discount rates which also include reference to environmental issues.

[5] Perhaps one of the more relevant rationales for arguing that social rates are less than private rates is that provided by Marglin (1963). He noted that the welfare of future generations is a public good to members of

resource depletion under private development generally happens more quickly than is socially optimal.

A second general result arising from the natural resource literature is the role of open access in resource exploitation. Whether in the case of mined resources (McKie and McDonald [1962]), fisheries (Gordon [1954]), or other biological resources (Clark [1976]), unregulated open access will generally yield rates of exploitation in excess of those which would occur optimally. This result normally arises because of two factors. First, when profits or 'rents' exist in any time period, more agents will enter the market to attempt to extract some of this rent. Second, even if others are barred from entering the activity, those already engaged in the activity have an incentive to try to capture more rent, even though this will decrease the total rent available in the future. In extreme cases, Berck (1979) notes that open access – with each agent behaving rationally – can readily lead to complete extinction of species. Generally the only cases in which open access has not resulted in over-harvesting are those where implicit or explicit contracts have been struck among participants. Such cases can arise through peer pressure, or simply where everyone behaves in a manner which attempts to maximise the welfare of the collective.[6]

## § 3.3 Rainforests and Environmental Economics

### 3.3.1 Introduction

Because the term 'environment' can be defined to include almost anything, environmental economics potentially covers many areas of study.[7] In practice, however, the discipline has concentrated on studying the interactions between natural environments and economic activities. As such, environmental economics has much in common with the overall field of natural resource economics; natural environments, and the manner in which they can be used optimally, can be addressed using tools developed in the area of natural resource economics. Nonetheless, there are a number of particular problems which have been addressed to a greater extent in the environmental economics literature, and it is thus

the present generation and that, on conventional efficiency (rather than equity) grounds, the present society as a whole would want to invest more than the aggregate of investments made by its individual members acting independently.

[6] For examples, see Ciriacy-Wantrup and Bishop (1975), Livingstone (1986), or Runge (1986).

[7] Indeed, there are some colossally vague definitions of environment, such as "... the components of the Earth and includes (a) air, land and water, (b) all layers of the atmosphere, (c) all organic and inorganic matter and living organisms, and (d) the interacting natural systems that include components referred to in paragraphs (a) to (c);...". While this definition might appear to be so all-encompassing that it is without practical application, it is, in fact, that given by the Government of Canada (1988; Article 3[1]) in the *Canadian Environmental Protection Act* which allows Federal Government interventions in *any* activity if environmental integrity is at stake.

appropriate to highlight some of the salient contributions which can be made by this literature.[8] Appropriately, I shall review each of the following areas in turn:

a) externalities and public goods;
b) uncertainty;
c) sustainable development;
d) linking the physical environment and the economy; and,
e) estimation of benefits.

### 3.3.2 Externalities and Public Goods

Although the theory of externalities and public goods applies to more than just problems of an environmental nature, many of the situations involved with evaluating environmental goods are virtually textbook cases of the theory of public goods. Before proceeding, however, it is useful to clarify the concepts of "externalities" and "public goods".

In the theory of welfare economics, economic agents interact through their effect on prices, and an externality occurs when one person's actions affect the environment or well-being of others *other than* by affecting prices. Externalities can in some cases be treated or 'internalised' by various mechanisms (such as taxes or the assignation of property rights) but, where untreated externalities arise, production and distribution is inefficient; goods having positive externalities will tend to be under-consumed or under-produced whereas those creating negative externalities will tend to be over-consumed or over-produced by private agents. In the case of tropical deforestation, for example, an externality arises because the damage inflicted on the world as a whole is not normally considered by those directly responsible for the deforestation.

The principal characteristic of a public good is that its general availability is not decreased as it is consumed or as it is used as an intermediate input into a production process. Samuelson (1954; 1955) described public goods as those for which "one man's consumption does not reduce some other man's consumption." Because of the nature of public goods, they are often regarded as a special case of externalities: if I choose to 'consume' one unit of national defense then everyone else, whether they like it or not, will consume that same unit of defense. Clean air is another example of a public good.

Although the theory of public goods has developed significantly over the past thirty years

[8] Useful texts on the topic of environmental economics are Dorfman and Dorfman (1977) and Pearce and Turner (1990). Chapter 1 of Pearce and Turner (1990) also gives an excellent review of the history of the discipline of 'environmental economics.' Krabbe (1989) provides a thoughtful essay on what he regards as the nascent field of 'environmental welfare economics'.

(see Oakland [1987] for a review), the lessons derived from the basic model apply quite well to typical environmental problems – including that of rainforest exploitation. The essential nature of a public good is that, for all individuals, we have:

$$x_i \leq X, \quad \text{for all } i, \qquad \text{... (3.1);}$$

where $x_i$ represents the consumption of the good by individual i and X represents total production. This is in sharp contrast to a pure private good, for which we are constrained by:

$$\sum_i x_i \leq X \qquad \text{... (3.2).}$$

It is clear that in the case of a public good, the amount available to any individual is not constrained by the amount consumed by others. The strict inequality in Equation (3.1) applies only if there is some exclusion possible, but, in general, it is possible for strict equality to hold over all individuals. Under these circumstances Samuelson (1955) demonstrated that, to achieve a first-base state, the aggregated marginal benefits of the public good should equal the marginal cost of supplying the good. This is in sharp contrast to the case for efficient production and distribution of a private good, for which the marginal cost of production will be equal to the marginal benefit to a single consumer and that, moreover, the marginal benefit to each consumer will be identical. The upshot of this is that, while prices will both allocate and pay for the production of a private good, the use of prices in public good provision will generally suboptimally exclude consumption of a good for some individuals. It is readily seen that, if for some individual $x_i<X$, then welfare can be improved costlessly by increasing $x_i$ by some small amount $\Delta x_i$. In other words, the appropriate pricing rule is that the public good should be free at the margin.

This raises two problems for the general provision of public goods: i) how to finance their supply, and ii) how to determine the optimal level of production when there is no obvious mechanism (such as prices) available to determine how much individuals would be willing to pay for them. The first problem is usually resolved by assigning the function of their production to some public authority or, alternately, to a private authority which is regulated or induced to supply the optimal quantities. The second problem is usually addressed by some combination of polling peoples' preferences, measuring revealed preferences, or reacting to voting behaviour. In practice, however, solving either of these problems successfully is far from trivial.

An important exception to this is where mechanisms are introduced which allow a 'Lindahl equilibrium' to arise (see Johansen [1963]). In this model, individuals are in principle taxed whatever price the service is worth to them at the margin. As it is often difficult to obtain a truthful revelation of preferences, however, one practical alternative is to attempt to achieve a 'subscription equilibrium', whereby individuals are given the opportunity to pay whatever price they believe a service is worth. A typical example of this is public broadcasting financed through private subscription, but it might be asserted that rainforest conservation groups funded by private donations play a similar role. But even under such mechanisms, "free-rider" problems might arise.

The incidence of free-riders is a chronic problem in the provision of public goods. It arises because any single individual will not generally find that their payment for the good will materially affect the amount of the good provided. Since they know that they can not be excluded from reaping the benefits of any public good, the rational individual will attempt to "free-ride" at the expense of those individuals who do pay for it.[9] Because of this free-rider effect, there is often a tendency to under-produce the amount of any public good. A corollary to this deals with public "bads" such as pollution: where individual contributions are relied on to pay for pollution clean-up, there is a tendency for pollution to occur at greater than optimal levels.

We can now distinguish between two separate issues relating to deforestation by drawing attention to the following generalisations.

Issue I. Physical consumption of rainforests at rate h affects the flow of environmental services e from the rainforest, and this creates an externality as those responsible for its consumption do not consider the effects of changes in e on others.

Issue II. The flow of environmental services e is a public good.

Issue I deals with the effects of physical production from the forest on the well-being of individuals other than those strictly responsible for the deforestation. As the environmental services are not priced, an externality is generated and – as most of the externalities can be regarded as negative because an increase in h reduces e which in turn reduces the well-being of others – the consumption of rainforest is greater than the optimal amount. It is important to note that this result is independent of whether e is a private or a public good.

With respect to Issue II, it is useful to define how certain aspects of the benefits from tropical rainforests can be regarded as public goods. First, the consumption of certain environmental services (such as weather control, information) by one individual does not

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9 There is a very practical dilemma in getting individuals to reveal their preferences for a public good. If you ask someone what something is worth to them and then require them to pay that amount, there is an incentive for them to understate the value and free-ride on others. In that case the good is provided but at a suboptimal level. If you ask someone what something is worth to them and then *do not* require them to pay (or pay some nominal amount which is independent of their answer), there is an incentive for them to *overstate* the value to ensure that the good will in fact be supplied. In that case the good will be provided at more than optimal levels and, often, its provision is not self-financing.

restrict the consumption of those services by others. Second, it would seem quite implausible to exclude individuals from consuming the services once they have been made available. As a public good, we know that there is a tendency for individuals to free-ride and for a suboptimal amount of the service to be provided. It is again important to note that *this* result is independent of Issue I.

In summary, therefore, the major generalisation which arises from the theory of externalities and public goods is that – to the extent that those responsible for consuming the TRF do not normally consider the effects of deforestation on the rest of the world, and to the extent that the environmental services from standing rainforests are public goods – an excessive amount of deforestation will occur.

### 3.3.3 Uncertainty

The second major contribution which can be made by environmental economics deals with uncertainty. Whereas Chapter 2 discussed the nature of this uncertainty and how it might generate some type of option value, the actual implications of this on optimal development are explored here.

Some of the earlier literature dealing with uncertainty formalised its notational treatment by regarding each possible state of nature to be a different attribute of a given commodity (Debreu [1959]). Subsequent literature investigated the implications of uncertainty on optimal investment decisions, and in two notable cases it was shown that the treatment of uncertainty by the 'collective' was rightfully different than that of individuals. Samuelson (1964) argued that, through what can be described as 'risk-pooling' – where individuals can pool risks by combining many risky projects – the collective will be apparently less risk averse than any one individual and, will, in aggregate invest more in the current period.[10] The same conclusion – that society should invest more than individuals – was arrived at in a celebrated article by Arrow and Lind (1970) which argued that uncertainty could be ignored under certain conditions. They proved that, in evaluating public projects, individual risk premiums (reflected in private discount rates) vanished in the limit and random variables could be replaced by their expected values if private and public risks were uncorrelated and if the public risks were absorbed by a large number of individual agents.

This 'risk-spreading' assertion by Arrow-Lind resulted in a substantial amount of

[10] In the literature dealing with discount rates this is also taken as an argument for using social discount rates which are lower than private discount rates.

theoretical debate on the nature and effects of uncertainty in the economics literature in general[11] and the environmental economics literature in particular. In much of the discussion of option values, and especially in articles by Schmalensee (1972), Fisher (1973) and Smith (1987), the Arrow-Lind hypothesis is attacked and shown to be of limited validity when an option demand exists for a service or a good. It is further argued by Arrow and Fisher (1974) and, more recently, by Viscusi (1988), that when investment is irreversible or when it has environmental effects which are irreversible, optimal investment decisions would involve less investment than might otherwise occur in the absence of such irreversibility.

Bishop (1978), however, asserts that typical optimisation procedures are not helpful in practice and that – where the possibility of extinction arises – development should be at levels which set a safe minimum standard for populations and that no amount of development should be pursued if these standards might be breached. It is not obvious, however, that such standards will necessarily lead to less investment or less resource depletion than would an invocation of the optimisation procedures. If, for example, we consider the organic population model in Figure 3.1b with critical depensation, one would presumably set the safe minimum standard at a population level $X_C$. One might well imagine that, if the expected growth function were known, optimisation procedures would under some circumstances generate results which allowed population levels to exceed $X_C$.

In short, while the generalisations provide useful insights, they provide little guidance as to the actual levels of investment which are optimal other than, as noted by Fisher (1989; p. 86), "to go slow".

### 3.3.4 Sustainable Development

It is worthwhile to review in somewhat more detail how the environmental economics literature treats the concept of sustainable development. While it was discussed briefly as a policy option in Section 2.6, the literature also argues that there is some theoretical basis for promoting sustainable development as an appropriate objective in and of itself. Unfortunately, the term 'sustainable development' is quite vague and it has often been used loosely. Only recently have some authors attempted to make the concept of sustainable development tractable by concentrating on the (perhaps equally vague) concepts of economic growth and environmental integrity.

There are essentially two contexts in which the term "sustainable" are found. The first

[11] See for example Henry (1974a; 1974b), Schmalensee (1976) and Sandmo (1972).

definition is fairly broad, to the extent that it generally applies to sustainable development of society or, indeed, of the planet, as a whole. The broad definition for sustainable development is exemplified by that of the World Commission on Environment and Development (1987; p. 43) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The second is a fairly specific definition – introduced earlier in the natural resource economics literature – relating to a distinct renewable resource base. The specific definition is that development is sustainable as long as the rate of harvesting does not exceed the long term growth rate. While the two apply to quite separate issues of resource management, many use the broad definition for asserting that we must harvest our renewable resources 'sustainably'.

One of the earlier positions, perhaps most strongly identified with Daly (1980; 1987a; 1987b), argues essentially that the traditional preoccupation with 'growth' is ill-founded because, ultimately, we shall run into various binding resource constraints for which there are no substitutes yet which are necessary for our continued economic well-being.[12] In this argument, the neo-classical model with substitutable inputs is not valid and must be modified to account for some necessary and non-reproduceable inputs. Daly essentially argues that although this does not preclude economic growth, such growth can only be achieved through increased efficiency with respect to the non-reproduceable inputs and that optimal management dictates that these inputs should be developed on a sustainable basis only. While standard growth theory does deal with such cases, the sentiment is well taken: we should not forget that some non-reproduceable inputs have no substitutes and pay close attention to their exploitation.

Even though many seem to construe sustainable development as maintaining environmental integrity, even this leaves scope for debate. While it might be analytically useful to regard environmental integrity, say $\Psi$, as a constraint to any development decision[13] (i.e., that we will choose a policy reform $d\omega$ only if $d\Psi/d\omega \geq 0$), we are then still faced with the problem of how to measure $\Psi$. In overcoming this, practical considerations often seem to suggest that one working rule is to require that individual assets be harvested 'sustainably', thus returning us to the specific definition of sustainability.

Although specific resource sustainability is then often further interpreted (Daly [1980], Wyatt-Smith [1987a; 1987b], Leslie [1987]) as its maximum sustainable yield (MSY), natural resource theory might dictate driving stocks to a lower level and – perhaps sustainably – continue exploiting the existing stocks at lower levels. While sustainable

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12 This position is also eloquently expressed in the natural resource economics literature by Boulding (1980) and Georgescu-Roegen (1971).
13 See Pearce, Barbier and Markandya (1989) and Pearce, Markandya and Barbier (1989).

development is often intended to mean MSY, it is equally conceivable that exploitation occurs on a sustainable basis at rates of less than the MSY. Suppose, for example, (and assuming that Figure 3.1 represents the growth function of the resource) the stock size in the current period is smaller than (to the left of) that which would be required to harvest at the MSY. Presumably, one could then harvest at the growth rate in perpetuity, or harvest at less than the sustainable growth rates and allow stocks to grow to the point where the MSY would be achieved, and then harvest at the MSY in perpetuity.

In short, while sustainable development is widely professed, in many respects, it is largely tautological: sustainable development is a good idea if one believes that it is *a priori* a necessary condition for our survival. Perhaps one of the most useful contributions of the sustainable development movement has been that it is sufficiently vague that it has allowed many to interpret it as an excuse for promoting environmental integrity.

On a related note, one of the contributions which the literature makes arises from an observation by Pearce and Turner (1990) that economic growth and environmental integrity are not necessarily substitutes. They assert, in fact, that at low income levels in developing economies the two are actually complementary: better environmental integrity allows higher incomes and vice versa. In richer developed countries, better environmental integrity can only be achieved by sacrificing some income, and increases in income will require sacrificing environmental integrity. While specific examples of projects can no doubt be found to support or refute this hypothesis, it will be interesting to see how the hypothesis holds up as empirical work is conducted. If it turns out to be correct, then we again find support for promoting conservation in developing countries.

### 3.3.5 Linking the Physical Environment and the Economy

The environmental economics literature has provided some important means by which to characterise the linkages between the natural environment and the economy. In defining such interactions, there are essentially two broad approaches which dominate in the literature. The literature in economics has a somewhat different approach from that in the area of the ecological sciences; yet the two approaches are complementary and can be merged to develop a framework for evaluating policy reforms.

The ecological literature concentrates on defining the technical interactions between various 'environmental functions' and 'environmental stocks'. In defining linkages between the economy and the environment, the economic literature concentrates on accounting for the demands of final and intermediate consumption of environmental goods and services. At this stage, it is useful to distinguish more clearly between stocks and flows, hence we shall denote environmental stocks by E and flows of environmental services by e. In addition, we shall distinguish direct harvesting of the resource stock as h. The services e can normally (but not necessarily) be characterised as public goods, and the direct harvest h is often (though not necessarily) tradeable output for which exclusion is possible.

Strictly speaking, one might regard the natural environment as a complex dynamic interaction of environmental flows and stocks, but the ecological literature dealing with rainforests has concentrated on characterising the various functions (goods and services) provided by standing rainforest. Formally, they concentrate on the relationship e=e(E). This is the position taken by Farnworth (1984), Margules (1986), and de Groot (1987, 1988a, 1988b), and most of this literature is descriptive in nature: attempting to highlight the various functions provided by natural environments. Unfortunately, the term 'function' in the ecological literature is used rather freely: it is used both for goods and services, and does not normally distinguish between the consumption of flows and stocks. Nonetheless, the categorisation of the various 'functions' does provide a basis for disaggregating various stocks and flows into environmental accounting structures often adopted by environmental economists.

A synopsis of relevant environmental functions pertaining to tropical rainforests – typical of that found in the ecological literature – is provided in Table 3.1. Here a distinction is made between regulatory, carrier, production, and information functions of the rainforest. Regulatory and information functions are normally passive in nature and involve no physical consumption. By contrast, uses involving physical harvesting are identified by production functions (referring to direct utilisation of rainforest products). Finally, carrier functions refer rather loosely to some element of the stock of the rainforest which provides some implicit flow of services. Using our nomenclature, the production functions would normally be included in h and the others would be included in e.

Much of the economic literature of modelling the linkages uses a simple input-output (I-O) approach to defining the interactions between the economy and the environment. Leontief (1970) and Lee (1982) incorporate environmental goods into a constant returns to scale I-O model of an economy. The materials balance approach adopted by Kneese, Ayers and D'Arge (1970) is also essentially an I-O model. In addition, the 'environmental accounting' literature which deals with integrating environmental quality into national accounting systems also essentially falls into the class of I-O models.[14]

[14] A recent survey of this field is found in the compendium edited by Ahmad, Serafy, and Lutz (1989). The

Table 3.1
Examples of Environmental Functions of Rainforests

| Regulatory Functions | Carrier Functions |
|---|---|
| Climate Regulation | Habitat for Indigenous People |
| Watershed Protection & Water Catchment | Cultivation Area |
| Erosion Prevention & Soil Protection | Dam Sites |
| Storage & Recycling of Human Waste & Pollutants | Recreation Sites |
| Storage & Transformation of Solar Energy | Nature Conservation Areas |
| Maintenance of Biodiversity | |
| Biological Control | |
| Provision of Migration Habitat | |
| **Production Functions** | **Information Functions** |
| Timber | Spiritual & Religious Information |
| Other Wood Products | Cultural & Artistic Inspiration |
| Non-wood Forest Products | Educational, Historical & Scientific Information |
| Genetic Resources | Potential Information |

Source: Based on de Groot (1987; 1988a) and McNeely (1988).

Depending upon the purpose, the usual approach is to model one of two different structures. The first approach is applicable when one is interested in knowing the consumption of some environmental good (such as water) or service (such as degree-days of weather). A typical structure would look something like:

| | | INPUT $x_1$ | $x_2$ | $h$ | $e$ |
|---|---|---|---|---|---|
| OUTPUT | $x_1$ | $a_{11}$ | $a_{12}$ | $b_1$ | $c_1$ |
| | $x_2$ | $a_{21}$ | $a_{22}$ | $b_2$ | $c_2$ |

... (3.3).

The second approach concentrates on the production of some good (such as pollution) and is characterised by the following structure:

| | | INPUT $x_1$ | $x_2$ |
|---|---|---|---|
| OUTPUT | $x_1$ | $a_{11}$ | $a_{12}$ |
| | $x_2$ | $a_{21}$ | $a_{22}$ |
| | $e$ | $d_1$ | $d_2$ |

... (3.4).

The two approaches are readily combined to reflect, for example, processes which both consume and produce environmental goods (one could, for example, designate clean water as an input and dirty water as an output). The primary advantage of such approaches is that

impetus behind this work is that national account data, and associated calculations for GNP or NNP, provide no measure of environmental quality or resource integrity. The adoption of environmental accounts – which are linked as satellite accounts to the System of National Accounts – is meant to represent the first step towards reflecting environmental value in national income accounting.

it is possible to determine the total environmental impacts of any change in economic activity and, where environmental goods or services are limited, explicit constraints can be specified. For example, a resource constraint on the first model can be characterised as $(c_iX_i) \leq \bar{c}_t$ for all i where X is the gross production vector and $\bar{e}_t$ is the total flow of environmental service available in any given period if e is a 'public' good. For the tradeable harvested goods for which complete exclusion is possible, the applicable constraint would be $\Sigma(b_iX_i) \leq \bar{h}_t$, where $\bar{h}_t$ is the maximum harvest. Constraints on the production of environmental 'bads' can be made in a like fashion.

While this topic provides no implications for policies, it provides a useful framework for formalising some of the connections between the economy and the environment. In particular, it focuses our attention on the specification or identification of specific goods or services provided by rainforests.

### 3.3.6 Estimation of Benefits

The literature in environmental economics provides important practical approaches to estimating the benefits of conservation, while also providing some interesting insights into the theory of valuation.

First, the literature is rich with examples of the measurement of environmental benefits. As public goods, free-rider problems normally prevent researchers from simply asking individuals what they feel a particular environmental good or service is worth to them. Although such information about individuals' demand curves is critical to determining the optimal amount which should be provided of any good or service, there are strong incentives for individuals to understate their preferences. Much of the literature has thus been occupied with using means other than direct polling to estimate demand curves. Where services have some spatial component, for example, individuals' preferences may be revealed by noting where individuals locate in relation to various levels of services. This mechanism, associated with Tiebout (1956), normally has limited practical applicability because of some very restrictive assumptions.[15] A more promising approach is to estimate the demand for environmental goods or services by observing individual demand for related private goods or services. In the demand for national parks, for example, this might involve analysing expenditures on traded substitutes (such as private

[15] Notably, it requires some restrictions on individual mobility and requires further that there be a large number of communities available for each taste class. For a full discussion of the Tiebout model, the reader is referred to Rubinfeld (1987).

theme parks) or – using more complex techniques[16] – on complements (such as camping equipment).

Finally, where no privately traded related services exist, a relatively simple means of estimating the value of an environmental service may be to estimate the costs of providing the comparable service through man-made mechanisms. In the case of the potential genetic benefits provided by rainforests to the pharmaceutical industry, for example, it may be more appropriate to attempt to estimate the amount of laboratory research effort that is saved by having access to the rainforest products than to measure the amount that society would be willing to pay for the better level of health.[17]

In addition to the practical aspects of measuring benefits, the literature provides an interesting forum for addressing the appropriateness of various measures of consumer surplus. The discussion has concentrated on two measures: willingness to pay (WTP) and willingness to accept (WTA). The WTA measure provides an indication of how much income compensation individuals would accept for the loss of some good or service, whereas the WTP measure estimates how much income they would be willing to give up in exchange for some benefit. Many argue that, conceptually, WTA is the appropriate measure when valuing losses in environmental services or losses in amenity. Although in theory the difference between WTA and WTP is normally small when evaluating price changes (Willig [1976]), empirical evidence (Knetsch and Sinden [1984]) has suggested that WTA can exceed WTP by up to an order of magnitude. This implies, for example, that an individual might be willing to pay £1 to have an extra tree to look at on the boulevard, yet might require £10 in compensation if one of the trees presently on the boulevard were to be removed. While it might be argued that this discrepancy is simply a measurement error related to the particular measurement techniques, there is also some theoretical basis for this discrepancy.

The economics literature provides one such rationale, as Hanemann (1984) illustrated that the difference between WTA and WTP could be large if there are no or few private substitutes for the environmental good or service. In addition, the result is not anomalous to psychologists who observe that people are usually more adamant about keeping what they have rather than getting what they do not have. Often, this is associated with the belief that they have innate rights to – or implicit ownership of – some existing (albeit publicly

[16] This process is described in detail by Bradford and Hildebrandt (1977).
[17] This argument is often overlooked in the conservation literature. Suppose that a cure for cancer would be worth $500 billion to the world and that we will find such a cure by keeping our rainforests intact for the next 50 years. But suppose as well that we will find the cure by spending $100 billion on laboratory research without access to the rainforests. The maximum we should be willing to pay to conserve the rainforests (if that is their only function) should then be $100 billion – not $500 billion.

available) asset.

If, as evidence suggests, WTA does indeed exceed WTP for environmental goods and services, and if this also applies to services provided by rainforests, then there are three important generalisations which arise from this. First, one obvious result is that analyses based solely on current WTP may still provide a suboptimal level of rainforest conservation. Second, as observed by Fisher (1989), there may be a tendency for WTA and WTP to diverge more in the future than they do currently if the substitution possibilities for the environment decline with time and, in that event, even basing analyses on current WTA will provide suboptimal levels of rainforest conservation. Finally, as noted by Pearce and Turner (1990), with the implied discontinuity in the demand function, there is a tendency for the optimal level of provision of an environmental good to occur at the level of the status quo. This is, in no uncertain terms, a relatively simple argument for conservation based purely on efficiency grounds.

While the foregoing sections have concentrated on summary arguments from the literature, considerable detail can be found in each of the areas discussed. For more general explorations into environmental economics and conservation, the reader is referred to Smith and Krutilla (1982) or Fisher and Krutilla (1985); Baumol and Oates (1971; 1975) and Smith (1972) treat externalities in further detail; and Hufschmidt, et. al. (1988), Johansson (1987) and Cummings et. al. (1986) provide excellent technical reviews of the current state-of-the-art in measuring and estimating environmental benefits. Empirical examples which attempt to quantify some of the environmental benefits associated with tropical rainforests can be found in McNeil (1986) and Peterson and Randall (1984).

## § 3.4 Rainforests and the Economics of Invention

Since Arrow (1962) drew attention to the fact that a suboptimal amount of inventive activity may be undertaken if inventors can not fully capture the value of their inventions, considerable effort has been dedicated to describing both theoretically and empirically the actual determinants of inventive activity and research spending. Whereas Arrow concentrated on the importance of 'appropriability' in determining the amount of inventive activity, others highlighted the importance of global demand growth (Schmookler [1966]) or investment (Nordhaus [1969] and Rosenberg [1969; 1974]) as driving forces behind research and development. Considerable theoretical debate has focussed on whether productive investment leads R&D investment, or whether R&D investment precedes productive investment, but empirical evidence suggests[18] that productive investment leads R&D and that the overall value of R&D investment is actually proportional to total demand.

While there is considerable scope for debate, there are a number of particular concerns regarding the actual measurement of R&D effort. Some of these problems were recognised by Kuznets (1962a), and they generally relate to the difficulty in separating R&D expenditures from other investments. As a proxy for inventive activity, researchers have often used patent data to estimate activity, but many of the most valuable discoveries have never been patented, while of those which have been patented, many are of extremely low value. Indeed, Shankerman and Pakes (1986) find that the patent system is not exceedingly effective in protecting the values of inventors' activities.

This brings us back, therefore, to Arrow's earlier concern regarding appropriability. A similar argument is put forward by Hirschleifer (1971), who draws attention to the fact that much inventive activity does not generate goods but generates information. Information is a public good but, if it is indeed free, then it will generally be under-supplied by private agents. The appropriability model is quite straightforward: if $V(r)$ is the social value of R&D at some level $r$, and if some proportion $\alpha \leq 1$ is appropriable by private agents for whom research costs $C(r)$, then an amount of research $r_p$ corresponding to $C'(r_p)=\alpha V'(r_p)$ will be undertaken, whereas the optimal amount $r^*$ would occur at $C'(r^*)=V'(r^*)$. With the usual downward sloping marginal benefit and upward sloping marginal cost functions, it is clear that $r_p<r^*$ and that research spending will be under-supplied.

In the case of rainforests, it has been noted in Chapter 2 that the products and inventions which might come from increased research of the biome could have a considerable value. But for a number of reasons, this value is not readily appropriable either by the governments of the countries or by companies which might be undertaking research in the forests. First, products occurring naturally are – under the rules of all patent systems – not patentable. While individual processes for extracting useful products from naturally occurring products are patentable, alternate processes are often readily designed to extract the useful ingredients. Second, even if a useful product is discovered, it is not usually an exportable commodity because many of the ingredients can be synthesised in laboratories (and subsequently patented) once scientists know what they are looking for.[19] Third,

[18] See Pakes and Shankerman (1984) and Lach and Schankerman (1987).

[19] This has been a common complaint in some developing countries. When natural products are given to laboratories outside of the countries to determine if they have any economic value, it is not uncommon to find synthesised quantities based on that product on the market a number of years later, with no benefits going to the country which initially supplied the product. The recurrence of this prompted Egypt and Ethiopia to ban exports of selected genetic materials (Prescott-Allen and Prescott-Allen [1983]) and has caused the Government of Cameroon to stop transfers of genetic materials to laboratories in France.

many developing countries do not have the research facilities available to investigate properly the genetic potential of products which occur in their rainforests, and Yankey (1987) notes that the patent systems within these countries are even less effective than those in developed countries for protecting the commercial interests of individual researchers.

In conclusion, the literature from R&D economics suggests that in practice – even if ownership rights are recognised or conferred – the total value of genetic resources, for example, will not be appropriable by the individual LDCs owning those resources. The reasons for this relate both to institutional constraints as well as the very practical fact that 'knowledge' or information is a free good once it is released. This result has important implications for valuing the potential benefits of conservation: if we rely solely on evaluating the benefits of current or recent research efforts, we may well understate the benefits of conservation and, therefore, under-invest in conservation initiatives. It suggests as well that normal market mechanisms may fail to provide adequate incentives to individual LDCs to conserve their rainforests, and that it may be appropriate to overcome this failure through providing additional incentives at an international level.

## § 3.5 Contract Theory and Rainforest Conservation

The previous section asserted that it is difficult for LDCs to capture the genetic value of their natural resources. To provide incentives for LDCs to conserve their rainforests, it is often argued that some sort of direct transfer must be made to them. In many respects, we can draw parallels to this in contract theory: which addresses the general problem of the optimal form of contract between two parties. In this case, the two parties are the LDC and the rest of the world (ROW). The specific problem is how to design a contract between the LDC and the ROW such that the rainforest will be conserved. Many of the issues addressed in contract theory have some application here, and hence it is illuminating to review some of the conclusions which might be drawn from this theory. In particular, I shall address the following specific issues:

a) moral hazard;
b) additionality;
c) the role of a third party; and,
d) the role of repetition.

The discussion in the following sections relies entirely on relatively straight-forward, intuitive arguments, and the formal models developed in contract theory are not presented here.[20]

[20] For a more formal treatment of this subject, the interested reader is referred to Holmstrom (1979; 1982), Mirrlees (1976), or Boyle and Butterworth (1988) for specific models, and to an excellent text on these

The concept of moral hazard arises from situations in which it is not possible to observe or control all of the actions of a particular agent. The basic situation is described concisely by Boyle and Butterworth (1988: pp. 169f):

> In the basic model of this genre there are two economic agents – the principal and the agent – who operate in an uncertain environment. The principal engages the agent to perform a certain task where the output is both a function of the effort exerted by the agent and the random state of nature that ensues. Both the principal and the agent strive to maximise their own welfare. The principal's problem is to design a contract that is efficient from a risk-sharing viewpoint and provides appropriate incentives for the agent. If the agent is work averse – an assumption normally made in these models – then he has an incentive to shirk if his actions are unobservable to the principal, giving rise to moral hazard.

It is clear that this situation has a close corollary in the relationship between LDCs with rainforest resources and the rest of the world. We want the LDCs to conserve the forests, we are perhaps willing to pay them for it, but we do no necessarily know what means they have at their disposal to do this nor can we necessarily monitor the means or effectiveness of their policies. We want to make sure that whatever agreement we strike will, ultimately, yield some amount of conservation.

But the situation implies that, because we cannot see what is going on, there is a good chance of shirking on the part of the LDC. The formal models normally show that optimal contracts arise when the timing and degree of compensation accruing to the agent corresponds in both timing and degree to the levels of benefits accruing to the principal. If rainforests provide a continuous service and benefit to the rest of the world, it would therefore imply that the optimal compensation formula would involve some on-going level of transfers.

Closely related to the problem of moral hazard is the issue of additionality. It is noted here that in some instances it is conceivable that an LDC will find it to be in its own interests to conserve a rainforest, possibly because of the local environmental functions it provides. Again, however, because the outside world may not be able to observe the value which the LDC attaches to these benefits, it could feel compelled to compensate the LDC for conserving rainforests which might have been conserved in any event by the LDC. Bergsman and Edisis (1988) argued that the issue of additionality is not a trivial component even in conventional investments in LDCs: they estimated that about one-third of recent debt-equity swaps undertaken in Latin America would have been undertaken even without the concessionary programmes and transfers implicit in these swaps. As "debt-for-nature" swaps are also becoming a popular mechanism for nature conservation,[21] and as most have

matters edited by Feltham, Amershi, and Ziemba (1988).

[21] A more detailed discussion of debt-for-nature swaps is provided in Chapter 4.

been modelled on simple debt-equity swap scenarios, there is some risk that donor funds will be diverted to projects which would have actually proceeded without external support.

The effects of both the moral hazard and additionality issues noted above can be mitigated by involving a third party which has interests which more closely resemble those of the principal. Without such a third party, the agent (LDC) is responsible for meeting its conservation obligations while also – presumably – addressing a host of other goals. The designation of a third party – having conservation as its primary objective – will decrease both shirking and the monitoring and information difficulties which gives rise to the shirking. The use of a third party has been adopted in a number of cases; local conservation groups have been given the mandate to oversee government programmes and – in some cases such as Costa Rica where the entire Park Service is private – have an express mandate to carry out the conservation programmes. One problem with this approach is that the third party has only a limited number of policy instruments available to it to promote conservation. It would presumably not have the authority, for example, to give kerosene subsidies to promote substitution away from fuelwood.

The complexion of the moral hazard issue changes considerably where repetition becomes a factor. In the standard principal/agent model, the contract is construed as a one-time agreement on a single project. With repetition, the potential exists for additional projects to be pursued at future dates. In the context of this study, it implies that the LDC might have different sections of rainforest which could be the target of international transfers for local conservation efforts. In such cases, if the agent – the LDC in this case – perceives that there is some potential for future support on other projects, then the incentives to shirk on earlier projects diminishes.

In summary, contracting theory and principal/agent theory do allow some useful generalisations to be made in approaching the problem of how to structure transfers to induce LDCs to conserve rainforests. It suggests that, with one-time lump-sum transfers, there is an incentive for LDCs to shirk in fulfilling their obligations to attempt to conserve the rainforests, and there is also a risk that international conservation efforts may not generate additional conservation activity. These risks are reduced, however, in cases where a third party (with conservation interests) can be made responsible for the conservation efforts, or where there is some chance of future projects being pursued. Specifically, one result which this suggests is that the best contract is not normally expected to be a one-time lump-sum transfer. Ironically, this is precisely what some agencies and countries are doing in the world right now: debt-for-nature swaps are (on the surface) one-time transfers; environment oriented development injections by conventional donors are similar in nature.

## § 3.6 Role of Economic Policies

### 3.6.1 A Recap

An important generalisation arising from the economic theory is that tropical forests are being developed too quickly with respect to the optimal rate. A corollary to this is that a sub-optimal amount of conservation is occurring. While this result has been derived using a number of different arguments from many parts of the literature (a number of which invariably have overlapping elements) some of the salient factors which contribute to it are:

a) much of rainforest exploitation is through conditions of open access;
b) the services rainforests provide to the rest of the world are public goods from which exclusion is essentially impossible;
c) those harvesting the resource do not take into account the effects their actions have on the rest of the world;
d) development is irreversible and benefits are uncertain; and,
e) typical valuation procedures of conservation benefits may understate social benefits because of free-rider effects, the lack of appropriability of research benefits, and potentially significant divergences between WTP and WTA.

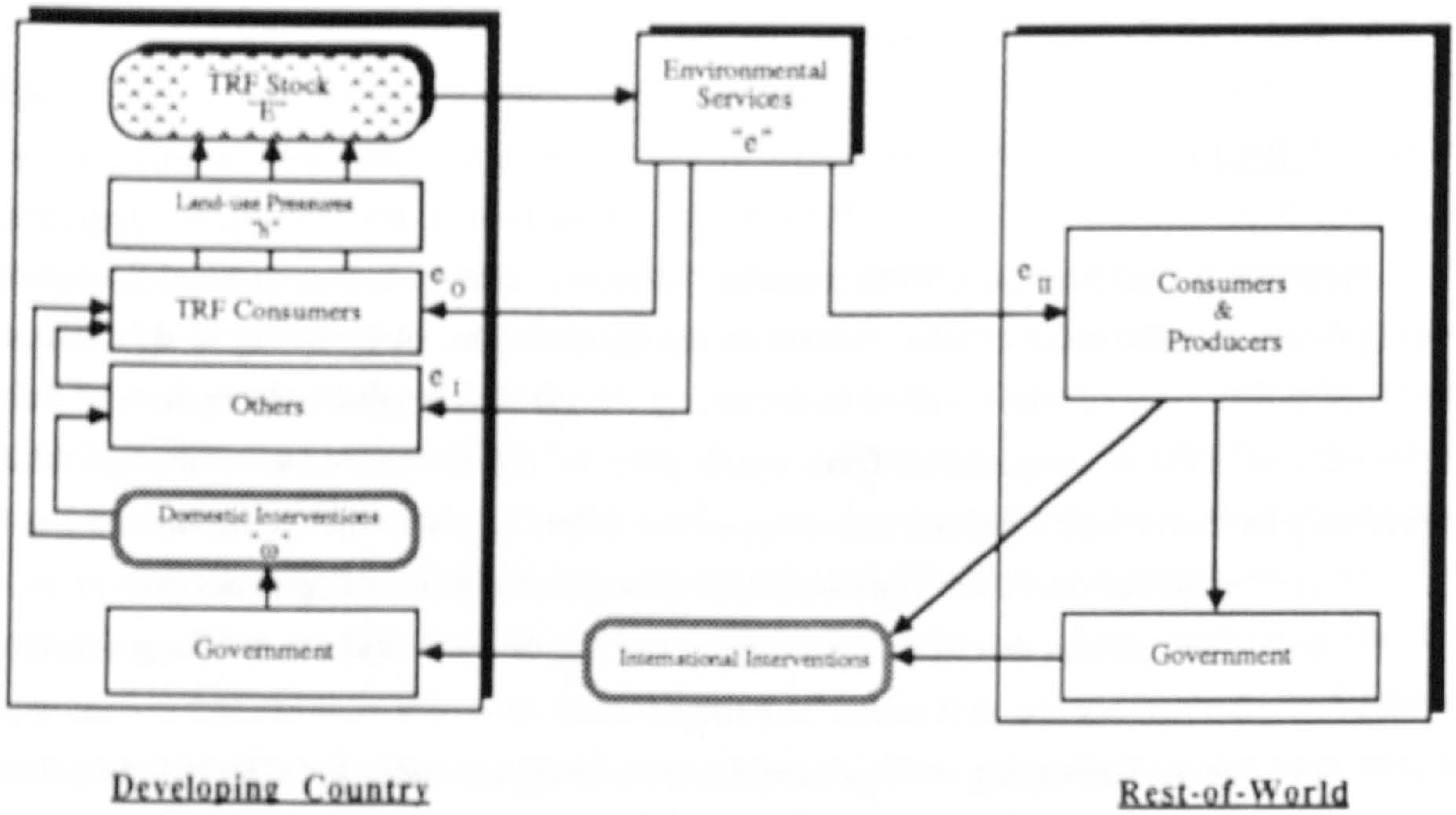
Although we might generalise that we should conserve more rainforest, we can not with the information available at hand estimate the deviation between the current rate of deforestation and the optimal rate of deforestation. While this may seem disconcerting, the theory has provided us with some sound rationales for promoting conservation, while also providing a framework in which a number of the relevant policy issues can be discussed. The practical problem is therefore reduced to finding policies which promote conservation.

It is important to identify first the linkages between the economy and the environment, and then to classify which groups in particular are affecting or being affected by the changes in the provision of environmental good and services. Based on some identification of this nature, it will be possible to focus on particular policy reforms. This section therefore describes a conceptual framework and highlights a number of salient features about policy design.

### 3.6.2 A Conceptual Framework

It is appropriate to commence with a stylised framework for addressing some of the major

Figure 3.2
Framework for Evaluating Policies Affecting Tropical Rainforests (TRF)




policy considerations. Figure 3.2 describes the general situation.

In this formulation, the tropical rainforest (TRF) can be regarded as the stock of environmental good E, from which flow environmental services e. A single group which we designate as the TRF Consumers is responsible for the land-use pressures which consume an amount h of the moist forest. The environmental services, however, are consumed by three groups in the amounts:

- $e_o$ - by the TRF Consumers;
- $e_I$ - by others in the developing country (LDC); and,
- $e_{II}$ - by the rest-of-the-world (ROW).

Although $e_o$, $e_I$ and $e_{II}$ have been designated as the consumption of an environmental service, strictly speaking the level of consumption will be the same by everyone (as it is a public good with no exclusion) and the true difference relates to the different values which each group attaches to the consumption of the environmental service. The reader should bear in mind that e is actually a vector of many environmental services and individuals will value them differently: shade could be useful to one farmer and a hindrance to the next. But designating consumption in this manner allows us to investigate the utility of each group in turn and, in the process, identify any 'externalities'.

The government in the LDC has available to it a policy set $\{s,\omega\}$, and can influence behaviour of agents in the LDC economy by introducing reforms $d\omega$, which we shall call Domestic Interventions. The policies s are endogenous and are assumed to adjust optimally to any exogenous perturbation $d\omega$. The $\omega$ policies are exogenous but are subject to policy shifts or shocks as in comparative statics. For analytical purposes the government has been separated from the TRF Consumers, but it is recognised that in some cases the government is actually the direct consumer and – in that event – it has a dual role.

The ROW can not directly influence individual agents in the LDC, but it has available to it certain interventions at the international level which I shall designate as International Interventions.

While this is a relatively simple framework, it depicts fairly accurately conditions involved in introducing economic reforms which are intended to conserve the TRF.

First, although $e_0$ can be regarded as the consumption of an environmental service, no externalities arise at the level of the TRF Consumer. This is because individual TRF Consumers will automatically internalise any adverse effects which their consumption decisions will have on them. Formally, if $U_0$ is the utility of the TRF Consumer, if $X_0$ is his consumption of goods and services, if $h$ is his physical consumption of TRF, and $e_0$ is his consumption of TRF services, then

$$U_0=U_0[X_0(s,\omega),h(s,\omega),e_0\,[E(h)]] \qquad \text{... (3.5);}$$

and he chooses $X_0$ and $h$ to maximise $U_0$ subject to various income and side constraints. Because $e_0$ explicitly enters his utility function, he can be expected to adjust his consumption level $h$ to optimise the total amount of $h$ and $e_0$ consumed. By way of example, suppose that the trees in the forest provide him with both fuelwood and shade for his crops. If he had no crops, then he would likely consume more wood than he would in the event that he did have crops. As such, to the extent that the individual is actually aware of the existence of such shading benefits, there is no externality. Although this seems like a trivial point, it is often overlooked when conservation groups attempt to convince local TRF Consumers that it is not in their self-interest to over-exploit the forest. An inordinate amount of effort is often expended trying to convince these individuals that they should conserve the forest 'for their own good' but – under the extant policy environment – these individuals are already doing what is in their opinion best for themselves. Although we might feel compelled to educate them – i.e., draw attention to the existence of such 'externalities' – there is little that can be done beyond that.

The true externalities arise when we consider the well-being of others in the LDC:

$$U_I=U_I[X_I\,(s,\omega),e_I\,\,[E(h)]] \qquad \text{... (3.6);}$$

where it is now clear that the well-being of these individuals depends on the actions of the TRF consumers. We shall call these Domestic Externalities. These often have both a spatial and temporal component. In the fuelwood harvesting example introduced above, the reduction in the TRF may lead to decreased agricultural productivity in areas downstream from the forest, or may reduce the future availability of genetic resources for meeting the LDC's own requirements for genetic feedstock. As noted earlier, the existence of such externalities will normally cause too much consumption in the current period. As shown in Figure 3.2, there are essentially two mechanisms which are available to internalise these externalities. The first involves direct negotiation between the party affected by the externality and the party causing the externality. As noted by Coase (1960),[22] as long as there is a clear assignation of property rights and parties can negotiate, then the externality will be fully internalised. In the diagram, this is depicted by the arrow from 'others' to 'TRF Consumers'. In LDCs, however, we seldom have clear assignation of property rights and the ability to negotiate is stymied by various practical considerations. Any internalisation of these externalities must therefore normally be done via government policies. These policies might include such programmes as taxing fuelwood consumption, establishing forest reserves and compensating TRF Consumers, or numerous other options within its control.

At this stage it is useful to raise an issue regarding the design of these policies. Let us assume for the moment that the government is aware of the externalities, and that it has designed its policies 'optimally' to the extent that it has – within the perhaps considerable constraints faced in making policies – selected a set such that some idea of social welfare has been maximised. Formally, if V is the social welfare function (SWF), then it has selected policies such that it has maximised:

$$V = V\{U_0[\ldots,h,c_0(.)],U_1[\ldots,c_1(.)],\ldots\} \qquad \ldots (3.7);$$

subject to any side constraints. Then, although this is at a national level now rather than at an individual level, a direct corollary can be made to the earlier statement relating to the internalisation of externalities by individual TRF consumers. In this case – with complete information – governments will do the best they can to design their policies optimally. We might spend lots of lobbying effort trying to explain to an LDC that the environmental services of the TRF are important for the country's future agricultural productivity, yet – once the LDC is aware of this – it may still choose to design its policies to promote deforestation if the benefits from that deforestation outweigh (in the SWF of the LDC) the costs of future declines in agricultural productivity.

But the assumptions required to make this argument work are perhaps too bold. There is often a lack of homogeneity within developing countries which causes policies to be formulated with only particular groups in mind. This is, after all, one of the exacerbating

[22] This is taken up further in Chapter 4.

factors which – as noted in Chapter 2 – often contributed to deforestation. In that event, such lobbying efforts as described above might indeed be effective means to promote conservation.

Finally, we turn to the situation of International Externalities. These arise because the utility of the rest of the world, which we can show as:

$$U_{II} = U_{II} \{...,c_{II} [E(h)]\} \qquad ... (3.8);$$

is dependent upon the actions of the individual TRF Consumer. As noted in Chapter 2, substantial services may be provided by the TRF to everyone in the world. As consumers, producers, and governments in the rest-of-the-world become aware of these services, there has been an increased commitment to promoting conservation. As indicated in the diagram, however, the rest-of-the-world does not normally have direct access to the individual agents causing the deforestation in the LDCs. Also, it has little direct control over the internal policies of LDC governments. It does, however, have certain mechanisms available (which we call International Interventions) to compel the government of the LDC to conserve TRF. In theory, we have a simple situation of an LDC having sovereign control over its TRF. Because in this case there are clear property rights (the TRF belongs to the LDC) it is presumed that some International Interventions can be put into place to benefit all parties. In the simplest sense, these interventions can be construed as payments to the LDC to conserve the TRF. In practice, these payments can take many forms: from direct grants to assist in the formation of national parks, to commodity agreements to induce activities which do not consume the TRF. The ultimate effectiveness of these payments will depend not so much on the nature of the International Intervention, however, but rather on the availability of effective Domestic Interventions.

### 3.6.3 Lessons for Policy Design

Much of the current emphasis in designing policies for conservation promotion is on convincing developing countries that it is in their self-interest to conserve their domestic forests. In addition, efforts are mounting to identify or create mechanisms which can effectively be used at the international level to compensate LDC governments for promoting rainforest conservation. Based on the preceding discussion, there are two primary lessons which I wish to highlight relating to designing economic policies for promoting rainforest conservation. These relate to the following:

a) internalising externalities and the role of education; and,
b) two-tier policy implementation.

First, attention was drawn to the idea that if individuals or LDC governments are already aware of the role of environmental services and the nature of the 'externalities' which arise from tropical rainforests within a country, then they might already be optimising the exploitation of the resource from their perspective. Changes to this rate of exploitation might only arise if new policy options become available, side constraints are changed, or inducements are offered to LDCs to change their policies.

Second, the formulation of the problem in the indicated manner highlights the fact that, even though there may be a substantial willingness-to-pay on the part of individuals in the rest-of-the-world, the ultimate onus for designing policies to promote conservation rests at the national level of the LDC. This suggests that a two-tier implementation strategy is appropriate: the first involves providing inducements to LDCs to conserve their rainforests; the second involves implementing policies at a national level which promote rainforest conservation.

It is noted that both the rationale for providing international inducements as well as the effectiveness of the domestic reforms will depend ultimately on how individuals in the LDC react to the reforms. Appropriately, when evaluating these policy reforms empirically, we are ultimately concerned with the sign of $dc/d\omega$. This we can expand to:

$$dc = \left(\frac{\partial c}{\partial E}\right) \left(\frac{\partial E}{\partial h}\right) \left(\frac{\partial h}{\partial \omega}\right) d\omega \qquad \text{... (3.9);}$$

where we have explicitly recognised that harvesting behaviour is affected by policies, and that the forest and the services from it in turn depend on that behaviour. If we accept that $\partial c/\partial E>0$ and that $\partial E/\partial h<0$, then the policy problem essentially becomes one of looking for policy reforms $d\omega$ for which $\partial h/\partial \omega \neq 0$ and then implementing the reform in the appropriate direction to achieve an increase in E.

It is also clear from this formulation that the preoccupation of the rest of the world is premised both on the idea that $\partial c/\partial E>0$, which in Chapter 2 we described as the effects of deforestation, and also on the assumption that $\partial U_{II}/\partial c>0$, which in the context of Chapter 2 can be construed as the awareness of these effects.

## § 3.7 Summary

The two-tier strategy suggested above can be reworded to reflect two questions of empirical importance to any given case of conservation in a developing country:

Q1. Are the international inducements we pay worth the conservation received?

Q2. Will the policy reforms available to the LDC achieve conservation?

Although these are only two elements of the overall problem, they provide ample scope for empirical study.

In the following chapters, I shall concentrate first on the fairly general issue of evaluating International Interventions. Because there are few examples of international interventions, it is not possible at this stage to undertake empirical studies based on statistically significant samples. Nonetheless, an analytical framework based on applied welfare economics can be developed which allows us to answer the question of whether such interventions are economically efficient. This analysis is undertaken in:

Chapter 4 The Rainforest Supply Price: A Step Towards Estimating a Cost Curve for Rainforest Conservation

In doing this, it is important to note in principle that this requires a valuation of the benefits of conservation (i.e., a measure of $\partial U_{II}/\partial E$). In practice, however, we shall concentrate first on generating a measure of the costs of conservation – which I call the rainforest supply price – which can then be used for comparative analyses of cost-effectiveness or compared to some estimates of how much individuals are willing to pay for conservation.

Second, I shall address more specifically the issue of Domestic Interventions. In some respects this level of intervention is the most critical because, whether the impetus for conservation comes from within an LDC to protect the local environment or from outside the LDC through International Interventions, the LDC will ultimately have to choose from amongst a number of internal strategies.

In selecting the reforms for evaluation, I shall concentrate on those which have been identified by aid agencies and governments as appropriate in this context. Also, the ones that are selected are those which are based on seemingly sensible rules-of-thumb and which are being pursued to a fairly extensive degree. Furthermore, recalling the major land-use pressures which existed – timber extraction, cattle ranching, forest farming, and fuelwood gathering – I will concentrate on the latter two pressures. This is not because timber extraction and cattle ranching are unimportant, but rather because they typically involve small numbers of easily identifiable agents responsible for the deforestation. The agents often have straightforward objective functions relating to profit maximisation, and the direction which reforms must take to promote conservation are often obvious.[23] Pressures exerted by the forest farmer and the fuelwood gatherer, on the other hand, involve large numbers of individuals. It is not normally obvious how such individuals will respond to policy reforms nor how their response will ultimately affect the rainforest biome.

The principle strategies identified deal with economic incentives through the injection of funds to provide individuals with something better to do than exploit the forests and fiscal reforms through indirect taxation. These are addressed in the following chapters:

| | |
|---|---|
| Chapter 5 | Development Incentives and Migratory Adjustment |
| Chapter 6 | Development Incentives and Human Interaction with the Forest |
| Chapter 7 | Indirect Taxes to Reduce Externalities |

Chapters 5 and 6 investigate two quite different aspects of the use of development incentives to promote conservation. Both aspects stem from rules-of-thumb which are being applied extensively as the basis for using such incentives. Economic development incentives are used, in this context, in buffer zones around protected areas. By injecting money into the buffer zones, the idea is that people will voluntarily leave the fragile protected areas and will find something better to do than exploit the forest. The two issues suggested by this argument are addressed independently: Chapter 5 looks at how income levels might affect migration out of a protected area into the buffer zone; Chapter 6 looks at whether economic incentives which are meant to give people something better to do than exploit the forest can actually be effective in promoting conservation. The empirical work in both of these chapters relies on original household survey data collected in 1988 around Korup National Park, Cameroon.

In evaluating the effectiveness of indirect taxes, we basically rely on the premise that it is efficient to tax any activity which creates externalities if property rights can not be traded. Where the particular activity is itself not taxable, we tax complements or subsidise substitutes. The empirical example which I investigate is fuelwood. Fuelwood is often regarded as untaxable because a large proportion of it does not go through any formal market, so governments rely on subsidising substitutes to reduce any consumption externalities resulting from fuelwood consumption. From a conservation perspective, however, the relevant empirical question is whether the subsidisation of substitutes – such as kerosene – will actually decrease or increase fuelwood consumption. Empirical work is undertaken in Chapter 7 relating to kerosene and fuelwood demand in India.

[23] See, for example, Binswanger (1987) relating to cattle ranching and Repetto (1988) regarding timber extraction and processing.

# CHAPTER 4
# THE RAINFOREST SUPPLY PRICE: A STEP TOWARDS ESTIMATING A COST CURVE FOR RAINFOREST CONSERVATION

## § 4.1 Overview

As noted in Chapter 2, perhaps the most significant effects arising from deforestation are those which fall outside of any particular LDC. A natural corollary to this is that the rest of the world may be willing to make significant transfers to LDCs in return for ensuring that the activities which cause these effects are reduced. In this chapter, therefore, I shall be broadly concerned with providing some means by which the rest of the world can evaluate whether it will be beneficial to make such transfers to a particular LDC. In the process, I shall concentrate on defining and operationalising a concept of "rainforest supply price" (RSP) as a practical tool for guiding certain types of policy decisions.

The RSP is essentially a measure of the amount which an LDC must be given by the rest of the world to induce it to institute reforms required to conserve a particular rainforest. In principle it is based on a one-time lump-sum transfer. But to permit comparative analyses between projects, the RSP is expressed as what might be regarded as an annual rental payment – such as ECU per hectare per year[1] – which reflects the amount which would be transferred to the LDC for the particular level of conservation which occurs. It is clear that, as the amount required depends entirely on the net costs of the necessary reforms within the LDC, we can then address the issue of whether it is worth this amount to the rest of the world to save a particular rainforest.

In addressing this issue, Section 4.2 first discusses the theoretical rationale for using some type of intervention to induce LDCs to conserve their rainforests. Section 4.3 expands on this rationale to discuss the potential role of cost-benefit analysis (CBA) and reform theory in identifying when it will be beneficial to save rainforests. The practical limitations of these approaches are illuminated – which relate to our present inability to quantify many of the more important benefit streams – and it is concluded that some other analytical tool is required which relies less on quantifying these benefits yet is still capable of providing some meaningful policy guidance. Section 4.4 proposes such a tool – the RSP – and discusses its meaning in theory and its basis in calculation. Its operational definition finds a parallel in a supply price concept frequently used in natural resource economics for long-

[1] Foreign currency transactions in this chapter are normalised to the European Currency Unit (ECU) to allow comparisons.

term planning. Section 4.5 illustrates how the RSP can be calculated for Korup National Park in Cameroon. Starting by conducting a cost-benefit analysis of this conservation project, it generates a numerical estimate of the RSP, and concludes with the question of whether it would be efficient for the rest of the world to compensate Cameroon this amount. Section 4.6 then, using the RSP, provides a comparative analysis of selected projects to illustrate what has *actually* been paid in direct compensation on several projects to ensure rainforest conservation. This analysis is conducted to illustrate how one might address the question of whether a particular project is too costly. Finally, Section 4.7 provides some general conclusions regarding the versatility and usefulness of this tool, and suggests directions for extending its use.

## § 4.2 Evaluating Interventions

### 4.2.1 Rationale for Intervention

The rationale for pursuing some type of intervention at an international level can be demonstrated graphically in a simple externality framework. Such interventions can be conceptually characterised as contracts between the LDC and the rest of the world (ROW). The general nature of the intervention is that the LDC is obliged to do something about promoting conservation and, in exchange, it receives some form of economic incentive. Primarily because of sovereignty issues, it is assumed that the world can not dictate which strategies the LDC ultimately chooses to promote conservation. From the perspective of the LDC, this is also desirable because it can choose the most efficient strategy (through Domestic Interventions) for meeting its contractual obligations.

In Figure 4.1, $MSB_{LDC}$ represents the marginal social benefit of rainforest consumption to the developing country after netting out any local conservation benefits, and $MSC_{ROW}$ represents the marginal social cost to the rest of the world. If the LDC has sovereignty and the ability to control its output, it would consume the rainforest to a level of C in the absence of any contracting with the rest of the world. The LDC would reap the area OAC in benefits, and the rest of the world would suffer a loss of ODC. In the example, it is clear that, if the parties were to negotiate, the optimal level of consumption $C^*$ would be attained and net global benefits would be maximised.[2] The gain in global welfare would be Area BCD, and it would be distributed between the parties according to the nature of the

[2] Throughout this discussion it is assumed that there are no costs to conducting the negotiations or to administering the terms of the contracts. In addition, it is assumed that the measurement of consumption – which is in principle necessary for the enforcement of contracts – is costless, although, as intimated in previous chapters, it might be difficult in some circumstances.

mechanism which was used to achieve the optimum.

Coase (1960) showed that, in such cases, the optimum could be reached by any of a number of mechanisms if the two parties are free to contract and if there is a clear definition of property rights. In this case, the mechanisms which can be applied include:

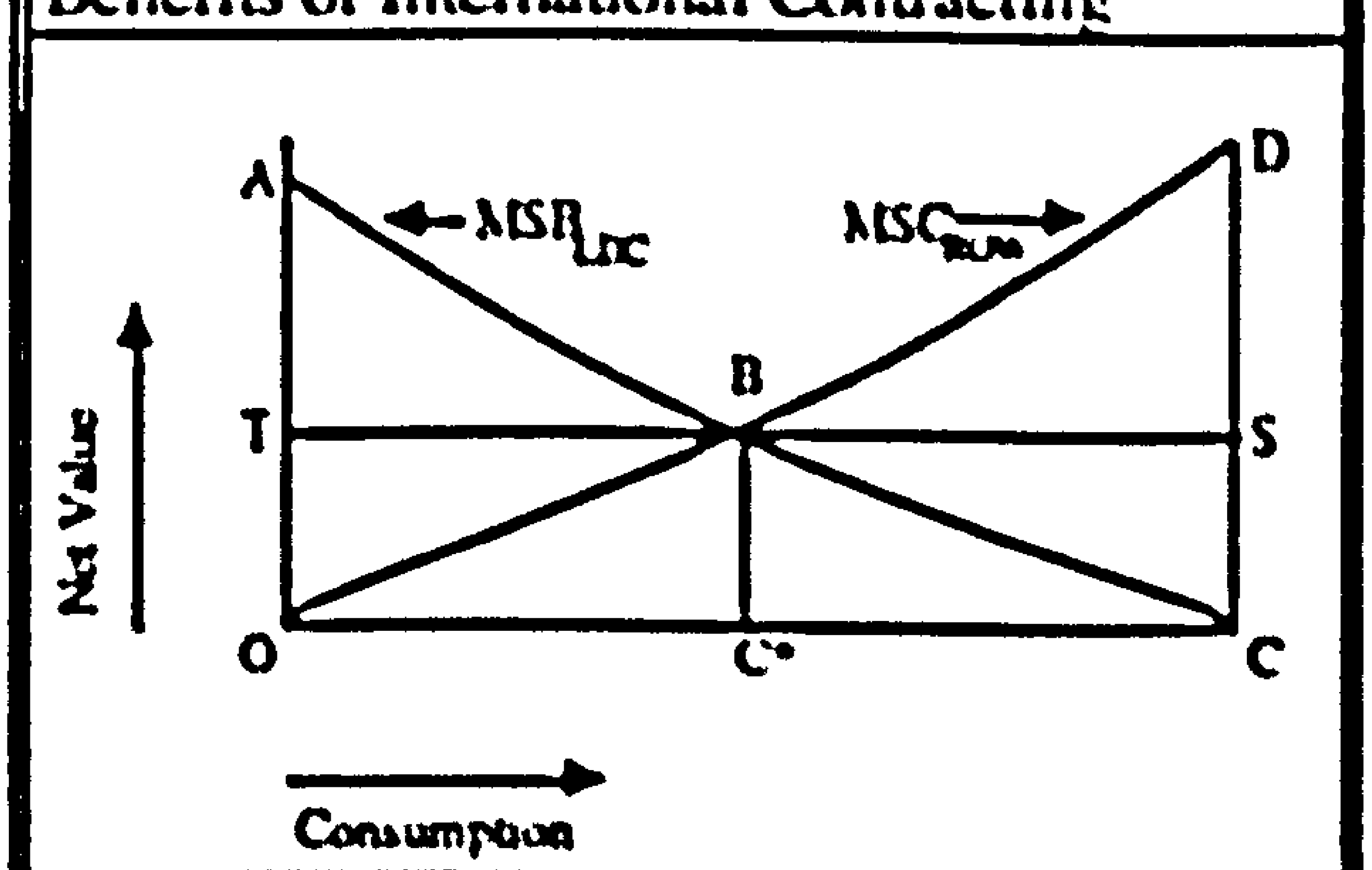
a) a consumption penalty;
b) a conservation inducement;
c) an assignation of freely traded property rights; and,
d) a lump-sum transfer tied to a specific consumption level.

In the case of the consumption penalty, a tax in the amount of OT would be applied to every unit consumed by the LDC. The LDC would consume an amount C*, the net benefit to the LDC would be ATB and to the rest of the world would be OTB. Such a policy can not, however, normally be regarded as feasible in a situation where the LDC has sovereignty over its resources.

The second alternative, a conservation inducement, would be made in the amount CS (by any account a subsidy which is, of course, exactly equal to OT) for any amount not consumed. The LDC then again would, voluntarily, consume up to C*. The net benefit accruing to the LDC would be OABC*+C*BSC and the net loss to the rest of the world would be OBC*+C*BSC. It is clear here that both parties would be better off than in the case where no negotiations took place and amount C was consumed.

If property rights were assigned to consumption and they were freely traded, no taxes or subsidies would be necessary and a price equal to OT would arise in the market. The LDC would own rights corresponding to C* units of consumption and the rest of the world would own rights for C-C* units of consumption which it would not, in fact, consume. Again, however, such a solution is regarded as infeasible in this case because of sovereignty issues of the LDC states.

Figure 4.1
Conceptual Model for Evaluating the Benefits of International Contracting




Finally, the fourth alternative involves some lump-sum payment "P" to the LDC in return for its commitment to consume only up to a level C*. As long as P were such that C*BC<P<C*BDC, the contract would be welfare-improving to both parties. Most of the mechanisms which

have been actually implemented can be characterised as falling in this category. As noted by McNeely (1988), although a wide range of mechanisms including loans, food grants, subsidies, debt swaps, commodity agreements, technical assistance, sanctions, and "peer pressure" are available at the international level, the most predominant strategies include direct transfers of some variety.

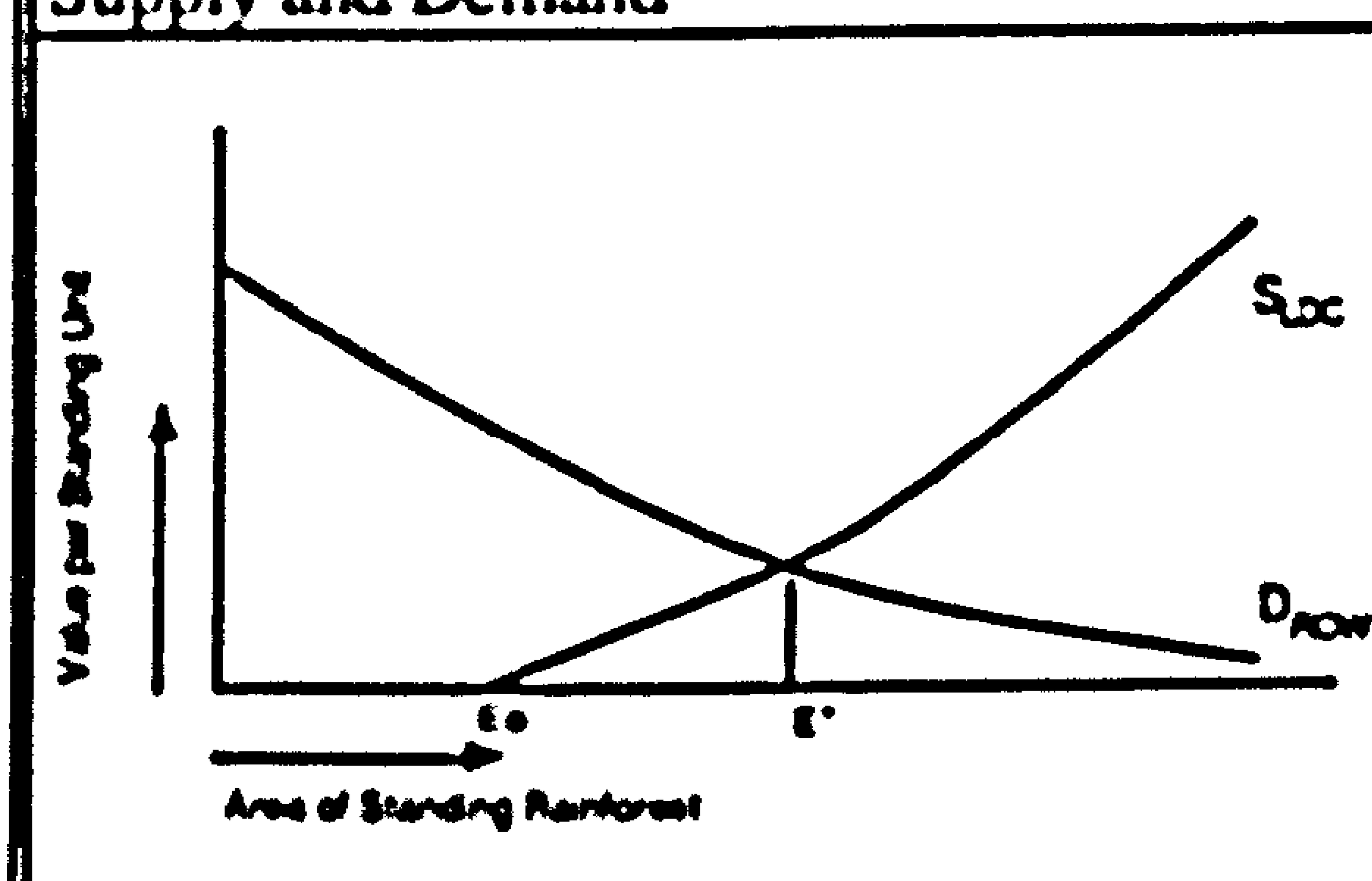
### 4.2.2 Rainforest Demand and Supply: A Global Perspective

The discussion in the previous section showed the case of one LDC negotiating with the rest of the world. In fact, however, it is clear that there are many countries with rainforests which, from the perspective of the ROW, may warrant saving. In that event, it may be preferable to consider the entire world demand and supply for the untouched rainforest.

Such a simple conceptual framework is shown in Figure 4.2. The demand for untouched rainforest is $D_{ROW}$, and is presumed to slope down to the right to reflect the idea that the marginal benefit to the rest of the world decreases as more rainforest is conserved. This is equivalent to the assertion in Figure 4.1 that $MSC_{ROW}$ of rainforest *consumption* is lower at low consumption levels. The supply curve for rainforests is depicted by $S_{LDC}$, and is drawn such that there is some amount $E_0$ which would be left untouched even at a 'zero price'. This reflects the idea that some LDCs might choose to conserve these rainforests for the local environmental fuctions they provide. If it were possible to transfer resources from the ROW to the LDCs to conserve rainforests, the optimal amount conserved would be E*.

There are a number of complications which arise from such a model, and it is useful to reflect on some of them at this stage. First, because of the 'public good' nature of the benefits arising from standing rainforest, the demand curve represents the usual vertical summation of 'individual' demand functions rather than lining up individuals (or countries) in order of decreasing willingness-to-pay. It leads to the potential for 'free-riders' to benefit from conservation while some other group finances that conservation. To the extent that this occurs, it may limit the amounts which LDCs are able to collect in the form of transfers.

Figure 4.2
Conceptual Model of Rainforest Supply and Demand



A second issue relates to the fact that there are relatively few organisations which have a mandate to make direct transfers to LDCs for conservation. If only one or a few organisations are actually involved in the process of directing transfers to LDCs: it could place individual LDCs in poor bargaining positions. This is because there are, in fact, multiple LDCs with rainforests causing the externalities. For example, if there is a single ROW negotiatior there is, in a sense, a monopsony for some of the environmental services provided by the world's rainforests. From a bargaining perspective, referring back to Figure 4.1, a country may previously have been able to extract an "incentive" of C*BDC for its rainforest's services. If, however, there are other LDCs all willing to accept incentives, if the world has limited resources to put towards such incentives, and if people are indifferent to saving rainforests in Brazil, say, to those in West Africa, then we presume that the incentives would go to the lowest bidder. In such a case, the LDC may eventually extract only marginally more than C*BC from the world. The competitive nature of this market limits the amount an LDC could get. While this may seem perverse from an LDC's perspective in that it gets only marginally more for conserving rainforest than it would for consuming it, it is actually efficient (from the point of view of optimal resource extraction) in that it implies that we would be spending our money first on conserving those areas which have the lowest opportunity cost. Conceptually, the supply curve in Figure 4.2 is then clearly a cost curve, and efficiency would normally dictate that the ROW provides incentives to those LDCs with the lowest rainforest supply 'cost' to stop consuming their forests. Countries with high rainforest supply costs would not be given incentives to conserve their forests.

A third issue which must invariably be addressed relates to the measurement of the actual rainforest 'commodity'. We have spoken relatively loosely of rainforest area, prices, and costs, tacitly assuming that rainforests can be treated equally: conserving a hectare of rainforest in Brazil is of no greater or lesser value than conserving a hectare of rainforest in West Africa. In fact, however, this is an oversimplification and conservationists often assert that some rainforests are more important than others: those with high numbers of endangered endemic species, for example, are generally of greatest interest. While this point is well taken, I shall assume for the time being that some area unit of rainforest can be considered as a common numéraire. At this stage I shall take this unit to be a hectare of tropical rainforest, treating all such hectares equally, and I shall return at the end of this chapter to how one might extend the analysis to using 'quality adjusted' or hedonic values.

Given some of these caveats, it is nonetheless clear that two types of information are required before we can determine the optimal amount of rainforest to conserve: the nature of the demand for such rainforests; and the supply of intact rainforest which might be offered by LDCs. A corollary to this is that, to determine the optimal amount, we must be in a position to measure the benefits of conservation as well as its costs. It is this connection which has prompted significant interest in the potential use of cost-benefit analysis to evaluate conservation projects.

## §4.3 Cost-Benefit Analysis and Reform Theory

Conservation groups are currently turning to the economics profession to provide evaluations of proposed conservation initiatives. Similar techniques which had been previously applied to evaluating the economic desirability of a specific development project are being applied with equal vigour to conservation projects. The most common technique being used involves the use of social cost-benefit analysis to justify such projects. Pister (1979), Porter (1982) and Loomis (1986) all provide examples of how cost-benefit analysis has been used to justify the conservation of wildlife or wilderness. Others provide no specific examples but make a general plea for the increased use of cost-benefit analysis to such applications.[3] In recent conservation guidelines published by the FAO, Gregersen et.al. (1987) suggest that social cost-benefit analysis be routinely applied to conservation projects. Given this great call for the use of cost-benefit analysis, it is useful to review briefly some of the strengths and limitations of this technique.

Although it is certainly beyond the scope of this chapter to summarise the vast literature dealing with the theory of cost-benefit analysis, we can highlight here a number of its salient features and requirements.[4] The primary goal of cost-benefit analysis is to identify projects which will improve social welfare. This requires first that the analyst be willing to specify some normative measure of social welfare. This social welfare function, which I shall call V(s),[5] is uniquely determined by an environment which is represented by a vector of signals "s" to which private agents respond. These signals include all of the variables (prices, quotas, taxes, and so on) which ultimately determine the behaviour of individual agents. The second requirement in cost-benefit analysis is to define a 'project' as some net change in the supply of commodities to the economy. We represent this as a small change 'dz', where z is a vector of production under the direct control of the planner. Finally, it

[3] Ahmad (1985) calls for a greater use of cost-benefit analysis in environmental decision-making and Barborak (1988) suggests that cost-benefit analysis can provide justifications for maintaining biological diversity.

[4] Useful manuals and examples regarding the subject are provided by Little and Mirrlees (1974), Bell, Hazell and Slade (1982), Squire (1985), and ODA (1988). Price and Nair (1984) illustrate the use of cost-benefit analysis in forestry practices, and Drèze and Stern (1987) present a formal description of cost-benefit analysis and examine its theoretical basis in welfare economics.

[5] The following discussion uses conventions similar to those in Drèze and Stern (1987), with the exception that net demands by the private sector are denoted here by the vector D(s).

must be recognised that planners exercise some control over $s$ subject to relevant constraints. The scope for choice may be very limited but we assume that such choice that is available is exercised to maximise V for any given z. We write $s=\phi(z)$ to denote the choice, however made (optimally or otherwise). The scarcity constraints say that $\phi$ must generate net demands (D) by the private sector equal to the net supplies (z) of the public sector.[6]

Given this framework, it is now possible to evaluate any project dz by determining:

$$dV = \frac{\partial V}{\partial s}\frac{\partial \phi}{\partial z}dz \qquad \text{... (4.1).}$$

A vector of shadow prices, $v$, which correctly identifies welfare improvements from a change dz must therefore be given by $\frac{\partial V}{\partial s}\frac{\partial \phi}{\partial z}$.[7] This is equivalent to $\frac{\partial V^*}{\partial z}$ where $V^*$ is the maximised value of V(s) given z in the case where the choices are optimal. The natural project selection rule then is to select any project dz for which $dV>0$, and this corresponds to selecting projects which have positive value, $v\,dz$, at shadow prices. While this may seem obvious, this formulation allows us to concentrate on two specific empirical points which are of special relevance to conservation projects:

a) project definition; and,
b) the role of 'optimal' policies.

Even though conservation proponents are now calling on cost-benefit analysis to justify their projects, much criticism has been directed to the mis-use of cost-benefit analysis to justify large-scale development projects without taking proper account of other impacts of these projects. Many cost-benefit analyses would either disregard environmental services or assign arbitrarily low shadow values to them. As a result, projects were funded which, in hindsight, would appear to have decreased social welfare when all of the impacts were included. Although this criticism does not invalidate the use of cost-benefit analysis, it underlines the importance of defining all of the changes in production which arise from a given project: a project defined as "use labour and chainsaws to chop down trees" may look perfectly reasonable until it is perhaps more completely defined as "use labour and chainsaws to chop down trees and create mass floods."

Fortunately, analysts now are taking better care to define projects which encompass more than the obvious direct inputs and outputs from any given project. But less attention is being paid to the role of optimal policy choices. In the formulation above, it is clear that shadow prices and hence welfare changes will actually depend upon the choice of policy.

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6 Formally, this simply states that $D(s)=z$, where $D(s)=x(s)-y(s)-m(s)$, and x is household consumption, y is private production, and m is a vector of net imports.

7 Note that $\partial V/\partial s$ is a vector and that $\partial\phi/\partial z$ is a matrix.

Planners will normally have more than one policy available to them and concentrating only on the project definition and ignoring potential changes to the policy environment can lead to foregone improvements in social welfare.

Indeed, in many circumstances the current demands being made on the economics profession by conservation interests are described as "cost-benefit analyses of projects", whereas they should probably be more accurately described as "evaluations of policy reforms". In this respect, it is useful to look briefly at how the theory of reform can contribute to evaluating the problem. There has been considerable interest recently in developing both a theory of policy reform and applying techniques for identifying welfare-improving reforms. Earlier work was specifically concerned with such problems as designing optimal taxation policies, whereas more recently some optimal taxation rules have been derived in a more general theory of policy reform.[8] The theory of reform parallels closely the theory of cost-benefit analysis of individual projects: both attempt to identify changes which improve social welfare.

Formally, let us consider some small policy change $d\omega$ and investigate its impact on social welfare $V(s,\omega)$, where we now distinguish between those signals which are under a planner's direct control (s) and those which are otherwise fixed exogenously ($\omega$).[9] Then we consider a reform $d\omega$ to be welfare improving if and only if:

$$dV^* = \frac{\partial V^*}{\partial \omega} d\omega > 0 \qquad \text{... (4.2);}$$

where $V^*$ has s chosen optimally such that it maximises V. Intuitively, what occurs is that a planner starts in some policy environment with all of the 's-policies' under his control chosen optimally; the '$\omega$-policies' are taken as exogenously fixed. Some small reform to an $\omega$-policy is undertaken, and adjustments in s-policies are made to accommodate any constraints. Drèze and Stern (1987) show that for small reforms, assuming that other policies *are* set optimally, we have:

$$dV^* = \left(\frac{\partial V}{\partial \omega} - v\frac{\partial D}{\partial \omega}\right) d\omega. \qquad \text{... (4.3).}$$

The marginal social value of some policy $\omega$ (i.e., $dV^*/d\omega$ which we call $MSV_\omega$) can thus

[8] The development of much of this theory in a general equilibrium framework can be found in Diamond and Mirrlees (1971; 1976), Mirrlees (1971), Diamond (1975), Atkinson (1977), Deaton (1979; 1981), Deaton and Stern (1985), and Bird (1987). A review and synthesis of the reform literature is provided in Stern (1987a) and additional applications of the theory can be found in Newbery and Stern (1987).

[9] We separate s and $\omega$: s will be regarded as adjusting optimally to any perturbation in $\omega$.

be interpreted quite reasonably as the gradient of the Lagrangian $\mathcal{L} \equiv V() - v\,[D() - z]$. Any small policy change $d\omega$ can be disaggregated into a direct impact on social welfare $\partial V/\partial\omega$ less the cost of the additional net demands at shadow prices $v\ \partial D/\partial\omega$. In any empirical work, the challenge is thus to find policies $\omega$ for which, locally, $MSV_\omega \neq 0$, and then to introduce reforms $d\omega$ in the appropriate direction.

In practice, however, the problem is more complicated than this. If $\omega$ are the exogenous policies, then presumably we would want these to be adjusted optimally once they come under the control of the planner: which presumably they have if they are being considered for some type of reform. The usual empirical caveat (see Ahmad and Stern [1984] or Guesnerie [1977]), however, is that the planner lacks the necessary information to do anything but make small reforms based on local information. The optimum may be a long way off and the reform approach crawls "up the hill" using local information all the way.

In addition, this brings us to a final caveat which must be considered in applied welfare economics: that relating to large projects or large reforms. Whether evaluating projects or reforms, most of the rules relating to shadow-pricing relate to small changes. In general, these shadow prices are gradients of a social welfare function – or 'surface' – with respect to a vector of supplies where the dependence incorporates feasibility constraints, side constraints, government policy, and the actual unconstrained welfare function. Large projects, and large reforms, require analysing this function at two discrete points which are not contiguous: we must determine if some change in welfare $\Delta V = V(z_1) - V(z_0)$ is actually desirable. While some authors have suggested approximations of $\Delta V$ for large projects under certain restrictive conditions (Hammond [1980; 1983]), the general solution would require more extensive global knowledge of the social welfare function rather than just the local information using conventional shadow pricing rules.

To summarise, there are a number of points which can be learned from the application of cost-benefit analysis rules. First, the projects should be defined to include all changes in goods and services. Second, where reforms are being proposed rather than projects, it is important to identify both the direct effects of these reforms on social welfare as well as the impact on the net demand for goods and services and then to evaluate any net changes in goods and services at shadow prices. Third, it must be recalled that the validity of many of these techniques requires that other policies under the planners' control are set using the same cost-benefit criteria to the best of the planners' control. Finally, the limited – though valuable – contribution of identifying 'small' projects or reforms which are welfare-improving may be all that can reasonably be expected for now.

## § 4.4 Rainforest Supply Price

### 4.4.1 Introduction

In support of cost-benefit analyses, considerable effort is currently being directed to evaluating the global benefits of conservation. Although progress is being made in measuring the value of certain local environmental functions, the global benefits of 'biodiversity value' or 'climate control value' are far from being quantified. In many informal analyses, it is often asserted that the genetic and climate control value attributable to the rainforests in LDCs is immense. It is not hard to imagine, therefore, that sufficiently large numbers might be applied to evaluate genetic resources or the integrity of the global climate such that, if one applies these values in a cost-benefit analysis, one can readily justify saving every rainforest in the world. Although this result may be of some philosophical interest, it is not particularly helpful to planners faced with limited budgets.

The very existence of these limited conservation budgets would suggest either that the 'large numbers' are wrong or, as noted in Chapter 3, that there exist some basic inefficiencies in market or social processes which prevent us from doing more to save the rainforests. But both of these issues have more to do with the valuation of global 'demand' than they do with the actual costs incurred by an LDC in conserving rainforests; it suggests that we might still be able to learn something useful by closely examining the 'supply' of such rainforests.

To provide a more meaningful decision-making tool, I shall develop in this section a concept which I shall refer to as the LDC Rainforest Supply Price (RSP). Quite simply, the RSP is the amount which an LDC must capture through direct transfers from the rest of the world in order for it to save a particular rainforest. Through selecting a common denominator (one hectare of rainforest), a step is taken towards defining a cost curve for rainforest conservation. While this does not allow us to select the optimum amount of rainforest to be conserved (which would still require an estimate of the benefit function), it does allow us to make cross-country comparisons, thereby giving donor agencies and international funding bodies an objective assessment of how much must be deployed in any given area to save a rainforest. In addition, the cost curve eventually derived would be a relevant input into any game, however structured, which describes positive outcomes.

The RSP effectively provides a preliminary measure to which standard cost-efficiency principles can be applied: if funding to save the rainforests is limited by a fixed budget or by some decreasing willingness-to-pay as more forests are saved, then efficient allocation of this funding quite simply involves applying it to those forests which are the cheapest to save. The following sections decribe first the theoretical basis of the RSP in terms of the notation of welfare economics, and then a practical mechanism of applying this theory as an adjunct to standard cost-benefit analysis.

4.4.2 Theoretical Basis

To extend the application of the approach taken in Section 4.3, it is useful to characterise explicitly some of the relationships in a stylised model. Essentially, the current situation is that outside interests are attempting to induce LDCs to conserve rainforests, and that they are willing to compensate LDCs for any losses which arise from rainforest conservation. Consider an LDC in some initial position where the value of the planner's social welfare function is W=V. The world is willing to make some small transfer of resources dR to that country in return for it conserving some incremental amount of forest dE. The reform required for the country to achieve this is $d\omega$, which – in the absence of the compensating transfer dR – results in a change in social welfare dV. For notational ease, we define the reform such that $dE/d\omega>0$, and think of W,V and R scaled in terms of a common currency unit. We assume that the transfer dR is just adequate to compensate the change in welfare required by the policy reform:

$$dW = 0 = dV + dR \qquad \text{... (4.4);}$$

where $dV=MSV_{\omega}d\omega$. We suppose that $dR \leq \beta dE$, where $\beta$ is the marginal willingness-to-pay of the rest of the world for saving the rainforest. If we let $\beta^*$ be the minimum amount which we must be willing to pay to compensate an LDC, then $dR=\beta^* dE$, and the amount which we must be willing to pay is:

$$\beta^* = -\frac{MSV_{\omega}}{(dE/d\omega)} \qquad \text{... (4.5).}$$

Expressed differently, the amount $\beta^*$ is the net social cost of the measures which are required to save a unit of rainforest. Recalling our definition of $MSV_{\omega}$, we can define $\beta^*$ more explicitly as:

$$\beta^* = -\frac{\frac{\partial V}{\partial \omega} - v\frac{\partial D}{\partial \omega}}{\frac{dE}{d\omega}} \qquad \text{... (4.6).}$$

Although $\beta^*$ is the minimum which we must be willing to pay, the LDC would actually require no compensation if calculations indicate that $\beta^*$ is negative. While I shall take up this point later, it suggests that the rainforest supply price – which is the minimum the LDC should be willing to accept to invoke the necessary reforms – can be defined as:

$$RSP = \text{Max}\{0, \beta^*\} \qquad \text{... (4.7).}$$

There are a number of important aspects to Equations (4.5) to (4.7) which merit comment.

First, there is an element of definition here which recognises explicitly that, even with external intervention, there is still some internal policy reform which must be undertaken to induce conservation, and that the indicated reform may effect both individual welfare as well as net demands in the economy. In practice, this highlights the fact that we must attempt to identify some *feasible* reform. While this may seem obvious, it suggests that one place to start is to look at reforming existing structures.

Second, recognising that an LDC will normally suffer some direct loss in social welfare from introducing the reform (i.e., that $MSV_\omega<0$) the formulation simply says that the supply price will be higher when the reforms which they have available are either very ineffective at conserving rainforests (i.e., $dE/d\omega$ is very small) or if the negative effects of such reforms are very large. These negative effects are large when $v\partial D/\partial\omega >> \partial V/\partial\omega$ (i.e., when there are very high input costs at shadow prices). This can occur when there is either a significant increase in the net demand for goods and services, or there are significant direct detrimental impacts arising from the necessary reform. Appropriately, from an empirical perspective, we should be concerned with identifying reforms which are effective at promoting conservation, have little direct negative impact on individual welfare, and generate few net demands on production.

Third, explicitly including an expression for $\partial V/\partial\omega$ highlights the fact that the supply price will be higher if the reforms affect disadvantaged groups and if the LDC government has a high degree of aversion to inequality. Empirically, therefore, it would be desirable to identify reforms for promoting conservation which also improve the well-being of the most disadvantaged.

Fourth, it is clear that there may be some policy reforms for which $MSV_\omega>0$ and $dE/d\omega>0$, in which case $\beta^*$ will be negative.[10] These will normally only occur when the particular LDC is unaware of the particular improvements to welfare which might arise from such a reform and, in such cases, it is in the interests of both the rest of the world and the particular LDC to promote such reforms. This aspect is often seen as the primary justification for 'educating' LDCs about the importance of the rainforests to the LDCs themselves. But it is also clear that such an education process depends on identifying correctly $MSV_\omega$, and it can be argued that the LDC is in a better position to assess that than the outside world. In particular, where the LDC *is* aware of the effects of its policies and it *has* adjusted them to the best of its ability, then one should probably normally presume that

[10] In Figure 4.2 this would correspond to the area of rainforest represented by $E_0$.

the only feasible changes in ω are in directions which decrease social welfare.

### 4.4.3 A Practical Formulation

The previous discussion illustrates how the principle of a rainforest supply price is readily expressed in the theoretical constructs of welfare economics. The theory also produces an equivalent expression which can be used in the practice of conducting a cost-benefit analysis of a rainforest conservation project. In deriving such an expression, the reader will note from Equation (4.6) that $\beta^*$ is, dimensionally, some value per unit E of rainforest. The specification of this unit is somewhat arbitrary and, as noted earlier, it is probably appropriate eventually to make some adjustment for the quality of the rainforest. For now, however, we concentrate simply on rainforest area.

The area of the rainforest is, in itself, not an adequate basis for expressing a price, primarily because services which are received from conservation represent a continuous flow. To reflect this concern, I shall select an evaluation unit of one hectare-year of rainforest. The definition of rainforest E is then formally a vector $E=\{E_0,E_1,E_2,...,E_t,...\}$ where $E_t$ is the area maintained intact in any given year t. A conservation project $\Delta E$ then generates some change in the amount of intact rainforest, where $\Delta E=\{\Delta E_0,\Delta E_1,\Delta E_2,...,\Delta E_t,...\}$. It will become apparent later that this discrete structure is easily accommodated within the cost-benefit accounting of rainforest conservation projects.

As an operational definition for the rainforest supply price, we again base it on the idea that we are attempting to compensate a host LDC for conserving some amount of rainforest $\Delta E$. To just compensate the LDC, the amount of compensation must be equal to the net cost of the project such that, [11]

0 = NPV of Project to Host Excluding Transfers
+ NPV of Transfers ... (4.8).

Let us now consider $\beta^*$ to be the constant real amount of compensation paid for every hectare-year of conservation. It is, in a sense, a year's rental for a hectare of untouched rainforest. While in principle the real rental could change over time, we shall assume for the moment that it remains constant in real terms. If we now introduce simple cost-benefit accounting conventions, we have the condition that,

$$0 = \sum_{t=0}^{\infty}(1+r)^{-t} * (B_t-C_t) + \sum_{t=0}^{\infty}(1+r)^{-t} * \beta^*\Delta E_t \quad ... (4.9);$$

[11] Throughout this discussion I shall assume that the NPV of the project in the absence of transfers is negative.

where $B_t$ is the stream of local benefits at shadow prices (excluding transfers) to the host LDC as a result of the rainforest conservation project $\Delta E$, $C_t$ is the stream of local costs at shadow prices, and r is the real discount rate. It is important that all of the *local* conservation costs and benefits (for example soil fertility maintenance and flood control) be included in this formulation.

Assuming still that $\beta^*$ is constant, we can rearrange Equation (4.9) to provide an operational definition for the rainforest supply price as RSP=Max{0,$\beta^*$}, where,

$$\beta^* = -\frac{\sum_{t=0}^{\infty}(1+r)^{-t} * (B_t - C_t)}{\sum_{t=0}^{\infty}(1+r)^{-t} * \Delta E_t} \qquad ...(4.10).$$

This fairly simple formulation allows one to calculate readily the minimum amount which we have to pay to get an LDC to conserve a unit of intact rainforest. It is similar to supply cost concepts used in defining the long-term costs of resource production,[12] and has a number of advantages in applied work.

First, it is readily added to cost-benefit analyses of conservation projects as the calculations required for such analyses can be extended to computing the supply price. In this case, however, the cost and benefit stream must be identified as that which is clearly accruing to the host country. From a donor's perspective, this may actually simplify the CBA as it does not require identification of conjectural benefits outside of the country.

Second, the explicit exclusion of the external benefit stream from the supply price calculation allows the estimation of such external benefits – which is often more complex and conjectural than estimating the supply price – to be relegated to a secondary activity. Depending on the circumstances, it may never be necessary actually to estimate this external benefit stream. Consider, for example, a donor which has 20 million ECU available to give to LDCs for rainforest conservation. Suppose that there are two projects (A and B) being considered with the following characteristics:

| Project | A | B |
|---|---|---|
| Conservation Area | 100,000 hectares | 200,000 hectares |
| PV of Local Costs of Conservation | 30 million ECU | 40 million ECU |
| PV of Local Benefits of Conservation | 10 million ECU | 20 million ECU |
| Foreign Transfers Required to make NPV=0 | 20 million ECU | 20 million ECU |

[12] In these formulations, ΔE is the incremental production of some commodity (such as oil), B is the revenue stream from associated products, and C is the capital and operating cost stream associated with an investment which generates the incremental production. Examples of this approach applied to depletable resource production can be found in Bradley (1979) or Ruitenbeek (1985).

It is obvious that, as long as the foreign benefits are dependent only on conservation, one would invest in Project A as it would have the lowest supply price. This decision would be independent of the actual external benefits of the rainforest (assuming still that a hectare of rainforest generates the same external benefits anywhere).

Third, the supply price is sensitive to the timing of conservation efforts in that it explicitly requires identification of $\Delta E$, which I shall refer to as the 'protection scenario'. This allows one to make comparisons between projects which have markedly different impacts on conservation. A national park investment programme which has expected permanent conservation benefits can be compared to projects which, for example, require short-term bridge funding to maintain parts of the biome intact while other planning efforts proceed for the long term initiatives. Specific examples of such projects will be evaluated in upcoming sections, but it underlines the importance of actually specifying the protection scenario which applies to any given investment. It is important to define because the first increment of conservation might not happen for many years as a result of an investment project. In the case of Korup National Park, for example, the major physical conservation benefits would not become apparent until about 2010 – which is when destructive logging of the park might commence.

Fourth, while it has been assumed that $\beta^*$ is constant over time, this assumption can readily be relaxed to allow it to grow. One of the most relevant cases to deal with empirically – and one of the most straightforward analytically – involves a case where the local real benefits and costs are growing at a real rate $g>0$, and where one might expect that the 'annual rental rate' $\beta_t^*$ should also grow at that same rate. In that event, we might be interested primarily in the time path of $\beta_t^*$ which is required to compensate the LDC. If we allow explicit accounting of the growth in $B_t$ and $C_t$, and suppose that $\beta_t^*=(1+g)^t\beta_0^*$, then Equation (4.9) can be generalised to:

$$0 = \sum_{t=0}^{\infty}(1+r)^{-t}(1+g)^t * (B_t-C_t) + \sum_{t=0}^{\infty}(1+r)^{-t} * (1+g)^t\beta_0^*\Delta E_t \quad \text{... (4.11).}$$

In this case (assuming that both r and g are small) we can approximate the base year supply price as:

$$\beta_0^* \cong -\frac{\sum_{t=0}^{\infty}(1+r-g)^{-t} * (B_t-C_t)}{\sum_{t=0}^{\infty}(1+r-g)^{-t} * \Delta E_t} \quad \text{...(4.12).}$$

The reader will note that this is equivalent to the case investigated in Equation (4.10) with the exception that the effective discount rate has been reduced from r to (r-g). Such a calculation is relatively simple and the case with escalating rentals is readily reflected in discount rate sensitivities typically undertaken in cost-benefit analyses.[13]

Finally, although I have assumed that all rainforests are of the same quality, it is conceptually not difficult to introduce some form of hedonic pricing and adjust for rainforest quality. If we let $\vartheta$ be a dimensionless index for rainforest quality, normalised such that $\vartheta=1$ for a standard hectare-year for some standard rainforest, then we can define a hedonic rainforest supply price $RSP^h$ as $RSP/\vartheta$, and higher quality rainforests would then appear as having lower hedonic supply prices. One would presume that $\vartheta$ could itself be a function of many criteria, and there is thus some risk of arbitrariness in specifying such quality. It would, nonetheless, give individual donors a means of ranking conservation alternatives.

## § 4.5 Calculating the Rainforest Supply Price for Korup National Park

### 4.5.1 Introduction

The purpose of this section is to illustrate how the rainforest supply price can be calculated for a specific conservation initiative. The project evaluated is Korup National Park in Cameroon, which was introduced in Chapter 1. The starting point for the evaluation is a cost-benefit analysis of the conservation project, undertaken from the perspective of the Government of Cameroon. The CBA uses WWF plans for park development as a design basis, and it attempts to make a preliminary estimate of the value of a number of local environmental functions to the Cameroonian economy. The actual key analytical criteria and shadow prices were selected through discussions with Government of Cameroon planners, and they are thus consistent with other project evaluation criteria used in the country. Because of the paucity of data available for the CBA, it should be noted that some of the cost and benefit streams are to a degree conjectural, and they represent best estimates at the time that the park planning was being undertaken. Nonetheless, the exercise demonstrates how the technique can be used to calculate the rainforest supply price and, as with many situations involving project evaluation, refinements would normally be expected as planning progressed and projects became better defined.

### 4.5.2 General Assumptions

The first step involved in the evaluation involves actually defining the 'project' and the

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[13] One must take care, however, in using $B_0^*$ as a comparative measure between countries and projects unless the same growth assumptions have been made across projects.

impacts which it has compared to a status quo case. Under the status quo case, normal exploitation of biological and forest resources eventually results in complete elimination of the primary forest, and the national park essentially directly protects two critical resource components: the trees (and other flora); and the animals (and other fauna).

The primary potential threat to the tree resource is far into the future; the forest's timber resources would most likely be exploited by logging between the years 2010 and 2040 in the absence of protective measures. This scheduling is consistent with the marginal nature of the timber and the current rate of exploitation in the *region*; it is expected that the forest on the Nigerian side, for example, will be eliminated by 2000–2010 without protective measures. By the simple expedient of gazetting the park at this time, it ensures that timber concessions – often granted ten to twenty years in advance of their actual exploitation – will not be made available to logging interests.

Protecting the animals in the area is a more immediate conservation goal and is, logistically, considerably more complex. Just gazetting a park will not, in itself, prevent continued hunting of endangered species. Two broad options are being considered by park planning authorities to protect the animals: (i) relocating people away from the park; or, (ii) providing direct compensation payments to those within the park in return for their compliance with hunting regulations. The relocation option, while mandated by current Cameroon legislation, is disruptive and costly; efforts are currently under way to introduce legislative reforms allowing individuals to live in the park and to pursue some traditional activities. The option of providing conditional compensation, by directly transfering funds to village authorities on a regular basis (about every three months), has proven successful elsewhere in gaining the cooperation of indigenous hunting populations in Zambia (WWF-UK [1989a]), Thailand (Praween, Tavatchai, and Dobias [1988]) and Zimbabwe (Child [1988]). This CBA assumes that some compensation mechanism will be instituted to promote compliance with the regulations and that relocation will not be necessary. As hunting losses are explicitly counted in the CBA as lost production, compensation payments are not included as project costs.

Reducing hunting would still, however, involve some regulation of hunting activities. The enforcement programmes designed for Korup – and the costs in the CBA – include: park boundary demarcation and maintenance; game guards with the mandate to patrol the park and enforce regulations; guard posts within the park; and adequate radio and other equipment to support the activities of the game guards. To decrease potential hunting activity, jobs as guards are given preferentially to males currently resident in the park area. The CBA assumes that such an enforcement programme will be required and will be successful.

A number of assumptions were made relating to key evaluation parameters required in the CBA. First, planners in the Government of Cameroon were consulted to establish what assumptions they used for project evaluations, and a case was developed which uses a real social discount rate of 8% and a labour cost of 50% of the market rate.[14] Official exchange rates were used to shadow price all goods.

Second, little detailed information was available regarding the composition of project costs. Although estimates of labour inputs were available, there were no estimates of the import or indirect tax components. In such circumstances, it is common practice to use a standard conversion factor (SCF) for costs to allow for differences between domestic and international prices caused by indirect import levies or other trade distortions. This practice was not, however, followed by Cameroon planners. In the interests of remaining consistent with Cameroon criteria, no SCF adjustment was made in the base case.[15]

Third, it was assumed that decision-makers placed the same welfare weights on people in the project area as they did in the rest of the economy; no explicit distributional benefits were assigned. If explicit account were made of some distributional characteristics of these households, the net benefits of the project might be different than those indicated here.

Finally, as the project is quite long, discounting was done over an infinite time horizon and it was assumed that no real increases in the cost or benefit stream occurred beyond the year 2040.[16] If populations and productivity in the area were going to increase, then the value of some local environmental functions of Korup forest might in that event also be higher.

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[14] Many different rationales can be given for discounting market wage rates for social valuation purposes; the reason given by Government of Cameroon planners was that 50% appeared to reflect the marginal productivity in the agricultural sector. By hiring someone to work on a project for one day at, say, 1000 CFAF, the lost output to the economy by removing that person from the agricultural sector for the day is only 500 CFAF. While the basis for such an assertion is often disputed in the cost-benefit literature, it is taken at face value here as it was being used with some consistency within the planning department.

[15] Planners in Cameroon believed that there was no shortage of foreign exchange and that no SCF adjustment was necessary. ODA (1988) notes that this assumption is often incorrectly made as the SCF is meant to correct for price distortions caused by trade restricting interventions rather than for foreign exchange shortages. Based on consultations with ODA and USAID representatives in Cameroon, a sensitivity analysis was therefore conducted by applying a conversion factor (CF) of 0.90 to the applicable cost streams. The result was that the net benefit of the project increased by 226 million CFAF from -1852 million to -1626 million CFAF. The relative insensitivity to this CF is attributed to two factors. First, budgets prepared by WWF excluded import duties on major import items such as vehicles and computing equipment; WWF has imported such equipment duty free under a special agreement and the CF was not applied to these costs in either the base or the sensitivity case. Second, the CF increased some of the opportunity costs of the project. An example is lost timber value: applying the CF to the direct costs of timber extraction improves its profitability and thereby increases the opportunity costs of conservation.

[16] If $B_t$ is the net benefit stream in year t, year T is the year in which net benefits reach a level $B_T$, benefits escalate annually at a rate 'g' thereafter, then, at a discount rate r, the net present value of this stream is:

$$NPV = \sum_{t=0}^{T-1} B_t * (1+r)^{-t} \quad + \quad (1+r)^{-T} * B_T * [1+1/(r-g)] \quad .$$

The second term is the value in year 0 of an annuity which grows annually over an infinite time horizon. The series is finite if and only if $g<r$. Where $g=0$, $r=0.08$, $T=2040-1989$, the second term is $0.2665*B_T$.

Table 4.1
Summary of Korup Project Cost and Benefit Streams
(millions of constant CFAF: 1989 values)

| | 1989-1995 | 1996-2009 | 2010-2039 | 2040-→ |
|---|---|---|---|---|
| **Direct Costs (at market prices)*** | | | | |
| Capital & Running Costs | 2338 | - | - | - |
| Infrastructure Costs | 3685 | - | - | - |
| Operating Costs | - | 280/yr | 280/yr | 280/yr |
| **Opportunity Costs (at shadow prices)** | | | | |
| Lost Timber Value | - | - | 147/yr | - |
| Lost Forest Use | 0-34/yr | 34/yr | - | - |
| **Direct Benefits (at shadow prices)** | | | | |
| Sustained Forest Use | - | - | 0-132/yr | 132/yr |
| Tourism | 3-24/yr | 24-48/yr | 48/yr | 48/yr |
| Fisheries Protection | - | - | 54-1628/yr | 1628/yr |
| Flood Control | - | - | 8-244/yr | 244/yr |
| Soil Fertility Maintenance | - | - | 4-120/yr | 120/yr |

* Summaries for 1989-1995 are period totals and are based on datings in WWF-UK (1989b).

### 4.5.3 Specific Cost and Benefit Centres

#### 4.5.3.1 Cost Summary

The impacts of the park project on the Cameroon economy are most readily summarised by disaggregating the major cost-benefit centres into four distinct time periods. It should be noted that the analysis ignores sunk costs (pre-1989). A summary of these cost and benefit flows is presented in Table 4.1, indicating the value and timing of each of the amounts. A discussion of each of the individual components follows.

#### 4.5.3.2 Direct Costs

The direct capital costs of the Korup project are based on budgets and plans in the Korup National Park Master Plan (WWF-UK [1989b]). Their derivation is shown in Table 4.2 and they total just in excess of 6000 million CFAF. The amount which actually eventually enters the CBA, however, is only 3272 million CFAF. Costs related to compensation payments are regarded as being purely pecuniary and are thus left out of the CBA. Also, certain costs involved with the road construction are not truly incremental to this project.

The capital expenditures for roads and airstrips, over the period 1989-1995, are 3350 million CFAF. Only 33% of the cost of these investments is regarded as incrementally attributable to this project for social valuation purposes. This reflects that some of the investment would be undertaken in any event for other regional imperatives. The level of 33% was taken as that proportion which was necessary to (a) accommodate specific park requirements and (b) offset the negative environmental impacts of this infrastructure.

Table 4.2
Summary of Direct Costs of Park Component of Korup Project, 1989-1995
(millions CFAF at market prices)

| | Direct Costs |
|---|---|
| Capital Costs of Park Infrastructure | 895 |
| Parks Vehicles & Equipment | 79 |
| Roads/Airstrips | 3 350 |
| Park Labour & Expenses | 690 |
| Monitoring & Administration | 205 |
| Compensation Provision | 256 |
| Contingency | 548 |
| Total Unadjusted Budget | 6 023 |
| Adjustments for Social Valuation | |
| Compensation Provision | - 256 |
| Non-incremental Roads | - 2 245 |
| Contingency Relating to Above | - 250 |
| Total Adjusted Budget | 3 272 |

Source: Based on datings in WWF-UK (1989b).

Operating expenses are forecast to be the equivalent of about 280 million CFAF annually commencing in 1995. This allows for all of the labour requirements of the park, as well as housing and overheads. Approximately two-thirds of this is direct labour cost for park administrative personnel, game guards, drivers, and maintenance workers.

4.5.3.3 Lost Timber Value

The lost timber value is that associated with commercially clearing the stands in the project area in the alternate development scenario. Land surveys of the region have typically concluded that the terrain does not lend itself well to commercial logging, and that the number of commercial species are limited. Nonetheless, there is some social value to harvesting the timber if one asserts that labour is valued at less than market wages. Because of the marginal nature of the land, and the existence of better tracts elsewhere in Cameroon, it is assumed that the clearing would not commence until the year 2010. This coincides also with the deforestation trends in neighbouring Nigeria ... it is anticipated there that no primary forest will exist after the turn of the century, hence it is even conceivable that the more immediate pressure may come from that direction.

Estimates of the net standing value of timber are based on current average export prices for Cameroon's lumber products of approximately CFAF 20,000/m$^3$, with direct non-labour inputs comprising CFAF 10,000/m$^3$ to bring the product to its export point. Labour inputs at market prices are estimated to be CFAF 7500/m$^3$, and royalties and resource rents are CFAF 2500/m$^3$. Commercial yields in the area are estimated to be only 2 m$^3$/ha, attributable to this project for social valuation purposes. This reflects that some of the investment would be undertaken in any event for other regional imperatives. The level of 33% was taken as that proportion which was necessary to (a) accommodate specific park requirements and (b) offset the negative environmental impacts of this infrastructure.

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#### 4.5.3.4 Changes in Forest Use

Under the Government of Cameroon regulations pertaining to national parks, people are not allowed to hunt and gather within the park boundaries. Part of the initial mandate of the Korup studies was therefore to determine how best to deal with the villages lying inside the boundaries. Currently there are six villages which fall into this category: Bareka Batanga, Esukutan, Bera, Ikenge, Ekundukundu and Erat. While the final strategy for compensating villages in the park has yet to be firmly established, it is clear that restrictions will be imposed on their traditional activities. Although the restrictions may be regarded as necessary to promote conservation, they may lead to lost production for the Cameroon economy and, in the context of the CBA, any changes in value must be estimated.

Estimating the change in forest use is by no means a trivial task. Broadly speaking, we want to know the contribution the forest makes to income and to what extent, in the presence of restrictions on forest harvesting, the labour will be productively used elsewhere. For example, if a hunter can no longer hunt within the primary forest zone of the park but can still – with little change in effort – capture the same amount of quarry by hunting in the secondary forest zone around the park, then the lost value is minimal. In a similar manner, if hunters simply revert to farming when hunting restrictions are imposed, then the hunting losses will to some degree be offset by applying labour to farm land. Alternately, one might imagine that some households might relocate to equally productive areas where there are no restrictions, thus incurring only relocation costs.

In addition, there is also an important dynamic element: although restrictions imposed in the current period may limit current income, they may – through protecting the integrity of the forest – permit sustainable harvesting of the forest over a longer period than would otherwise have been possible. Depending again on how labour shifts from one activity to the other, there may therefore be some net gain in future income by maintaining access to the forest.

Valuing the net effects depends, therefore, on how individuals will react to restrictions on their activities in the face of other opportunities available to them. When opportunities abound and labour is mobile, the restrictions may in fact have little impact on production within the economy. But it is difficult to assert that such generalisations will always apply – particularly in developing countries. In the case of Korup, the household surveys and field work conducted for the project provided some important empirical information for evaluating the changes in income, while also providing some equally important impressions of how income opportunities might change in reaction to restrictions on activities. Chapters 5 and 6 of this thesis provide detailed investigations into household and individual behaviour but, for the purposes of the CBA, the following observations are relevant.

a) Villages inside the park – involving some 800 people – would have few other immediate opportunities available to them if they were prevented from hunting and gathering. It is assumed that all hunting and gathering income is lost and is not replaced by other activities. While this may overstate the loss as it assumes that the labour freed would have a marginal productivity of zero elsewhere, such an assumption may, in fact, not be far off the mark in this case. First, they are prevented by traditional tribal and village land-use customs from using the secondary forest zone outside of the park. Second, they cannot under Cameroonian law clear more land within the park for farming. Finally, relocation is apparently more costly than their income losses.[17] In summary, it seems likely that the restrictions would, to a large degree, reduce incomes markedly.

b) Villages outside the park, while they depend as well to varying degrees on hunting and gathering, generally have access to forested areas in which they could continue their traditional activities. It was therefore assumed that the restrictions would have no effect on their incomes in the current period.

c) Over the longer term, it was assumed that – in the absence of the park and if the area were logged – the gathering income would be lost even for those living on the forest peripheries and the displaced labour would have a marginal productivity of zero elsewhere. While again this latter assumption may involve overstating the benefits of conservation, it is believed to be reasonable given that the gathering activities are apparently highly productive (require fairly little time) and are conducted primarily by women and children in their spare time.

While some of these assumptions are certainly debatable, they provide a preliminary basis for estimating the impacts on forest use. We explicitly separate them into two components: the opportunity costs involved with the lost forest use of the households within the park; and the longer-term benefit of the sustained forest use arising from conservation of the primary forest.

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[17] In the original budgets set out for the Korup project, the Government of Cameroon had allocated 300 million CFAF to a relocation programme which would have moved the villages to areas where they could have continued their traditional hunting and gathering practices. By comparison, the present value of the hunting and gathering losses are just over 200 million CFAF.

Lost Forest Use (Opportunity Cost)

The household surveys were used as a basis for estimating the proportionate values of income from various activities for all of the villages in the forest area. If we let Y be the average income of villages in the park, and define further income shares $S_h$, $S_c$, $S_f$, and $S_o$ as shares of income from hunting, cashcrop production, forest product production, and 'other', the lost forest use value in any period is readily estimated. In our specific example, defining N as the population of the six villages, the value of lost forest use (VLFU) in any period becomes:

$$VLFU = N*Y*(S_h+S_f),$$

which explicitly assumes that these villages can still continue to have access to their cashcrop and other income (primarily from remittances, trading and livestock) but, as noted earlier, that income from these other sources does not increase. From the surveys of the villages in the park, the value Y is estimated to be 63,700 CFAF and the lost share is estimated as 67% for the CBA calculations. A total population of 800 individuals is involved and it is thus estimated that VLFU is 34.14 million CFAF once full enforcement of park programmes occurs in 1995. The loss is phased in to reflect partial enforcement levels of 50% in 1993. Note from Table 4.1 that VLFU=0 after 2010 as it is assumed that the villages would not have had access to this income in any event if clearing of the area commenced at that time.

Sustained Forest Use (Benefit)

The existence of the park will ensure the availability of forest products to the entire population of the region for longer than they would otherwise have access to these. Under the assumptions noted earlier, we can estimate this for years *beyond 2010* as:

$$SFU = Y*N_a*S_f,$$

where $N_a$ is the area population which obtains some share of its income through harvesting forest products. Again, from the household surveys, the relevant estimates of the parameters differed depending on where the individuals were. For this calculation, survey results for villages in the "Eastern Buffer Zone" were used to characterise forest use in the rural development zone around Korup National Park. This implies that about 12,000 people would benefit from sustained gathering activities at 11,000 CFAF per capita annually; these activities would likely halt quite abruptly once logging commenced in the area. In the year 2010 and beyond, this amounts to an annual benefit of about 132 million CFAF.

### 4.5.3.5 Other Direct Benefits

#### Tourism Benefits

No detailed tourism study has been undertaken to this date, hence estimates are somewhat conservative and conjectural. The estimate is based on an assumption that the park will generate an incremental 50 visits from *both researchers and tourists* in 1989 and 1990, 100 visits in 1991, and then escalating to 1000 visits annually by the year 2000. Based on typical expenditures and itineraries elsewhere in Cameroon, the average visitor is assumed to spend 7 days on a visit, spending £225 on goods and services. At the assumed shadow wage rate, the net income component of this expenditure to Cameroon is estimated to be 43% of the gross. The resultant net tourism benefits are about £96,000 annually, or 48 million CFAF.

#### Fisheries Protection

Both the Korup Project rainforest area and its complement in Nigeria – Oban Park – protect a vast onshore and offshore fishery which has been estimated by some to exceed £100 million annually.[18] The connection between the rainforest area and this fishery provides an interesting example of an environmental service provided by the rainforest, and it is not atypical of how coastal communities might depend on the integrity of inland environmental resources.

As shown earlier on the map in Figure 1.2, there exists a vast area of mangrove swamps along the shores of Nigeria and Cameroon. This mangrove area supports a wide range of species – including whitefish, shrimps, and alligators – which are commercially harvested. The connection which the mangroves have to the rainforest 100 km away has to do with the fact that three major river courses collect water from the rainforest and flow into the ocean at this point. Large variations in water levels of these rivers arise as a result of fluctuations in the amount of rainfall occurring over the forest. At periods of high water, the mangrove areas are inundated with fresh water whereas, during low periods, the salt water from the ocean finds its way inland along these river courses. Because of the large variations in river volumes, the mangrove area is larger than would typically arise from just tidal variations. But the entire mangrove ecosystem has evolved and flourished as a result of these phenomena: major changes in the freshwater environment would likely change the mangroves. For example, removing the rainforest canopy of Korup forest would increase the peak flows of the rivers which, in addition to decreasing the salinity of the mangrove

[18] See Reid (1988) for a discussion of this.

area, would carry a greater volume of sediment into it.

The scientific evidence (Reid [1988]) suggests that major changes in the freshwater flows – such as that arising from deforestation – would alter the ecological balance in the mangroves to the extent that many of its commercial species would be lost. Further, there is some speculation that the offshore fishery resource depends to some degree on food fish which breed in the mangroves. Although the ties between the forest and the offshore fishery are somewhat speculative, there is less doubt that the forest plays an important role in maintaining the important onshore mangrove fisheries. Appropriately, while no estimate of the value of offshore fisheries was made, estimates of the value of the onshore fishery can be derived.

Two independent methods are used to estimate the value of the onshore fisheries: (i) fish production; and (ii) economic activity levels. The fish production estimate is based on the observation (Reid, 1988, p.45) that the total productive capacity in the relevant areas of Nigeria and Cameroon together is about 12,800 metric tonnes. At typical fish prices of 500 CFAF/kg in Cameroon, this provides an imputed annual value of £12.8 million. The second estimate is based on economic activity levels. From available data, the population dependent on fishing is about 5000 in Nigeria and 13,000 in Cameroon. Using average per capita incomes in the mangrove regions, which are about £200 in Nigeria and £750 in Cameroon, the total fishery value is about £10.75 million annually.[19] Although these estimates are, admittedly, somewhat crude, they lend support to an annual value somewhat in excess of £10 million for the total onshore fishery.

But this value falls under the watershed of both Korup and Oban. Given that Korup represents about one-third of the regional forest, the size of the annual benefits supported by the Korup forest is proportionately reduced to £3.59 million. Further, this benefit only comes into play fully in the year 2040 in the CBA, being phased in through equal increments of £120,000 starting in 2010. Finally, an adjustment must be made to reflect the value of this to Nigeria. This adjustment is based on the economic dependence of the local populations which, as can be computed from the assumptions above, is 9.3% of the total; i.e., 90.7% of the benefits from maintaining Korup intact accrue to Cameroon, hence the sustained (post 2040) environmental benefit of Korup to Cameroon's onshore fisheries

[19] These calculations were based on discussions with the Department of Fisheries, in Yaoundé, Cameroon, and with the Ministry of Agriculture in Calabar, Nigeria. It is noted that the income levels in the mangrove area of Cameroon are about 5 times those in the Korup National Park area. From visits which I made to some villages in the mangroves, there was an apparent accumulation of wealth which was absent in Korup: many households had electrical goods, and many boats had petrol engines. While this does not prove that fishing incomes were high (there was also purported to be a great deal of cross-border smuggling activity), it does lend some support to the higher overall income levels.

is 1628 million CFAF.

## Flood Control

It is often asserted that rainforests play both important global as well as local meteorological functions. While there is little basis for estimating – for a single rainforest such as Korup – the incremental benefits from these functions, it is possible to estimate the potential benefits from distinct functions such as flood control. As rainforests disappear, the peak and trough levels of surface water flows become more pronounced. In a high rainfall area such as Southwest Province, the potential flooding increases with deforestation.

While it is impossible to predict exactly when a devastating flood might occur, one can approach the problem by replacing the net present value benefits with the *expected* net present value of benefits. It requires assuming that society is risk-neutral and that it has perfect perceptions of the risks involved. In practice it means that compensatory programmes are available to assist flood victims, that some form of crop or flood insurance can be purchased by individuals, or that other market mechanisms (such as land prices) reflect the relative degrees of flooding risk. As none of these circumstances normally exist in developing countries, using the expected value approach is likely to *understate* the potential benefits to social welfare of maintaining the forest intact. Nonetheless, the assumptions of risk-neutrality and perfect perceptions are made here.

The expected value loss of flooding in any year t can be estimated as:

$$\text{Flood Control Benefit}_t = \frac{N_{fc} * (A_d/A) * Y_{fc}}{T}$$

where $N_{fc}$ are the number of people expected to be effected by a flood event, and $A_d/A$ is the proportion of the deforested area of forest to the total area. $Y_{fc}$ is the per capita income in the region lost due to a flood event. The flood event is assumed to occur every T years.

For calculating the N.P.V. benefit, it was assumed that $N_{fc}$=20,000, which corresponds to the population in the Korup Park rural development zone as well as about 8000 people living along river courses between Korup and the coast (it excludes those in the mangrove estuaries). The income loss is estimated to be that corresponding to all livestock income and one season of cashcrop income as the flooding would likely occur in July or August and the major harvest occurs in October.[20] Based on the survey, it is estimated that

[20] Strictly speaking, the major harvests are from annual tree crops and the actual damage may be to the tree itself rather than to just the pods or beans on the tree. Any permanent damage to the tree would be reflected in lower productivity for some years to come, and this approach might therefore understate the lost income. On the other hand, it is expected that not *every* crop in the area will affected, and some product will no doubt still be marketable in the case of a flood event. Whether these two offsetting influences are equal in

$Y_{fc}$=61,000 CFAF. This corresponds to livestock income of 1000 CFAF, and cashcrop income of 40,000 CFAF to which a conversion factor of 1.5 has been applied to reflect differences between producer and world prices. Producer prices paid by marketing boards to coffee and cocoa farmers are regulated in Cameroon at levels which, during the time the survey was undertaken, were about two-thirds of the world price. The profits realised by the marketing boards would thus also be foregone in the event of this crop loss, and are appropriately valued by the application of such a conversion factor. With full deforestation, and the expectation that such a flood event would occur about once every five years, the expected flood losses at shadow prices would approach 244 million CFAF annually.

Soil Fertility Maintenance

Although the soils in the area are not generally of very high quality, it has been asserted that rainforests contribute to some maintenance of soil fertility through various mechanisms. Although these benefits are somewhat conjectural, an order-of-magnitude estimate can be made based on an estimate of the regional agricultural product. Specifically, it is assumed that, without the Korup forest, there would be a 10% loss in the value of the cashcrop income in the area. This loss would commence in 2010 and manifest itself fully (at about 120 million CFAF annually) by the year 2040. It should be noted that this *does not necessarily* mean that there will be a loss in output if the fertility losses can be offset by increases in other inputs (such as fertilisers), in which case the assumption reflects the increased costs of these inputs (at shadow prices) to meet the same output levels.

value is purely conjectural, but the assumption is nonetheless made that they are.

Table 4.3
Summary of Korup National Park Cost Benefit Analysis

| | Net Present Value (million CFAF) | |
|---|---|---|
| SOCIAL COSTS | | |
| Total Capital Costs - excluding Roads | -1 988 | |
| Total Capital Costs - Roads | -1 022 | |
| Total Long-term Operating Costs | -2 381 | |
| Labour Adjustment for Direct Costs | 916 | |
| Lost Timber Value | -353 | |
| Lost Forest Use | -223 | |
| TOTAL COSTS | | -5 051 |
| SOCIAL BENEFITS | | |
| Sustained Forest Use | 354 | |
| Tourism | 680 | |
| Fisheries Protection to Cameroon | 1 770 | |
| Control of Flood Risk | 265 | |
| Soil Productivity Maintenance | 130 | |
| TOTAL BENEFITS | | 3 199 |
| NET BENEFIT | | -1 852 |
| RATE OF RETURN | | 6.2% |
| Evaluation Year (Year 0) | 1989 | |
| Social Discount Rate | 8% | |
| Shadow Wage Rate | 50% | |
| Years of Deforestation | 2010-2040 | |
| Road Costs Included | 33% | |

### 4.5.4 Results

#### 4.5.4.1 Cost Benefit Analysis Results

Table 4.3 summarises the results of the cost-benefit analysis base case, showing the contributions of major cost and benefit centres. All figures are in constant 1989 terms, discounted to the year 1989. The net present value of the project, at an 8% rate of discount, is about *minus* 1852 million CFAF for Cameroon. The benefit and cost flows at shadow prices correspond to a real internal rate of return of 6.2% from Cameroon's perspective. As the NPV is negative, the CBA indicates that the project would not be welfare improving to Cameroon if all of the costs were incurred internally. In short, one would not expect Cameroon actually to take steps to conserve Korup unless some transfers or other incentives were forthcoming from the rest of the world. The analysis indicates that the current value of such incentives must be at least 1852 million CFAF to provide an adequate inducement to Cameroon to pursue the park initiative.

Table 4.4
Korup Project Sensitivity Analyses
(million CFAF)

| Case | N.P.V. |
|---|---|
| Base Case | - 1 852 |
| Exclude Onshore Fisheries | - 3 622 |
| Social Discount Rate = 6% | + 319 |

A number of sensitivity analyses were conducted, and the results presented in Table 4.4 merit some brief remarks. First, a sensitivity analysis was undertaken to illustrate the effect of excluding the protective benefits of the forest to the onshore mangrove fisheries. Excluding these benefits essentially doubles the (negative) social cost of the project, and it underlines the importance of this environmental function of the forest in the overall project evaluation. Second, results were calculated at a discount rate of 6%. As noted earlier, this would be equivalent to assuming that the base case cost and benefit streams were growing at a real rate of 2% per year. In this case, the project shows a slight positive NPV of 319 million CFAF, indicating that the project would be welfare improving to Cameroon in the absence of international transfers. To a large degree this can be attributed to the considerable local benefits of conservation which occur beyond the year 2010; at a lower discount rate these become significantly more pronounced.

4.5.4.2 Protection Scenario

The infrastructure and programmes mobilised by the Korup Project would not, as noted previously, show immediate conservation benefits and it is important in calculating the rainforest supply price to be specific about how much forest is actually protected. To estimate this, we must estimate the amount of deforestation which would occur in the absence of the park programme. There are actually two separate sources of deforestation which we consider: the first deals with a reduction in the area of primary forest through its 'conversion' to secondary forest by populations living within the park; the second deals with physical destruction of primary forest from harvesting timber. The relevant areas are summarised in Table 4.5 and are discussed below.

The first component relates to the non-destructive 'conversion' of primary forest to lower quality secondary forest. Strictly speaking, this conversion is not likely to effect the environmental functions relating to local climate control, but – if it becomes permanent and wide-spread – it does effect the overall species diversity of the forest. It represents a relatively small proportion of the whole and is assumed to correspond to the activities of the populations within the park. The conversion occurs because, through living in the forest, land is cleared for village sites, temporary shelters, farms, and general access trails. Devitt (1988) estimated this conversion to be about 25 hectares per person, noting, however, that

Table 4.5
Korup National Park Protection Scenario

| Year (t) | Area (ha) of Primary Forest Converted to Secondary Forest by Local Populations | | Area (ha) of Primary Forest Harvested for Timber | | Net Area (ha) Protected $\Delta E_t$ |
|---|---|---|---|---|---|
| | Without Park (1) | With Park (2) | Without Park* (3) | With Park (4) | With Park** (5) |
| 1989 | 20,000 | 20,000 | 0 | 0 | 0 |
| 1990 | 20,000 | 20,000 | 0 | 0 | 0 |
| 1991 | 20,000 | 20,000 | 0 | 0 | 0 |
| 1992 | 20,000 | 20,000 | 0 | 0 | 0 |
| 1993 | 20,000 | 10,000 | 0 | 0 | 10,000 |
| 1994 | 20,000 | 10,000 | 0 | 0 | 10,000 |
| 1995 | 20,000 | 0 | 0 | 0 | 20,000 |
| | ... | ... | ... | ... | ... |
| 2010 | 8,300 | 0 | 11,700 | 0 | 20,000 |
| 2011 | 0 | 0 | 23,400 | 0 | 23,400 |
| | ... | ... | ... | ... | ... |
| 2020 | 0 | 0 | 128,700 | 0 | 128,700 |
| | ... | ... | ... | ... | ... |
| 2030 | 0 | 0 | 245,700 | 0 | 245,700 |
| | ... | ... | ... | ... | ... |
| 2040 | 0 | 0 | 351,000 | 0 | 351,000 |
| 2041→ | 0 | 0 | 351,000 | 0 | 351,000 |

* Assumes clearing of 11,700 hectares per year, commencing with those areas converted by local populations.

** Column (5) = [(1)-(2)] + [(3)-(4)]

the forest often 'recovered' quickly once people had left the area – provided that there was still a large area of primary forest adjacent to the disturbed area. Without the park, therefore, the converted area associated with its 800 inhabitants is about 20,000 hectares. With the park, it is estimated that 50% of this would be able to 'recover' in 1993 and the remainder in 1995.

The second component corresponds to the protection of the intact forest which was assumed otherwise to be clear-cut for timber over the period 2010–2040. As noted in Table 4.5, it is assumed that some 11,700 hectares of primary forest would be cleared annually over a 30 year period commencing in 2010. By the year 2040, in the absence of the park, some 351,000 hectares of primary forest would have been lost.

Through inspection of these components, the actual 'protection scenario' afforded by the park is therefore clear. In the very short term, no protection is afforded because the population currently living in the park are assumed to continue their activities. After about 5 years, restrictions on these activities effectively protect 20,000 hectares of forest area which otherwise would have been lost. It is not until after 2010, however, that the major protection benefits might be realised, corresponding to the restrictions on logging imposed by the park. Over the long-term, the existence of the park effectively protects 351,000 hectares in perpetuity.

#### 4.5.4.3 Korup Rainforest Supply Price

We are now in a position to calculate the rainforest supply price according to Equation (4.10). The 'present value' of the protection scenario detailed in the previous section is:

$$\text{P.V. Area Protected} = \sum_{t=0}^{\infty} 1.08^{-t} * \Delta E_t = 513{,}800 \text{ discounted hectare-years.}$$

Given that the required transfer was calculated to be 1852 million CFAF in the cost benefit analysis, it is clear that the rainforest supply price for Korup National Park is about 3600 CFAF per hectare per year. This implies that if the rest of the world were to give Cameroon anything above 3600 CFAF for each hectare protected in *any* given year, Cameroon would have an incentive to protect the park.[21]

To allow a more meaningful comparison to other projects, we can express this in some common international currency. As the selection of currency is arbitrary, I shall use the European Currency Unit (ECU) which, at the time of preparing the budgets for the Korup plan, stood at an exchange rate of 340 CFAF/ECU. The rainforest supply price for Korup then is 10.60 ECU per hectare per year (or 1060 per $km^2$ per year) of rainforest.

It should be stressed that the RSP need not be interpreted as a programme which involves continuous transfers which build up slowly starting in 1993 and peak in 2040. In theory, the exercise says simply that *any* programme of transfers with a present value in excess of 1852 million CFAF will be adequate to conserve the forest. In practice, this programme would likely include a combination of capital transfers to fund the initial infrastructure, as well as ongoing transfers to underwrite the operations of the park.

The operative question is now whether it is worth just over 1000 ECU per $km^2$ per year to the rest of the world to induce Cameroon to conserve Korup. One means of answering this question is to investigate the global benefits of conserving rainforests. But the rationale for concentrating on the supply price was to allow comparisons to be made to other projects, hence I shall now review briefly some other conservation projects where actual transfers to LDCS *have* occurred.

[21] While dividing the project into hectares in this manner provides a convenient pedagogical basis for comparisons to be made with other projects, it should not be taken to imply that the project is divisible into hectare elements.

## § 4.6 Calculating Willingness-to-Pay: Some Specific Examples

### 4.6.1 Introduction

The purpose of this section is to investigate a number of cases where direct transfers to LDCs have occurred for rainforest conservation. The previous section indicated that Korup would require transfers equivalent to about 1000 ECU per km$^2$ per year, and one specific objective of this section is therefore to investigate whether Korup would be a bargain or relatively dear from the point of view of the rest of the world. In the process, it will also become clear what sorts amounts people have been willing to pay to conserve certain rainforest areas.

I shall be investigating six specific transfers, all of which occurred over the period 1987 to 1989. Four of these transfers involve debt for nature (DFN) swaps, and two are targeted fund raising campaigns to conserve specific rainforest projects. The transfers investigated are:

a) Beni Reserve DFN Swap - Bolivia, 1987
b) Amazonian Parks DFN Swap - Ecuador, 1987
c) St. Paul Park DFN Swap - Philippines, 1988
d) Santa Rosa Park DFN Swap - Costa Rica, 1988
e) Monte Verde Cloud Forest Direct Mail Campaign - Costa Rica, 1988
f) Oban Park Founder's Bond - Nigeria, 1989

Before addressing each of these individually, however, it is useful first to review how the calculations relating to these projects correspond to the rainforest supply price.

### 4.6.2 Evaluating Willingness-to-Pay

It will be recalled that the RSP is the minimum amount which a host LDC must receive before it will conserve its rainforest. In this section we shall not strictly be looking at the RSP, as we are investigating actual transfers. One would normally presume that these transfers are more than the RSP for the project and, depending on the bargaining positions of the various parties, it is conceivable that the particular LDC would have collected substantially more than what they would have been willing to accept. As we are not in the position of evaluating the bargaining positions of the various parties in the negotiations, the evaluations which follow can not necessarily be construed as RSP evaluations. They can, however, be taken as some measure of how much the rest of the world was willing to pay for a given conservation programme. As such, they provide a useful comparison to projects for which the RSP is known (such as Korup).

As a corollary to $\beta^*$ given by Equation (4.10), the calculation of the revealed willingness to pay $\beta$, is then given as:

$$\beta = \frac{\sum_{t=0}^{\infty}(1+r)^{-t} * R_t}{\sum_{t=0}^{\infty}(1+r)^{-t} * \Delta E_t} \qquad ...(4.13);$$

where, again, $R_t$ is the amount actually transferred to the LDC and $\Delta E$ is the expected protection scenario. It is particularly important in these evaluations, as well, to specify $\Delta E$ carefully as all of the six programmes evaluated in this section have a rather short effective life. The DFN swaps, for example, will typically provide protection for only a few years.

### 4.6.3 Debt for Nature Swaps

As four of the transfers investigated involve some form of DFN swap, it is useful to review briefly the nature of such deals.[22] The DFN swap was first proposed as a conservation tool by Lovejoy (1984) when he recognised that many LDCs struggling to meet debt repayment terms might prefer to redirect a proportion of their debt service payments to domestic conservation initiatives. The basic mechanism involving a DFN swap is that an external donor purchases a country's debt paper on the discounted secondary market and returns this debt paper to the LDC in return for some conservation 'consideration'. The consideration can take many forms, but the most common is that a local currency bond is established (usually at a face value which is also discounted somewhat from the face value of the debt paper which was returned) which pays interest and/or principal over a fixed period to underwrite the expenses of a local conservation project.

One of the primary benefits of such swaps to an LDC is that it effectively gives it a backdoor access to the secondary market of its own debt. Cohen (1988), for example, characterises the secondary market as a partitioned market which works perfectly freely with everyone allowed to participate in the trading of debt paper except the LDC itself. Contracts are structured in this way to prevent the LDC from having perverse effects on the value of its own debt. If a country did have access, it could announce or undertake a series of apparently 'bad' policies which drove the value of its debt down in the secondary

[22] For a detailed discussion of DFN swaps, the reader is referred to Bramble (1988), Simons (1988), von Moltke (1988), Sevilla (1987, 1988), Fuller and Williamson (1988), and WWF-US (1988a). For further detail on the role of debt-equity swaps and secondary debt markets in alleviating LDC debt, relevant recent texts include Simonsen (1985), Nordhaus (1986), Bergsman and Edisis (1988), Cohen (1988), Cohen and Sachs (1986), Cuddington and Smith (1985), and Sachs (1988).

market. Once the value reached a low enough level, it could buy back the debt, reverse the policies, and continue on a debt-free course. While the DFN swap does give LDCs indirect access to their secondary markets, it is not likely that countries will start to do silly things to depress the secondary market just so they can sign more DFN agreements: to date the DFN agreements have been small in relation to the outstanding debt.

Although the DFN agreements have not made a significant impact on the outstanding debt, they have been relatively large in relation to the amounts of money which conservation groups have traditionally been able to muster. The four DFN swaps investigated in this section are cases in point.

### 4.6.4 Description of Projects

A total of six transfers were evaluated using the framework described above. They were selected because in each case there was a simple direct transfer of funds intended to conserve a particular rainforest area in the countries. In all cases, reasonably good relations existed between the initiating donor agency and the host government, and the expectations were that the transfers would indeed promote effective conservation of the rainforest, albeit in some cases for a limited time only.

The first project investigated involves a protected area in excess of 1.5 million hectares in the Beni Nature Reserve in Bolivia (WWF-US [1988a]). The Beni Reserve is in the Amazonian region of northern Bolivia, and supports 13 of Bolivia's 18 endangered animal species. The programme involved a DFN swap in July 1987 in which debt paper having a face value of US$650,000 was purchased by Conservation International for US$100,000. The Bolivian government in return elevated the protected status of the reserve and turned the equivalent of US$100,000 in local currency over to a local non-governmental organisation (NGO) for establishing the reserve. In addition, a direct transfer of US$150,000 was provided by USAID to the NGO. The total funds are not anticipated to be adequate to protect the reserve in perpetuity as their primary intent was to initiate protection of the reserve and remove very short-term land use pressures.

The second project involves a total of about 1 million hectares of rainforest in two areas of the Amazonian region in Ecuador (WWF-US [1987]). These areas are threatened by spontaneous colonisation and industrial encroachment from oil exploration. It also involved a DFN swap in 1987 in which debt paper having a face value of US$1 million was purchased for 35.5% of its face value. The Bolivian treasury transferred local currency instruments having an equivalent of US$1 million to Fundación Natura, a local

NGO entrusted with the conservation projects. The project was part of a total US$10 million which the Ecuador Government had agreed to treat in this manner for conservation including projects in the Andes and in the Galapagos Islands, although it is understood that the initial injections were meant to alleviate some of the immediate pressures on the Amazonian portions.

The St. Paul Park in the Philippines is an area of 5753 hectares containing montane and coastal forests as well as a unique underground river (WWF-US [1988c]). The area is native habitat to a number of endemic endangered species including the Philippines crocodile, pangolins, and the Palawan bear-cat, and green turtles are known to nest on beaches in the park. The area is threatened by shifting cultivation and illegal logging, and there is a lack of local government resources to fund the park department adequately to ensure its protection. In 1988, WWF agreed to exchange a face value of US$390,000 in debt – which it had purchased at a 50% discount – in return for the Philippines Government support for a selection of conservation initiatives: the largest of which was the St. Paul Park project. About 40% of the funds were targeted to this project, and the government agreed to transfer local currency in that amount into an instrument which would allow a local NGO – the Haribon Foundation – to provide support for the area for about 9 years.

The last DFN swap I investigate involves some 16,000 hectares adjoining the Santa Rosa National Park project in Costa Rica (WWF-US [1988b; 1988d]). This is actually one of many DFN swaps in which Costa Rica has been involved, but most of the others involved multiple projects which involved only total unprogrammed budgets and thus precluded analysing specific components. Specifically for the Santa Rosa Park, a face amount of US$270,000 in debt paper was purchased by WWF in 1988 for US$100,000 and returned to the Central Bank of Costa Rica. Also, some 10% of a face value US$5.4 million debt swap is earmarked for the Santa Rosa project. In exchange the Central Bank issued a local currency bond paying principal and interest over a five year period to the National Park Service (which is operated independently from the government), the proceeds of which were to be dedicated to the protection of this area.

The fifth project involved a direct transfer to purchase critical lands from local farmers in the Monte Verde Cloud Forest area of Costa Rica (WWF-US [1988b; 1988d]). Funds were raised by WWF-Canada through a direct mail campaign and individual donations, and involved a total of about Cdn$300,000 in 1988 dedicated to protecting some 3600 hectares of the Monte Verde Cloud Forest. The forest is in Northwest Costa Rica and it contains rare and endangered species found in typical mid-elevation rainforests. It protects the watershed of Costa Rica's largest hydroelectric facility, but it was being threatened by land speculation and illegal logging. Transfers through the programme, which may be channelled through a DFN swap arrangement, would be anticipated to provide protection for the forest for about five years.

The last project investigated involves the Oban National Park project in Nigeria having a core protected area of about 250,000 hectares (WWF-UK [1989a]). Oban Park is adjacent to Korup National Park in Cameroon and contains similar primary rainforest as that found in Korup. While WWF and the Government of Nigeria were undertaking long term planning for Oban, however, it became evident that immediate pressures from logging and bush fallow agriculture were threatening the integrity of the forest. A fund raising campaign in the form of an "Oban Park Founder's Bond" was thus initiated in the U.K. whereby participants would for £25 receive a certificate saying they assisted in the establishment of the Oban Park. Some £700,000 were raised in this manner in 1989 and the entire proceeds were used to underwrite the expenses of eliciting a National Park decree from the Government of Nigeria and paying for immediate enforcement efforts necessary to keep the area intact over its first year. It is expected that the longer-term funding requirements of the park will be met once a long-term plan is established and mobilised.

### 4.6.5 Results

A summary of the results of the willingness-to-pay calculations for these transfers is provided in Table 4.6. As the projects were undertaken at separate times and used different currencies, all calculations were normalised to ECU at 1989 values using appropriate adjustments for both inflation and currency exchange rates. In addition, an 8% discount rate was used for discounting to allow comparisons to be made to the Korup evaluation (although it is noted that the results are less sensitive to discount rates over the short protection and transfer scenarios shown here).

Although the sample is not meant to provide a statistically significant cross-section of conservation, it does provide some indication of how much individuals or organisations have been implicitly willing to pay for conservation. As noted previously, however, these figures should not be construed as the minimum amount which would be necessary to induce conservation nor should they necessarily be construed as the maximum that the world is willing to pay: all one can say with certainty is that they fall between these extremes.

Table 4.6
Estimates of Revealed Willingness-to-Pay and Rainforest Supply Price

| | |
|---|---|
| Real Discount Rate | 8% |
| Currencies Normalised to: | ECU |
| N.P.V. Normalised to: | 1989 |

Willingness-to-Pay Calculations

| Project Description | Protected Area ($km^2$) | Protection Scenario | N.P.V. of Actual Transfers ('000 ECU) | P.V. Area Protected ('000 $km^2$-yr) | Revealed Willingness-to-Pay (ECU/$km^2$/yr) |
|---|---|---|---|---|---|
| Beni Reserve Bolivia (1987) DFN Swap | 15420 | 1 Year | 234 | 15.42 | 15.18 |
| Amazonian Parks Ecuador (1987) DFN Swap | 10000 | 1 Year | 332 | 10.00 | 33.24 |
| St. Paul Park Philippines (1988) DFN Swap | 57.5 | 9 Years | 353 | 0.39 | 910.34 |
| Santa Rosa Park Costa Rica (1988) DFN Swap | 160 | 5 Years | 265 | 0.69 | 383.84 |
| Monte Verde Forest Costa Rica (1988) Direct Mail | 36 | 5 Years | 245 | 0.16 | 1575.76 |
| Oban Park Nigeria (1989) Founder's Bond | 2500 | 1 Year | 1029 | 2.50 | 411.76 |

Rainforest Supply Price Calculation

| Project Description | Protected Area ($km^2$) | Protection Scenario | N.P.V. of Required Transfers ('000 ECU) | P.V. Area Protected ('000 $km^2$-yr) | Rainforest Supply Price (ECU/$km^2$/yr) |
|---|---|---|---|---|---|
| Korup Park Cameroon (1989) | 3510 | Protection of 200 $km^2$ From 1993 Until 2011 Phased In to Full Protection by 2040 | 5448 | 5.14 | 1060.15 |

There is a considerable range of results even within this small sample: the Beni Reserve deal was the least expensive at about 15 ECU per $km^2$ per year, whereas the amount contributed for protecting the Monte Verde Cloud Forest approaches 1600 ECU per $km^2$ per year. Abstracting from potential differences in bargaining position, and assuming that the amounts are determined by some consistent mechanism or mechanisms, I shall offer a number of potential reasons for these differences. The first is that the amounts paid do actually reflect the supply prices of these projects fairly closely, in which case we may conclude that some of the readily identifiable 'bargains' had been spotted quite early – the projects in Bolivia and Ecuador were indeed the first to be initiated – and subsequent projects are going to cost one to two orders of magnitude more. A second reason for the differences may be in the quality of the area being protected: if we assume that all six of these transfers have the same hedonic price, it implies that we regard the quality of a hectare in Monte Verde to be about one hundred times greater than a hectare in Amazonia. This may not be an unreasonable result given that cloud forest such as that found in Costa Rica is rarer than Amazonian rainforest. A third potential reason for the differences is that they reflect expectations of success in the particular protection scenario. This is similar to the quality argument above, except that in this case one might argue along the lines that the chances of success in Monte Verde are one hundred times greater than the chances in Amazonia. Formally, this means that the protection scenario has been mis-specified (recall that it is the *expected* protection) but it suggests that there may be some merit in explicitly identifying the probability of success when evaluating such projects.

While there is little – if any – basis for testing these conjectures at this stage, the framework which has been used does allow us to start making comparisons and asking relevant questions. For example, in the case of Korup National Park, we see that, at 1000 ECU per $km^2$ per year, it is not necessarily one of the great bargains in the world, yet the level of transfers which is required is not out of line with that which has been raised or paid elsewhere. Given that Korup is regarded by many to be one of the most important rainforest areas on the African continent, 'quality' considerations may suggest that the necessary funds to pursue the project could be raised.

## § 4.7 Summary Comments

This chapter has suggested an analytical mechanism – the rainforest supply price – for evaluating the level of transfers which are required to induce an LDC to conserve a particular rainforest project. One particular advantage of this tool is that it allows one to address questions of allocative efficiency without necessarily requiring that broad issues relating to the valuation of *global* benefits of rainforest conservation are discussed. Also, it allows one to make comparisons between many types of rainforest conservation projects on a consistent basis.

One attribute of the tool is that, as it is currently formulated, it does not take explicit account of the quality of any particular rainforest. While some might regard this as a weakness, the approach actually allows one to isolate the issue of required compensation levels and address the matter of quality as a separate issue. Treating quality as a *demand* issue rather than a supply issue is perhaps more appropriate in any case. It was illustrated that, if some subjective or objective measure of rainforest quality can be constructed, it can be readily incorporated into the framework suggested here.

Specific applied work in a cost-benefit analysis framework relating to Korup National Park illustrated that the project was not in Cameroon's interest if Cameroon were required to pay for the entire project. Transfers in the amount of just over 1000 ECU per $km^2$ per year would be required to compensate Cameroon for the area actually protected by the park programme. Transfers of twice this level would be necessary were it not for selected local environmental benefits afforded by rainforest conservation – in particular the protection of Cameroon's onshore mangrove fisheries.

An analysis of six other rainforest projects pursued between 1987 and 1989 indicated that funds had been raised for these projects which fell into a range of 15 to 1575 ECU per $km^2$ per year. Given this result, one might conclude that the cost of supporting transfers for the Korup project is not a mis-use of resources given that similar projects have attracted transfers of this order. Indeed, one might assert that – given that Korup is regarded by many conservation interests as being of high quality – supporting transfers for Korup would be an efficient use of scarce conservation resources.

In closing, one other result arose from the cost-benefit analysis which relates to the types of transfers which one might wish to consider for a project such as Korup. The long-term cost and benefit projections for Korup indicated that annual financial costs of the project would be about 280 million CFAF, and that the level of benefits at shadow prices approached 2200 million CFAF annually. At the surface it might therefore appear that – once the capital outlays were over and the project was well established – there would be a significant incentive for Cameroon to continue funding for the park programme. A common problem with projects of a 'social' nature in LDCs, however, is that local governments do not meet ongoing current budgetary needs for programmes which generate few revenues. Korup Park would fall into this category, as most of the environmental benefits are to maintain income or production levels elsewhere in the economy and they do not directly increase the amounts in government coffers. This suggests that one potential area for transfers is to pay for the ongoing expenses of the national park. While this approach deviates from both the short-term nature of DFN swaps and the traditional aid programmes which involve injections only at the start of projects, it may provide a greater chance of successfully promoting rainforest conservation. In addition, continuous transfers are more in line with the ongoing benefit which the rest of the world purportedly receives from the environmental functions of rainforests.

# CHAPTER 5
# DEVELOPMENT INCENTIVES AND MIGRATORY ADJUSTMENT IN KORUP NATIONAL PARK

## § 5.1 Introduction

International aid and development agencies are becoming increasingly responsive to the idea that promoting rainforest conservation may be an effective means of improving economic prospects within developing countries. As these organisations have traditionally had – and continue to have – access to substantial amounts of funding, we are seeing a far greater propensity to invest in conservation projects in the name of local economic development. In contrast to nation-wide tax policies which are difficult to target, development incentives in the form of rural development programmes or direct cash grants are more easily targeted and often have greater political appeal. In addition, institutional channels in many countries are reasonably well established for directing international funds to specific projects. Although the goals of a rainforest conservation project may differ markedly from those of traditional development projects, the logistical and managerial requirements are sufficiently similar that administrative networks developed for traditional rural development programmes can readily accommodate the requirements of conservation projects.

One of the advantages of using local development incentives is that it is possible to target the incentive and custom-design it to meet conservation objectives effectively. But this very attribute also makes it difficult to generalise about the effectiveness of such programmes. As with many policies which are intended to promote conservation, economic theory can be used to guide empirical verification that the programmes will work. Although some degree of ex post evaluation of such programmes has been undertaken (Repetto and Gillis [1988]; Repetto [1988]; McNeely [1988]) to criticise ineffective programmes, such hindsight is not available to us for new programmes. We rely more heavily on theoretical constructs, rules-of-thumb, and our own ability to recognise and correct programmes which appear to be going wrong. In this regard, our ex ante evaluations must be used not so much to evaluate the effectiveness of the programmes, but rather to identify critical economic linkages and factors which will guide the design of the programmes. This is especially important with conservation incentives which are incorporated into rural development programmes. It is much more difficult to correct or reverse a rural development programme that was misconceived than it is to correct or reverse an incorrectly designed tax.

In this spirit, Chapters 5 and 6 investigate the effectiveness of development incentives in a rural setting of an LDC. The premise behind many of these programmes is that, when targeted to a region adjacent to a protected area, they will induce migration out of the protected region as well as causing people to switch from activities which cause deforestation to activities which promote (or at least do not interfere with) conservation. Because there are essentially two quite different propositions to be tested with different theoretical paradigms, they are dealt with in separate chapters: this chapter investigates the migratory adjustment process in detail, whereas the following chapter looks more closely at how people's hunting activities respond to changes in income. As the migratory adjustment process is hypothesised to depend – among other things – on income levels, this chapter also devotes some attention to characterising household incomes in the region under study.

In contrast to the previous chapter which concentrated on the Korup project as a whole, the analyses in Chapters 5 and 6 require very specific local household data. The process of transcribing and analysing these data from raw surveys is an original contribution of this thesis but, so as not to encumber the text here with all of the details, a description of the data collecting, reduction and management process is presented in the Appendix and discussions within the chapters are confined to summaries of the relevant portions of the data. It should be noted, however, that the richness of the household survey data allows some explorations into areas not directly related to conservation. While the focus of this thesis is on evaluating policies relating to rainforest conservation, the data reveal other interesting characteristics of rural communities in a developing country. In particular, the data allowed more detailed analyses of two other issues which often feature in policy planning in developing countries:

a) income distribution and inequality; and,
b) the relationship between education levels and income.

These issues are therefore also addressed in this chapter.

Given that this chapter concentrates on the role of migratory adjustment when evaluating development incentives, Section 5.2 reviews the theoretical basis for using development incentives to promote conservation. It describes in a simple theoretical model the conditions under which development incentives can lead to a migratory adjustment process which favours conservation goals. It then draws primarily on the specific theory dealing with migratory adjustment, indicating that there is ambiguity as to whether individuals will actually migrate in response to income differentials such as those contemplated here. Section 5.3 introduces the particular case study for which the household data were analysed. It deals with Korup National Park and the surrounding management area in Southwest Province in Cameroon. Section 5.4 provides a descriptive profile of income composition and distribution in the Korup area, while Section 5.5 addresses the supplemental analyses relating to the issues of rural income and education levels. Section 5.6 provides the results of econometric studies of migratory adjustment in the Korup area. Some concluding remarks summarising the role of migratory adjustment in designing development incentives are made in Section 5.7.

## § 5.2 The Case for Development Incentives

### 5.2.1 Policies and Principles

It is becoming increasingly common to promote conservation projects in LDCs by establishing a buffer zone around a park. Oldfield (1988; in McNeely [1988; page 195]) describes a buffer zone as:

> An area on the edge of a protected area which has land use controls which allow only activities compatible with the objectives of the protected area; appropriate activities might include tourism, forestry, agroforestry, etc. The objective of such zones is to give added protection to the reserve, and to compensate local people for the loss of access to the biodiversity resources of the reserve.

In practice, rural development is initiated in the buffer zone in an attempt to draw people away from the park and give them an alternative to exploiting the park. I investigate in this chapter and the next how effective such development incentives will be in promoting conservation goals.

Ultimately, the typical goal of any such exercise is to identify specific policies or policy reforms which will:

a) improve income levels;
b) improve income distribution;
c) provide incentives to individuals to move away from the core rainforest area; and,
d) provide incentives to individuals to conduct activities which remove direct pressures from the biome.

The first two elements – relating directly to income – can be regarded as 'development goals' whereas the latter two elements can best be regarded as 'conservation goals'. While ideally one would want to consider every possible policy or reform to identify the best available, practical considerations normally preclude this and one usually can – at best – identify some feasible policy and analyse the consequences of that policy.

In pursuing these goals, the buffer zone concept provides appeal both as an analytical concept as well as a tool for facilitating project implementation and management. It can be argued that development incentives which are concentrated in the buffer zone will directly improve income in that area. This establishes an income differential which induces migration away from the core or protected area into the buffer zone. By preferentially supporting certain types of activity in the buffer zone (such as cocoa farming), individuals are induced to spend their time on these activities rather than those which destroy the protected area (such as hunting). Furthermore, by properly targeting the programmes to certain types of activities which are traditionally carried out by those which are less well-off, income distribution can also be improved.

In selecting appropriate policies, it is clear that fairly specific data are required regarding incomes in and around the core protected area, and on describing how individuals behave in response to income differentials or alternate income opportunities. In this chapter I shall concentrate on describing how individuals respond to migratory pressures. In the process, a description of the income data will also reveal how specific programmes might be targeted to assist those who are the poorest and the most 'deserving'.

### 5.2.2 A Simple Model of Migratory Adjustment

Empirically, we wish to know whether increasing incomes in a buffer zone is likely to (i) draw people away from the core area, and (ii) remove land-use pressures from the core area. While in principle the first may appear to imply the second, I wish to consider a further potential effect: that of decreased emigration from the buffer zone in response to higher income levels.

A simple conceptual model is illustrated in Table 5.1. There is some population $N_i$, in each of three zones: the protected area (i=p), the buffer zone (i=b) and the rest of the country (i=c). Per capita incomes in each of these regions are characterised by $Y_i$. We define $\theta_i$ as the proportion of income $Y_i$ attributable to 'forest harvesting activities'. At this stage, I shall use the term 'forest harvesting activities' to designate those activities which are not consistent with the conservation goals.[1] The total income from the forest harvesting activities in each zone is then $F_i=\theta_i Y_i N_i$, and the total 'pressure' on the forest can be denominated by $F=F_p+F_b+F_c$. Formally, in terms of the nomenclature used in Chapter 3, we note further that $E=E(F)$ and that $\partial E/\partial F<0$, such that the identification of policies which

[1] In practice, as will be shown later in this chapter, some activities pursued in the rainforest (such as fruit gathering) are sustainable and not at all in conflict with conservation goals. Although these activities might be regarded semantically as 'forest harvesting', I shall strictly not regard them as such in $\theta$.

Table 5.1
A Three Zone Model of Migratory Adjustment

| | Region | | |
|---|---|---|---|
| | Protected Area (i=p) | Buffer Zone (i=b) | Rest of Country (i=c) |
| Regional Population | $N_p$ | $N_b$ | $N_c$ |
| Per Capita Income | $Y_p$ | $Y_b$ | $Y_c$ |
| Income from Forest Harvesting | | | |
| - Proportion | $\theta_p$ | $\theta_b$ | $\theta_c$ |
| - Total | $F_p=\theta_p Y_p N_p$ | $F_b=\theta_b Y_b N_b$ | $F_c=\theta_c Y_c N_c$ |
| Income Shock | 0 | $\Delta Y_b$ | 0 |
| Migratory Adjustment | $\Delta N_p$ | $\Delta N_b=-\Delta N_p-\Delta N_c$ | $\Delta N_c$ |

Change in Pressure on Forest

- if $\Delta N_c=0$

$$\Delta F = \Delta N_p\theta_p Y_p + \Delta N_b\theta_b Y_b = \Delta N_b(\theta_b Y_b - \theta_p Y_p)$$

- if $\Delta N_c\neq 0$

$$\Delta F = \Delta N_p\theta_p Y_p + \Delta N_b\theta_b Y_b + \Delta N_c\theta_c Y_c = \Delta N_b(\theta_b Y_b - \psi\theta_p Y_p - [1-\psi]\theta_c Y_c)$$

where: $\psi \equiv -\Delta N_p/\Delta N_b$

promote conservation involves identifying those reforms $d\omega$ for which $\partial F/\partial\omega<0$.

The standard justification for increasing incomes in a buffer zone is that it will draw people away from the protected area and that the pressures on the forest will therefore decline. Increasing $Y_b$ by some amount $\Delta Y_b$ will lead to a change in $N_p$ by $\Delta N_p$ as people move away from the protected area into the buffer zone. The net change in income from forest harvesting activities is then[2]:

[2] Note that this assumes that any increase in income in the buffer zone is directed towards those activities other than forest harvesting activities. Strictly, $\theta_b$ falls in proportion to the increase in $Y_b$, and in this formulation '$\theta_b$' is that which prevails before the incomes in the buffer zone are enhanced. Rigourously, if we define per capita income explicitly by period (t) and source (f=forest harvesting; o=other), then:

$$Y_{b:t}=Y^f_{b:t}+Y^o_{b:t} \quad \text{and} \quad \theta_{b:t}=Y^f_{b:t}/Y_{b:t}.$$

The change in direct pressure on the forest from inhabitants in the buffer zone is then:

$$\Delta F_b=(N_b+\Delta N_b)Y^f_{b:2}-N_bY^f_{b:1}.$$

Given, however, that the entire income improvement in the buffer zone is through enhancing the profitability of 'other' activities, we have $Y^f_{b:2}=Y^f_{b:1}$, and hence it follows that:

$$\Delta F = \Delta N_p \theta_p Y_p + \Delta N_b \theta_b Y_b \qquad ...(5.1);$$

and, as $\Delta N_p = -\Delta N_b$, pressures on the biome will fall if:

$$\Delta N_b > 0 \qquad ...(5.2a);$$

and,

$$\theta_b Y_b < \theta_p Y_p \qquad ...(5.2b).$$

As it is normally assumed that $\theta_b = 0$ (or in any event very small), it is obvious that a policy which enhances incomes in the buffer zone will lead to a decrease in pressures on the forest.

But the above approach ignores the migration process between the buffer zone and the rest of the country. One could equally well argue that enhancing incomes in the buffer zone will not only draw people away from the protected zone, but it will also draw people from the rest of the country into the buffer zone. This would have no effect on the biome if an individual in the buffer zone exerted as much pressure on the biome as one in the rest of the country (i.e., $\theta_b = \theta_c$). But if $\theta_b > \theta_c$, then it could well lead to an increase on the pressures on the forest. Indeed, in this case, it is readily shown that the change is:

$$\Delta F = \Delta N_p \theta_p Y_p + \Delta N_b \theta_b Y_b + \Delta N_c \theta_c Y_c \qquad ...(5.3),$$

and, as $\Delta N_b = -\Delta N_p - \Delta N_c$, pressures on the biome will fall if:

$$\Delta N_b > 0 \qquad ...(5.4a),$$

and,

$$\theta_b Y_b < \psi \theta_p Y_p + (1-\psi)\theta_c Y_c \qquad ...(5.4b),$$

where we have defined $\psi$ – the proportion of the migrants coming from the protected area – as $\psi = -\Delta N_p / \Delta N_b$. It is clear that Condition (5.2) is simply a special case of Condition (5.4) for which $\psi = 1$.

Condition (5.4) is helpful in that it allows us to specify more precisely when a policy which enhances income in the buffer zone actually promotes conservation goals. While it is largely an empirical exercise to determine the values of the individual parameters in any particular case, two particular cases merit comment at this stage.

First, when there is nobody living in the protected area and those in the rest of the country place no direct pressures on the forest, then we effectively have $\theta_c = 0$ and $\psi = 0$, and Condition (5.4b) reduces to: $\theta_b Y_b < 0$. This implies that, where migratory adjustment occurs under such circumstances, enhancing income in the buffer zone will never lead to a decrease in pressures on the forest and will normally lead to an increase in pressures on the

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$$\Delta F_b = \Delta N_b Y^f_{t:1} = \Delta N_b \theta_{t:1} Y_{t:1},$$

which is equivalent to that given in Equation (5.1) if $\theta_b$ and $Y_b$ are construed as the values before the income improvement policy was implemented.

forest as long as some forest harvesting activity exists in the buffer zone ($\theta_b>0$). Indeed, the result suggests that the preferred policy in this case – for promoting conservation goals – would be to *depress* incomes in the buffer zone. This would induce emigration from the buffer zone to the rest of the country, and take pressures off of the forest. In most LDCs – where rural-urban migration is in itself often regarded as a phenomenon which should be reversed through policy interventions – any such policy reform would normally be a non-starter.

Second, we consider the case where individuals in the buffer zone are as active in forest harvesting activities as those in the protected area. Formally, this implies that $\theta_b Y_b = \theta_p Y_p$, and for cases where there is some migration from the rest of the country ($\psi<1$) Condition (5.4b) reduces to: $\theta_b Y_b < \theta_c Y_c$. If we again normally assume that there are no direct pressures on the forest outside of the buffer zone ($\theta_c=0$), this condition would never hold and the preferred policy from a conservation perspective would again be to *depress* incomes in the buffer zone.

Although I have treated the above two as special cases, the parameter values assumed in those cases do probably characterise many rainforest areas. In those circumstances, policies which promote income improvements in a buffer zone area would normally lead to increased pressures on the rainforest from migratory adjustment. Ultimately, however, only applied research will allow us to decide whether Conditions (5.4a) and (5.4b) actually hold in any given area.

### 5.2.3 Theory of Migratory Adjustment

The previous section highlighted the importance of measuring the intensity of forest harvesting activities in and around the protected area, but it is also clear that the arguments only applied when there is actually some response of migration to incomes. Clearly, if $dN_b/dY_b=0$ then the arguments favouring income enhancement to attract individuals away from the protected area are groundless. Furthermore, if increasing incomes in the buffer zone drives people out of the buffer zone[3] ($dN_b/dY_b<0$), then satisfying Condition (5.4b) would lead to an *increase* in pressures on the forest. As we are concentrating in this chapter on whether individuals actually migrate in response to alternative income opportunities, it is appropriate at this stage to review some of the theory of migratory adjustment.

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[3] Although we discuss this further below, such circumstances might arise if higher incomes were a prerequisite to increased mobility.

Ultimately we want to know why it is that individuals migrate. Most of the received theory[4] now accepts that individuals will migrate in response to economic factors and that – in so doing – they are attempting to make themselves better off. As such, it is not surprising that 'income' plays a critical role in most theories of migration. Sjaastad (1962), Gugler (1968), Stiglitz (1969) and Frank (1971) provide arguments and evidence that people tend to be 'pushed' away from areas of low income and are 'pulled' towards areas of high income. In a classic article by Harris and Todaro (1970), they develop a two-sector model which argues that individuals in LDCs will migrate according to expected incomes and that the very process of migration causes wages to equilibrate to levels where $p_u w_u = p_r w_r$, where p is the probability of finding work at wage w, and the subscripts refer to the urban and rural sectors. In equilibrium, high urban wages corresponded to the lower probability of finding employment in that sector.

One of the empirical problems with the Harris-Todaro model was that it usually overpredicts the urban unemployment rate in LDCs (Turnham [1971]). A number of articles followed which attempted to resolve this 'stylised fact'. Bhagwati and Srinivasan (1974) attempted to resolve it by arguing that wages are actually rigid and tend not to adjust in LDCs: all adjustment occurs via migration and that there are barriers to migration which work against income differentials. Fields (1975) enhanced the Harris-Todaro framework through adding a 'murky' sector which absorbed much of the work-force as it was moving from the rural to the urban sectors. More recently, Heady (1981; 1987; 1988) suggests that the failure of the Harris-Todaro model to predict urban unemployment rates is that we need to equilibrate expected utility levels rather than expected income levels. Through this mechanism, it is possible to construct a utility function of expected income which accommodates both the income level and the risk of unemployment to describe extant conditions.

In short, however, regardless of how income and migratory adjustment eventually leads to an equilibrium in any given economy, most analysts find that expected income does play a role in the decisions which individuals make. Further, many have argued that this position is reinforced by the fact that young people – who would normally expect to be able to earn the higher levels of income for longer periods upon migrating – have a higher propensity to migrate. The propensity of the young to migrate to better areas was first discussed by Sjaastad (1962), and empirical work by Jolly (1969) and Bowles (1970) confirmed that younger individuals were more prone to migrate than their elders.

Although there often exist economic incentives to migrate, economic and social pressures

[4] A review of the early literature relating to migration can be found in Yap (1977).

also at times provide barriers to migration. This barrier or 'cost' of migration often enters in two forms: (i) as a real cost of relocation; and (ii) as the cost of obtaining information regarding job opportunities at other locations. Both of these factors are used for arguing that physical distance should be used as a proxy in any empirical work for such costs. As distance to the regions with higher wage opportunities goes up, it becomes more costly to obtain information and to move, and it is less likely that an individual will have effective contacts in that area. While such distance variables are often found to be significant empirically, there is disagreement as to how they should be specified: Hagerstrand (1957) suggests using logarithmic distance as a variable on the grounds that distance is more important when you are close to a source than far from it, whereas Courchene (1970) suggests using linear distance as a variable. Empirically, Vanderkamp (1971) found that reciprocal distance was the most useful explanatory variable for modelling costs, and that – for remote rural regions far-removed from urban centres – distance made little difference.

As an additional proxy for information costs, some authors suggest that a 'relatives and friends' variable be used to explain migration.[5] The rationale behind it is that individuals are more likely to move to regions where they have relatives and friends, as these contacts provide both an information function as well as a form of social security while job-search activity occurs. Empirically, this is often captured in a migratory stock variable which specifies the number of individuals which have previously migrated to a given area.

In summary, a typical migration model will define migration $M_{ij}$ from region i to region j as:

$$M_{ij} = M_{ij}\,(Y_i, Y_j, U_i, U_j, D_{ij}, MS_{ji}) \qquad ...(5.5).$$

where Y is income, U is unemployment, D is distance, and $MS_{ji}$ is a migratory stock variable. This formulation captures the income opportunities through Y, the risk elements through U, the costs through D and the information function through MS. In particular, as we are trying to estimate the role of incomes on migratory adjustment, it is useful to elaborate somewhat on the values of $\partial M/\partial Y$.

Most of the empirical literature finds that $\partial M_{ij}/\partial Y_i<0$ and $\partial M_{ij}/\partial Y_j>0$, which is consistent with the idea that individuals move from low income to high income areas. Vanderkamp (1970) argues, however, that there should be no *a priori* expectation that $\partial M_{ij}/\partial Y_i<0$, due to either productivity or wealth effects. If a region is characterised by a low income level then, to the extent that incomes reflect average productivity, one might argue that the region has a lower quality labour force which is less likely to migrate. It follows that a higher income in the origin region will increase migration from that region. This effect is

[5] This position is held by Nelson (1959), Greenwood (1969) and Langley (1974l).

compounded by wealth effects: if individuals require funds to finance a move or to provide security during job search, then – to the extent that income and wealth are correlated – one would expect that those from higher income regions are more likely to migrate. This effect may be particularly important in developing countries where individuals are living at subsistence levels and have few financial resources on which to fall back in the event of unsuccessful job search activities.

An issue which is not always explicitly addressed in migration theory relates to the relationship between education, wealth and mobility. Vanderkamp (1970) argued as above that if financial barriers to moving existed, then increased wealth would lead to higher mobility and individuals from higher income regions would be more mobile. But many empirical studies find that education is also an important contributing factor to labour mobility, and that higher education leads to greater mobility. In countries where individuals are required to finance their own education, one might therefore expect that individuals will be less likely to migrate from areas of lower income. Explicitly, for any individual k, where $M^k$ represents, say, his mobility in terms of the probability that he will migrate, the 'wealth argument' is premised on:

$$M^k = M^k[W^k(Y^k,...),...] \qquad \partial M/\partial W>0 \qquad \partial W/\partial Y>0, \qquad ...(5.6a);$$

whereas the 'education argument' is premised on:

$$M^k = M^k[S^k(Y^k,...),...] \qquad \partial M/\partial S>0 \qquad \partial S/\partial Y>0, \qquad ...(5.6b);$$

where W represents wealth and S represents schooling. While both models will yield the result that higher incomes lead to higher mobility ($\partial M/\partial Y>0$), the adjustment *mechanism* clearly differs. Although this might make little difference over long time frames, one would probably (but not necessarily) expect that the model which specifies education as an explanatory variable will be less responsive to changes in income over the short-term. Unfortunately, a model formulated in terms of Equation (5.5) will shed little light on the mechanisms by which incomes actually influence migratory behaviour, and data respecting wealth and education are usually unavailable when modelling aggregate migration.

To conclude, while incomes are theoretically important in determining the direction and magnitude of migratory adjustment, the theory is ambiguous regarding the actual direction of the migratory flows. In the context of our previous problem, enhancing incomes in a buffer zone may cause individuals to move to that zone if income is a strong attractive force, or they may cause individuals to leave that area if the higher income facilitates their mobility.

5.2.4 Summary

To evaluate the effectiveness of development incentives in promoting conservation goals through a migratory adjustment mechanism requires knowledge of how people use the forest and how they migrate in response to changes in income. Empirically, we must estimate incomes from various sources in both the buffer zone and the protected area, and characterise the factors which cause individuals to migrate into and out of the buffer zone. In the empirical studies contained in the following sections, I shall be investigating a number of fairly specific hypotheses relating to migration and income. Individual household data are analysed for a specific national park initiative in an LDC, with the ultimate goal of identifying appropriate policy reforms which will be consistent both with the rural development goals in a buffer zone and the conservation goals of the protected area. In particular, I shall be concerned with the following:

a) measuring total household incomes, by source;
b) characterising income distribution and inequality, decomposed by source;
c) exploring the relationship between income and education levels;
d) describing migratory behaviour;
e) analysing the linkage between migration decisions and income levels; and,
f) analysing the linkages between migration decisions and other characteristics relating to the individual.

Total household incomes will provide estimates of $\theta$ and Y for various regions, which are relevant in determining whether Condition (5.4b) holds. Issues relating to migratory adjustment are important primarily in determining whether $\partial M_{ij}/\partial Y_i>0$ is true, but also to test whether such factors as age, sex, or education are important in describing migratory flows. Finally, from the income data, income distribution and inequality can be characterised to gain some insights into what sorts of policies might actually improve income distribution in the buffer zone. The goal is ultimately to provide some idea of what types of development incentives are likely to promote conservation, improve incomes, and reduce income inequality.

In the empirical work which follows, there are three points which merit highlighting. First, while many studies of incomes in developing countries concentrate on wage income or income from cash crops, the empirical work here attempts to capture all sources of income to a household. The purpose of this is to determine what the contribution is of traditional forest-based hunter-gatherer activities to total incomes.

Second, with respect to migration, I shall concentrate on the individual migration event rather than on the mass migratory flows between regions. While this requires a fine level of detailed information on both individual and household characteristics for many individuals, the approach relies on data which can be gathered using household surveys in developing countries. This avoids relying on aggregated regional migration data, which – although readily available in developed economies – are normally not available or are unreliable in LDCs. Also, this approach allows explicit investigation of a number of the linkages between education and income. While these linkages may be of only limited relevance to conservation objectives, they are of considerable importance in most developing countries and – as the household survey provides the opportunity to investigate such linkages – some supplementary analysis is pursued to take advantage of these data.

Finally, the third point that I wish to demonstrate is that household surveys which are undertaken in association with socio-economic impact studies for rainforest conservation projects can – if analysed carefully – provide useful information about incomes and migration which will assist in selecting appropriate policies.

## § 5.3 Korup National Park: A Case Study[6]

The management plan for Korup National Park (WWF-UK [1987]) called for three potential areas of development and income support:

a) new agricultural initiatives;
b) support for existing agricultural initiatives; and,
c) intensification and support of sustainable forest gathering initiatives.

First, the promotion of new agricultural initiatives is intended to be primarily a long-term development initiative to improve agronomic standards and incomes in the region. It concentrates on agroforestry techniques which are appropriate to the area (Newman [1987]; Djimde and Raintree [1988]) and forestry practices (Synnott [1988]). Second, support for existing agricultural initiatives was meant to concentrate on a price support scheme for cash-crop farming of cocoa and coffee. This was identified primarily because farmers often complained of difficulty in getting these crops to market and receiving fair and timely payments upon delivery. Also, such schemes would be relatively quick and easy to administer through existing marketing boards and cooperatives. Finally, support for forest product production centred on improving marketing structures and 'farm-gate' prices for natural products gathered from the forest and for goods manufactured from forest products. This alternative was again thought to be important as it did not require the introduction of

[6] Further background to the Korup National Park project and to the survey work conducted to generate the data used in this and the following chapter is provided in the Appendix.

new techniques and could fulfil short-term income and development needs.

In this chapter, we concentrate primarily on whether income support for the latter two programmes will indeed support conservation and development goals. While the first programme – the introduction of new agricultural techniques – has interesting attributes as well, we are concerned for the moment in promoting initiatives which will be effective over a five to ten year time horizon, as this is the critical period for the conservation objectives.[7] Appropriately, the specific problems being addressed for Korup National Park are the following:

Q1. Will increasing incomes in the buffer zone reduce pressures on the core area through inducing voluntary resettlement or migration?

Q2. Will increasing incomes in the buffer zone provide effective alternatives to individuals who would otherwise hunt in the protected area?

In answering these questions, I shall be characterising incomes in and around the park area and shall try to describe those factors which actually cause individuals to migrate. Chapter 6 specifically investigates problem Q2.

In addition, the data will allow us to investigate the following question:

Q3. What type of income support strategy (cash crops or traditional harvesting) is more likely to improve income distribution in the region?

While income distribution is not normally regarded as a conservation concern, Chapter 4 first raised the issue in recognising that such issues might explicitly enter into the rainforest supply price for any project. The basic idea is that – if the LDC government has some adversion to income inequality – then income support which benefits low income groups would have a lower net social cost than the same level of income support for higher income groups. If the strategies have equal effects on conservation, then the best strategy from the point of view of the rest of the world (assuming it is interested only in conservation) is to target the low income group; that strategy would generate the lower RSP and the level of transfers required to compensate the LDC for instituting such reforms would be commensurately lower.

[7] This is primarily because of the very immediate pressures of hunting. It is anticipated that, if such pressures are not reduced, within ten years many of the animals would be lost and hunting itself would have become a marginal enterprise for individuals. In a sense, therefore, the programmes might be seen as inducing circumstances which would have occurred naturally in any event in ten years time. We note as well, however, that, in some regions or countries, new agricultural techniques could become well established within this time frame. The "Green Revolution", for example, is at times characterised as such an occurrence. In this area, however, the major agricultural improvements are believed to involve agroforestry techniques. Because of the relatively slow growth of tree crops, it would take five to ten years simply to demonstrate the technical and economic feasibility of such improvements in this setting, and their widespread adoption would take commensurately longer.

As a conservation goal, we are interested primarily in reducing hunting and, as such, there are only a limited number of feasible policies available to do this. Because many of the non-labour inputs (guns, cartridges, and carbide) as well as the final products (bushmeat) are smuggled from or to Nigeria, taxation of inputs or outputs is ineffective. For the same reason, subsidising substitute protein sources (chicken or livestock) is not feasible as most of the consumption is in Nigeria. Forced resettlement with compensation is technically feasible but currently politically unviable.[8] This leaves direct control of hunting – through anti-poaching controls – as the only remaining direct alternative. Such control requires the availability of trained game guards willing and able to police the forest estate. In the case of Korup, those best qualified for this task are those currently active in hunting and – normally – they are hesitant to enlist in an activity which would involve policing their family and friends. Training outsiders can be expensive and – as witnessed by a recent murder of a game guard in Korup – outsiders face other risks and deterrents for which they must be compensated. Hence, while some degree of regulation will be instituted, the most attractive and apparently feasible alternative is to use economic incentives to induce individuals to migrate and to undertake activities other than hunting.

In summary, the particular short-term problem of promoting conservation is quite tractable here because there is only one major pressure which is regarded as unsustainable. The potential externalities arising from this pressure are easily defined: there is a potential positive externality from hunting those animals which might otherwise destroy crops, and there is also a positive externality from not hunting for which outsiders are willing to pay. The other externalities often considered for rainforests – including in this case the maintenance of mangrove fisheries and various environmental functions – are more closely associated with the immediate integrity of the forest estate rather than the animal biomass.[9] Furthermore, migration into the region is apparently restricted by cultural traditions, hence we can concentrate on modelling emigration decisions without distorting our picture of migratory adjustment. Finally, the number of feasible policy alternatives for limiting hunting is relatively small, and the use of some form of development incentive in a buffer zone appears at the outset to hold promise. But, as noted in the preceding section, the actual success of such development incentives in promoting rainforest conservation is not a

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[8] In addition, however, there is some question whether this would indeed be effective. One might argue that at present the forest is being treated as a common property resource by those currently in it, with exploitation rights informally allocated to those resident in or near the forest. If the area were depopulated, then any traditional patterns of land tenure would disappear and essentially an open access condition would prevail. For example, whereas traditional hunting areas exist and are respected by outsiders, such areas would disappear and the area would be open to increased hunting pressures. Hence, while the original inhabitants might be resettled and compensated, others might enter the forest estate to continue where those which had been resettled left off.

[9] It can, of course, be asserted – as it was in Chapter 2 – that degradation of the animal biomass will eventually lead to degradation of the forest estate. As there is no manner of formally modelling this, however, study of this is beyond the scope of this thesis.

foregone conclusion, and hence empirical work is useful to define the behavioural responses which will occur.

In support of the empirical work, data were analysed from 357 households in the Korup National Park protected area and buffer zone. A complete description of the survey and data reduction process is provided in the Appendix, along with summaries of the data. There are a total of 30 settlements which are found within a 3 kilometre wide buffer zone around Korup National Park. Of these villages, 24 were surveyed in the demographic and income survey. As indicated in the following table, this represented all of the villages in the Park and the Western Buffer Zone (WBZ), and 12 of the 18 villages in the Eastern Buffer Zone (EBZ).

| Region | Villages in Region | Villages Surveyed |
|---|---|---|
| Western Buffer Zone | 6 | 6 |
| Korup National Park | 6 | 6 |
| Eastern Buffer Zone | 18 | 12 |

Referring back to Figure 1.2, the WBZ was defined for analytical purposes to include those villages in the strip of forest reserve between the northern part of Korup National Park and the Nigerian border, and the EBZ included the area to the east and south of the park. The target population within all 24 villages consisted of 379 households, although demographic data were obtainable for only 357 (94%) of the households, and income data were analysed for 341 (90%) of the households.

A sample of the survey form is provided in Appendix Figure A.1. Data were collected in the following areas for each household:

a) demographic data on each individual in the household (age, sex, schooling);
b) migratory status of each individual ;
c) food crops grown;
d) farming problems; and,
e) annual income by source.

Demographic data included all of those individuals normally present as well as those who were 'normally' absent and had left in the previous 5 year period.[10] In specifying the "migratory status" of each individual, they were eventually categorised as either: present, absent at school, absent at work, or absent not-specified. If they were absent, information was obtained regarding their whereabouts. No data were collected on consumer durables or major assets.

[10] The five year period was an informal guideline and – no doubt – some individuals were missed and others were noted as having migrated when in fact they had been gone for more than five years.

Table 5.2
Population of Households Surveyed, 1988

| | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Total Households | 129 | 115 | 113 | 357 |
| Total Population | 997 | 806 | 915 | 2,718 |
| - Present | 662 | 740 | 761 | 2,163 |
| - Absent (at School) | 81 | 25 | 42 | 148 |
| - Absent (at Work) | 209 | 37 | 83 | 329 |
| - Absent (not Specified) | 45 | 4 | 29 | 78 |

## § 5.4 Empirical Evidence: Income in Korup

### 5.4.1 Population Summary

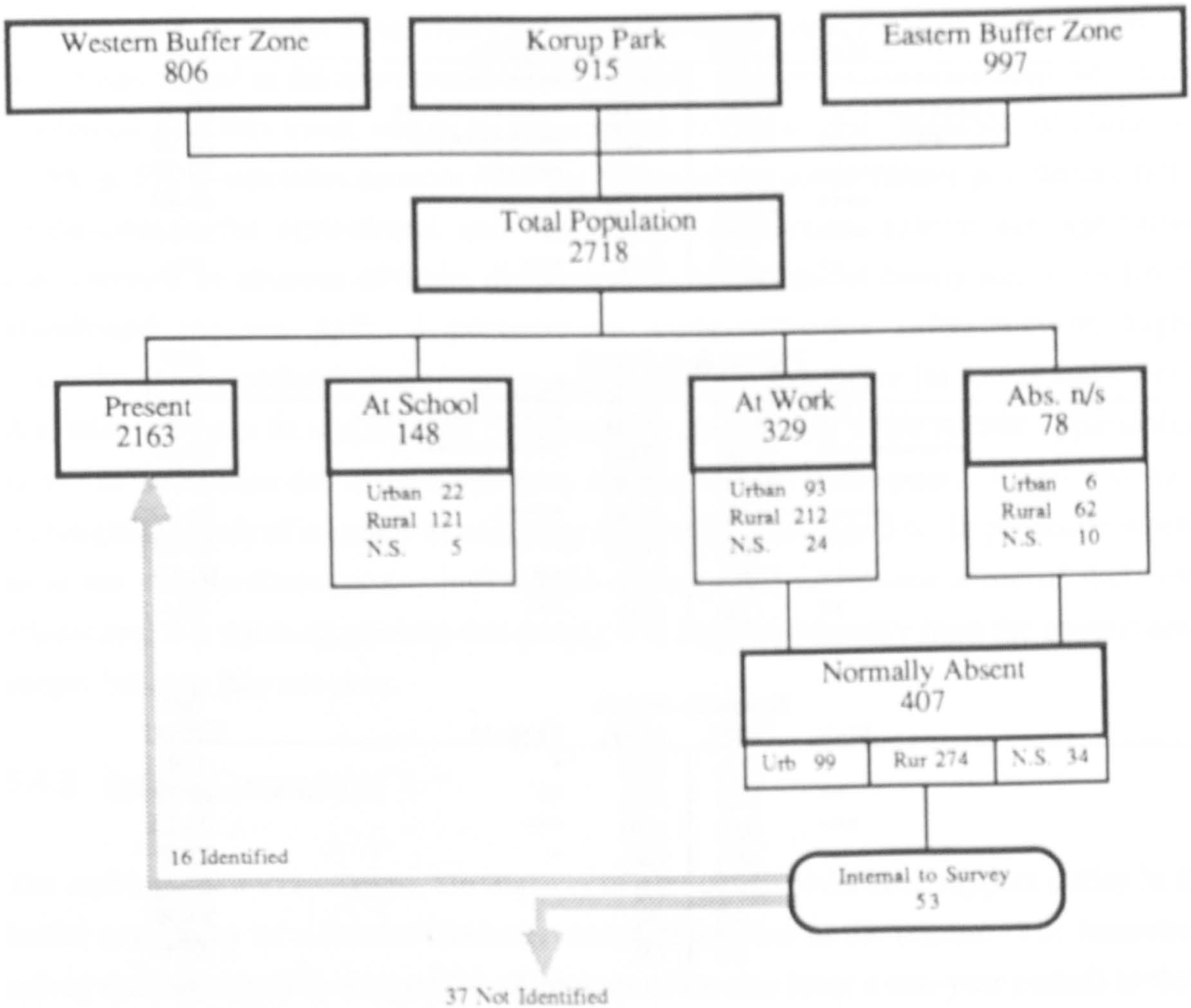
A detailed breakdown of population statistics is provided in Appendix Tables A.2 to A.5. Summaries of these are presented in Figures 5.1 and 5.2, and in Table 5.2.

Figure 5.1 and Table 5.2 indicate that the total survey population is 2,718 individuals, of which 407 were normally absent due to work or other reasons. The remaining population of 2,311 individuals were actually present or away at school. Per capita income figures presented later are based on this subset of 2,311 individuals as it is assumed that those normally absent will have their own sources of income or means of support. Income statistics obtained from this survey included income accruing only to those actually present, and children away at school were treated as part of those 'normally present' in the household as they would normally be supported by their home family.

Figure 5.2 provides a summary of the population structure of those normally present or at school by sex and age cohort. Two results are of particular note here, especially as they relate to work being carried out in subsequent sections of this chapter. First, over one-half of the population in the survey area is under twenty years of age. This trend is little different from that found in the rest of Cameroon,[11] and is responsible for the increasing budgetary requirements of education in Cameroon. In meeting these requirements, the government relies heavily on private schools and – in some parts of the country – enrollment in private schools represents 85% of total attendance. For the country as a

[11] The 0-19 year age group was estimated to represent 54.7% of the total population of Cameroon in 1986 (Republic of Cameroon [1986]).

Figure 5.1
Summary of Survey Population




**Households**

| | |
|---|---|
| Total Households in Villages | 379 |
| Total Households Surveyed - Demographics | 357 |
| Total Households Surveyed - Income | 343 |
| Total Households Analysed - Income | 341 |

Figure 5.2
Survey Population Age Structure

Total Survey

| Male | (1359) | (1359) | Female | Age Cohort |
|---|---|---|---|---|
| •••••••••••••••• | (392) | (400) | •••••••••••••••• | 0-9 |
| •••••••••••• | (309) | (300) | •••••••••••• | 10-19 |
| ••••••••• | (237) | (269) | ••••••••••• | 20-29 |
| ••••••• | (163) | (154) | •••••• | 30-39 |
| •••• | (106) | (112) | •••• | 40-49 |
| •••• | (95) | (58) | •• | 50-59 |
| •• | (57) | (66) | ••• | 60+ |

Present & at School

| Male | (1151) | (1160) | Female | Age Cohort |
|---|---|---|---|---|
| ••••••••••••••• | (369) | (377) | ••••••••••••••• | 0-9 |
| ••••••••••• | (268) | (244) | •••••••••• | 10-19 |
| ••••••• | (168) | (190) | •••••••• | 20-29 |
| ••••• | (116) | (128) | ••••• | 30-39 |
| ••• | (87) | (103) | •••• | 40-49 |
| •••• | (89) | (55) | •• | 50-59 |
| •• | (54) | (63) | ••• | 60+ |

Normally Absent

| Male | (208) | (199) | Female | Age Cohort |
|---|---|---|---|---|
| • | (23) | (23) | • | 0-9 |
| •• | (41) | (56) | •• | 10-19 |
| ••• | (69) | (79) | ••• | 20-29 |
| •• | (47) | (26) | • | 30-39 |
| • | (19) | (9) | | 40-49 |
| | (6) | (3) | | 50-59 |
| | (3) | (3) | | 60+ |

Note: • represents 25 individuals

whole in 1986 about one-half of total enrollment was in private schools, both at the primary and secondary level. (Republic of Cameroon [1986]) The government currently has an explicit policy which requires families to finance much, if not all, of the current expenses for education. This policy is intended both to assist in financing education in the country as well as creating a disincentive to traditionally high birth rates. As censuses have been only sporadic in Cameroon, it is impossible to determine from the historical data whether this policy has been effective in curbing birth rates but, at present, Cameroon is estimated to have among the lowest birth rates in Africa.[12] A potential criticism of the policy, however, is that it makes even a basic education a privilege of wealth. Whether or not this criticism is valid in the current survey sample is investigated further in Section 5.5.

A second notable attribute of the population structure is that – of those normally absent –

[12] At an estimated crude birth rate of 42.5 births per thousand population, it ranks twelfth lowest in 49 countries in Africa (World Resources Institute [1987]).

more than 36% are from the 20 to 29 year age cohort, even though this age group represents only 18% of the total population. This is also consistent with trends in the rest of the country: migration away from rural areas has been concentrated disproportionately in what many regard as the most productive age group. Cameroon government policy is also concerned with this trend, and in its most recent five-year plan (Republic of Cameroon [1986; p. 5]), it expresses concern over the "aging of the active farmer population, fall in production in the agricultural and stock-breeding sectors, subsistence agriculture characterised by absence of trade, disintegration of traditional family structures [in the abandoned regions, and ...] pressure on socio-economic infrastructure, higher unemployment, mushrooming of slums, and juvenile delinquency [in towns and cities]." A similar story can be told in many developing countries, and, while income opportunities in towns and cities are often cited as a magnet for the rural poor, I will test more thoroughly the role of incomes in migratory behaviour in Section 5.6. In particular when – as is the case in Cameroon – individuals are required to finance some of their own educations, it is not at all obvious that people will migrate primarily from the poorest areas simply because they are poor.

### 5.4.2 Income Composition

The starting point to analysing the impacts of any potential income support policy in the buffer zone must be a careful characterisation of income in the region. The household survey thus attempted to account for all sources of income (over a one-year period) to those normally present in the household. Two types of questions were asked in relation to income. The first was simply "what was the total household income in the previous year?" Most respondents had difficulty in answering this question and, of a minority who did answer, the reported figures normally were about two-thirds of the total income deduced from the second set of questions. This second set concentrated on a fairly fine disaggregation by income source, and most respondents were readily able to provide estimates of individual income sources when it was appropriately disaggregated. The major difficulty which was at times encountered then related to estimating incomes over a full one-year period. Fortunately, both the major cash crops (cocoa and coffee) and the major gathered crop (bush mango) have distinct harvesting seasons and respondents were able to remember incomes from their most recent harvest. Activities which were undertaken on a more regular basis (such as trading) were at times estimated during the interview on a monthly basis and multiplied by the respondent's estimate of how many months the activity took place. It should be noted that most activities were at least to some degree seasonal, as travel for the purpose of trading, hunting, or gathering can become particularly difficult during the rainy season from June to August.

Table 5.3
Per Capita Income Composition by Source
(CFAF/Year)

| | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Total Households | 125 | 113 | 103 | 341 |
| 'Present' Population | 721 | 753 | 759 | 2,233 |
| Households with No Income* | 4 | 10 | 1 | 15 |

| Income Source | EBZ | WBZ | KNP | Total | |
|---|---|---|---|---|---|
| All Income Sources | 67,894 | 46,467 | 63,708 | 59,246 | (100.0%) |
| Cash Crops | 40,428 | 9,139 | 12,226 | 20,291 | (34.2%) |
| - Cocoa | 30,607 | 3,707 | 8,555 | 14,040 | (23.7%) |
| - Coffee | 9,215 | 31 | 1,543 | 3,510 | (5.9%) |
| - Other | 605 | 5,400 | 2,128 | 2,740 | (4.6%) |
| Livestock | 822 | 471 | 1,100 | 798 | (1.3%) |
| Hunting | 5,732 | 3,526 | 11,911 | 7,088 | (12.0%) |
| Trapping | 2,884 | 6,148 | 8,002 | 5,724 | ( 9.7%) |
| Fishing | 2,860 | 3,138 | 2,747 | 2,915 | (4.9%) |
| Trading | 2,550 | 2,865 | 4,011 | 3,153 | (5.3%) |
| Forest Products | 10,853 | 21,131 | 20,055 | 17,447 | (29.4%) |
| Remittances | 1,765 | 48 | 3,656 | 1,828 | (3.1%) |

* See Table A.10 for descriptions of the circumstances of those households with no cash incomes.

The following discussion of incomes is primarily descriptive. The collection of data relating to the input requirements for all of the activities was beyond the scope of the household survey, and hence one can not draw any explicit conclusions regarding the production functions of the various activities or the nature of the production process. An exception to this arises with hunting, which is analysed more rigourously in Chapter 6. Nonetheless, when supplemented with knowledge gained about the various income sources, a number of interesting observations can be made from even the descriptive data provided by the household survey. Appropriately, the following discussion highlights a number of results relating to:

a) per capita income levels;
b) income sources from conventional market activities;
c) income sources from traditional hunting and gathering activities; and,
d) income levels inside and outside the National Park.

The summary results provided in Tables 5.3 and 5.4 provide the basis for these discussions, and additional data regarding participation in each of the activities are provided in Appendix Table A.9.

The mean per capita income in the sample was just under 60,000 CFAF per year from all sources.[13] When based on an economically active population of age groups of 15 to 54 years of age – comprising 49% of the population – this translates to average earnings per active individual of about 120,000 CFAF per year. Although earnings figures are not available for Cameroon as a whole, income in this region is comparable to that which would be paid to individuals in cities and towns for jobs requiring modest skill levels. Based on employment ministry figures, an unskilled Cameroonian worker could expect to earn at most 74,000 CFAF per year, and a semi-skilled worker could expect to earn 101,000 - 170,000 CFAF per year.[14] On the basis of wages alone, therefore, earnings in the survey area do not appear to be overly depressed when compared to wages in the formal sector. There are, of course, additional benefits available in the formal sector – such as pensions and higher levels of services in the towns and cities – but most households in the survey group are self-sufficient from their own farming, hunting and gathering activities. There is, of course, a fairly wide distribution of income within the survey, and this aspect is addressed in further detail later in Section 5.4.3.

[13] The CFA Franc (CFAF) is essentially a hard currency as it is pegged and convertible freely to the French Franc (FF) at a fixed rate of 50 CFAF per FF. At the time of conducting the survey, the exchange rate to £ Sterling was approximately 500 CFAF/£.

[14] These are based on public sector pay categories. On a scale comprising 12 categories, unskilled is defined as Categories 01-06, and semi-skilled is defined as categories 07-09. Unskilled labour comprises 58% of the public sector work force. Highly skilled Category 12 jobs can pay up to 450,000 CFAF annually, but only 23% of these positions are filled by Cameroonians. The public sector represents about 43% of total formal employment, and wages in the private and public sectors are comparable for unskilled labour. (Republic of Cameroon [1986; pp. 276-7])

Table 5.4
Per Capita Income from Forest Product Gathering and Manufacturing
(CFAF/Year)

| | EBZ | WBZ | KNP | Total | |
|---|---|---|---|---|---|
| Total Households | 125 | 113 | 103 | 341 | |
| 'Present' Population | 721 | 753 | 759 | 2,233 | |
| Income Source | EBZ | WBZ | KNP | Total | |
| Total Forest Products | 10,853 | 21,131 | 20,055 | 17,447 | (100.0%) |
| Gathered Products | 8,333 | 13,592 | 15,512 | 12,547 | (71.9%) |
| - Timber | 2,080 | 1,859 | 72 | 1,323 | (7.6%) |
| - Bush Mango | 3,713 | 8,194 | 9,808 | 7,296 | (41.8%) |
| - Njangsang | 2,187 | 1,745 | 3,648 | 2,534 | (14.5%) |
| - Njabe | 117 | 762 | 573 | 490 | (2.8%) |
| - Shell Nut | 94 | 753 | 608 | 491 | (2.8%) |
| - Wild Onion | 0 | 0 | 229 | 78 | (0.4%) |
| - Pepe | 14 | 7 | 346 | 124 | (0.7%) |
| - Kola Nut | 73 | 0 | 66 | 46 | (0.3%) |
| - Miscellaneous | 55 | 272 | 162 | 165 | (0.9%) |
| Manufactured Products | 2,521 | 7,540 | 4,542 | 4,900 | (28.1%) |
| - Cane Rope | 0 | 635 | 0 | 214 | (1.2%) |
| - Woven Bags | 251 | 43 | 164 | 151 | (0.9%) |
| - Fish Nets/Baskets | 36 | 165 | 88 | 97 | (0.6%) |
| - Mats | 346 | 96 | 632 | 359 | (2.1%) |
| - Furniture | 0 | 133 | 175 | 104 | (0.6%) |
| - Building | 21 | 504 | 0 | 177 | (1.0%) |
| - Afofo or Wine | 1,839 | 4,990 | 2,561 | 3,147 | (18.0%) |
| - Canoes | 0 | 963 | 0 | 325 | (1.9%) |
| - Palm Oil | 28 | 11 | 922 | 326 | (1.9%) |

The economic development literature relating to urban-rural income differentials often tends to concentrate on wage levels in the two areas and, indeed, most of the frameworks which try to explain migratory adjustment tend to concentrate on wage rate differentials. Where the nature of rural labour markets is such that most income is not from wage contracts – as is the case here – it is necessary to characterise incomes from the various income sources. Because of information constraints, estimates are often made based on what I shall term 'conventional' market activities. These include the net proceeds from cash crops (including surplus food crops), livestock, trading activities, and remittances from wage income or other family members. In the context of this study, such an approach would grossly underestimate the earnings in this region, as such 'conventional' sources generate only 44% of the total income. The remaining 56% of the income is generated by 'traditional' activities which include hunting, trapping, fishing and the gathering and manufacture of forest-based products. Without this traditional income it might appear that substantial income differentials exist between this rural area and the formal sector. As noted earlier, however, when all sources are included the average income levels are comparable.

It is clear from Table 5.3, however, that cash crops do provide an important source of income in the area. While most of the per capita income of 20,000 CFAF per year is attributable to cocoa production, coffee and other crops also play an important role. These other crops include primarily oil palm but – in the WBZ – much of the additional cash crop income comes from the sale of surplus food crops. Most of it is in the form of garri – a staple of partially fermented and processed cassava – and it is sold locally to feed Nigerian traders travelling through the area. Cocoa is produced throughout the region but it is most significant in the EBZ. This is partially because of growing conditions but also partially because of access: all of the cocoa grown in the region must be head-loaded to a road and terrain conditions mean that the WBZ is the most isolated and the EBZ has the best access. It is notable that there is very little coffee production in the WBZ. This is not so much due to its isolation as it is attributable to the growing conditions: because of soil, terrain, and climate, coffee production becomes technically more difficult as one proceeds east to west through the region and, across the border in Nigeria, no coffee is grown at all whereas cocoa is still produced. It is equally notable that cash crops continue to play an important role even in the primary rainforest. Although wild oil palm can be harvested directly, villagers will normally clear areas in the rainforest to grow coffee or cocoa.

Although livestock is kept by almost one-half of the households, it represents only a small income source in the region: less than 1,000 CFAF per capita annually. Cattle are not raised in the area, and goats and pigs have been banned in most villages because of their tendency to destroy crops. The goats and pigs which are kept are restricted to those which would be slaughtered for special village ceremonies or feasts. The livestock income which is received thus comes almost entirely from poultry farming. Many households keep chickens and they are a regular source of food protein when bushmeat or fish are unavailable.

Trading represents a source of income for one-half of the households surveyed, but on average contributes only about 3,000 CFAF per capita to annual income. Trading is fairly common primarily because of the relative isolation of some of the villages. Individuals leaving with cash crops, bushmeat or gathered products for sale in the regional markets will often return with quantities of cigarettes, dry goods, alcohol, or kerosene for trading in their own villages or villages on route.

An important characteristic of the region is that few people receive cash income from jobs. The category of 'remittances' in the survey included remittances from family members who had left the household, wage income, as well as direct cash grants to some individuals from churches. Even under this definition, only 28 households had income from this source, and on average the remittances represented less than 2,000 CFAF per capita annually. The small amount of wage income earned reflects, to a significant degree, the free availability of land and the tendency to use household labour to conduct most of the farming activities. Women and children typically tend the food crops, gather forest products, fish and do routine weeding of cocoa and coffee crops. All family members are most active on the farms during the cocoa and coffee harvesting periods, and some of the larger farms do hire labour for a four to six week period at this time. In those cases, however, the labour applied is usually transient labour from outside of the village: most villagers will be busy with their own crops and, in any event, the surveyor's were often told that there was a stigma attached in the Korup villages to being in another's employ. While this might cause a downward bias in the responses, the general nature of land tenure and the labour market in the area seemed to confirm the relatively low income from this source.

In addition to contributing to subsistence requirements, traditional activities continue to play an important role in providing cash income to the region. For the entire survey as a whole, these activities account for over one-half of the cash income.

Income from hunting and trapping represents a per capita income of almost 13,000 CFAF annually in the entire region. Inside the park it accounts for almost 20,000 CFAF per capita. Hunting is conducted exclusively by adult males, although young boys often join hunting parties for fun or – on longer expeditions – to take the bushmeat (or simply 'bif' in the local pidgin) away to be sold. Hunting is typically conducted using shotguns, dogs and lights. Carbide lights are used to dazzle the prey to allow hunters a few clear shots, and dogs are used to chase monkeys and drills into the trees both to allow the hunters clear shots as well as allowing them to shoot upwards (thus decreasing the risk of injuring fellow hunters). Hunting parties often venture into the bush for two or three weeks at a time, living in 'bush huts' or in the open, and eating the organs of their prey as well as root crops which are either carried with them or grown in proximity to the bush huts. The most common prey are monkeys, drill, and duiker. Larger mammals – buffalo, elephant, and chimpanzees – are also found in the forest, but they are seldom captured as most hunters do not have the required fire power. Most hunters will claim that they hunt primarily for cash income, but also for meeting household food requirements, keeping animal pests away from farms, and because it is a traditional pursuit which increases an individual's stature within the village.

Trapping is conducted as quite a separate exercise from hunting, and is often concentrated closer to the villages as a means to protect crops and provide bushmeat. Snares, deadfalls, and occasional leghold traps are set and are checked regularly by younger members of the family. The most common animals trapped are porcupines, rat moles and the African grasscutter – all common pests. Monkeys, duiker, snakes and crocodiles are also caught on occasion in these traps.

Although in rare circumstances captured prey can be sold as stock for foreign zoos, most of the hunted and trapped products find their way to the cooking pot either locally or – more often – to a booming bushmeat market in Nigeria. From informal discussions with hunters in Cameroon and with buyers in Cross River State in Nigeria, it was estimated that as much as 90% of the bushmeat caught in Cameroon was sold in Nigeria. There is a definite local preference in taste for bushmeat, over cattle, chicken or small ruminants, and bushmeat commands somewhat higher prices than its substitutes (Malleson [1987]). Bushmeat is typically dried for transport and storage, and chopped into bits and cooked as a hot stew which has been spiced with 'bush pepe' (a peppery forest spice derived from the leaves and seeds of *Piper guineensis*, a forest climber) and thickened with dried 'bush mango' (a local forest fruit). This mixture is then eaten with garri, cocoyams, plantains, or bananas.

While bushmeat captured through both hunting and trapping is most pronounced in the forested zones of the park and the WBZ, it is notable that it also contributes substantially (12.7%) to incomes in the EBZ. This is consistent with accounts that hunting parties from some of the villages outside of the park have traditional hunting rights in areas which extend well into the park and, indeed, right to the Nigerian border.

Fishing is a traditional activity undertaken almost exclusively by the women. It provides an important staple as well as contributing about 3,000 CFAF annually to per capita income in all parts of the survey area. Fish are normally caught with nets, dried after being caught, and sold locally for consumption in stews as an alternative to bushmeat.

The most significant source of income from traditional activities is associated with the gathering of forest products and the manufacture of goods derived from forest products. In the entire survey, these sources contributed more than 17,000 CFAF per capita annually to income, comparable to that provided by cocoa and coffee cash crops together. In addition, 84% of the households were involved in some way with gathering forest products, and 59% of households surveyed were involved in manufacturing goods from forest products. Table 5.4 highlights the types of goods involved.

The survey asked respondents what types of forest products were harvested and how much they would earn from each product. Of the gathered products, all of those gathered for sale (with the exception of timber) were fruits or bark used for consumption either in cooked foods or – as with the kola nut – as a stimulant eaten separately. Medicinal plants were not usually gathered for sale as these were normally gathered and used exclusively by the village healers. The one exception to this was 'chewing stick' (*Garcinia menii*) which is used widely for dental hygiene. Because all of the gathered products are readily available, they were not usually sold to fellow villagers but rather were 'exported' or were sold in small quantities to transient travellers (usually Nigerian traders). Such exports concentrated on bush mango (*Irvingia Gabonensis*) and Njangsang (*Ricinodendron heudelotii*). Bush mango is processed by drying and is sold as a base and thickener for soups or stews. Seeds from the Njangsang are ground up and used as a flavouring in soups. It should be noted that, with the exception of the timber gathering, all of these forest products were gathered almost exclusively by women and children.

Goods manufactured from forest products included any commodity which required some amount of processing beyond simple preservation mechanisms commonly undertaken for fruits and spices. It ranged from fairly simple tasks: such as weaving raffia fronds for bags or sleeping mats, to highly skilled crafts such as canoe building. While many such small-scale 'industries' were important in a few households, the most common – it was done in 38% of the households surveyed – was the production of palm wine or distillates. It contributed about 3,000 CFAF per capita to annual income and – as with the gathered products – most was sold outside of the village or to traders visiting the village. It was also commonly expected that any visitor – including the interviewers – purchase a few bottles locally as a gift to the village chief.

Finally, it is appropriate to make a few comments on the aggregate income levels inside and outside the primary forest zone. First, it can not be said from the data that those inside the forest are generally any better or worse off than those outside – from the point of view of incomes. Although in the EBZ substantially more is made from cash crops, hunting and gathering activities in the forest zone of the park apparently compensate for the lower cash crop incomes. An exception to this is the area I have designated as the WBZ. Incomes here are about 70% those in the rest of the region: hunting, cash crop, trading and remittance incomes here are less than those in villages not far away in the KNP area.

Before continuing with a discussion of the income distribution in the region, a few comments regarding the reliability of responses are in order. In any household survey, it is always appropriate to question what precautions were taken to ensure that the responses actually reflected facts. First, this was the third survey undertaken in the region and most households were aware of the project and had previously met someone associated with it. Interviewers had gained the confidence of villagers on previous visits and – when accompanied by an interpreter – generally had a good rapport with survey respondents. Second, a major concern arose from the questions dealing with hunting and trapping activities. Technically, these activities are illegal in the park and – outside the park – hunters are required to have permits for their guns although few actually had such permits. One might have expected therefore that responses related to these activities were conservative. In spite of regulations, however, most people think that they are 'exempt' because they have traditional rights and – in any event – none of the regulations had been enforced. As a result, individuals did not generally hesitate in providing answers to these questions. In addition, Infield (1988) spent seven months accompanying hunters on their hunting parties and – although no explicit attempt was made to reconcile his observations with those in this survey – he noted that hunting regulations were not enforced and that responses from interviews which he had with hunters were generally consistent with observations made on trips.

### 5.4.3 Income Distribution

Although one of the primary goals of development incentives is to improve income levels in the buffer zone, a supplementary goal was to improve income equality in the area. As noted by Warford (1987), natural resource management strategies often include some provision for trying to improve the lot of those which are the worst off and – in the case of Korup National Park – the particular question has arisen as to whether giving income support to those growing conventional cash crops such as coffee and cocoa would be any more or less regressive than giving similar support to forest gathering enterprises. In this section I present results relating to the current income distribution in the region, and provide a suggestion for the answer to this question. Two basic approaches are used: the first simply uses descriptive statistics relating to population means and variances to determine if any generalisations can be made regarding income distribution by *region*; the second uses conventional indices of inequality to highlight income inequality in the entire sample and to describe how different *sources* of income contribute to or mitigate income inequality.

First, Table 5.5 provides a summary of the statistics relating to population and income distribution. The mean ($\mu_i$) and standard deviation ($s_i$) are provided for the sample by survey block as well as for the sample as a whole. A coefficient of variation ($s_i/\mu_i$) is calculated to provide a summary statistic of the variation in incomes in each region. As noted, there is a large distribution of incomes in all parts of the region: some households

Table 5.5
Population and Income Statistics (341 Households)

| | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Total Households | 125 | 113 | 103 | 341 |
| 'Present' Population | 721 | 753 | 759 | 2,233 |
| Household Size (individuals per household) | | | | |
| Mean | 5.77 | 6.66 | 7.37 | 6.55 |
| Standard Deviation | 3.68 | 4.12 | 3.98 | 3.97 |
| Coefficient of Variation | 0.638 | 0.619 | 0.540 | 0.606 |
| Minimum | 1 | 1 | 1 | 1 |
| Median | 5 | 6 | 7 | 6 |
| Maximum | 20 | 20 | 25 | 25 |
| Per Household Income (CFAF/yr) | | | | |
| Mean | 391,611 | 309,645 | 469,460 | 387,964 |
| Standard Deviation | 609,951 | 556,221 | 751,618 | 641,197 |
| Coefficient of Variation | 1.558 | 1.796 | 1.601 | 1.653 |
| Minimum | 0 | 0 | 0 | 0 |
| Median | 150,576 | 108,400 | 188,002 | 150,576 |
| Maximum | 3,609,875 | 4,074,000 | 4,347,200 | 4,347,200 |
| Per Capita Income (CFAF/yr) | | | | |
| Mean | 67,894 | 46,467 | 63,708 | 59,246 |
| Standard Deviation | 112,231 | 80,244 | 87,469 | 94,429 |
| Coefficient of Variation | 1.653 | 1.727 | 1.373 | 1.593 |
| Minimum | 0 | 0 | 0 | 0 |
| Median | 31,871 | 20,173 | 38,122 | 27,001 |
| Maximum | 902,469 | 679,000 | 869,440 | 902,469 |

have no cash income whereas the maximum incomes exceed 4 million CFAF. The per capita income statistics are derived based on the number of individuals in each household and, as such, the standard deviations should not be used for calculating any significance statistics,[15] but the data again illustrate the substantial variation in per capita incomes. It is also clear from these data that the large income earners are distributed such that the median household (and per capita) incomes are substantially less than the means. For example, although the mean per capita income for the entire survey is almost 60,000 CFAF, one-half of the individuals have an income of less than 27,000 CFAF.

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[15] For example, the means and standard deviations for any sample assumed that there were $n_i$ observations at $y_i$ for any given household, where $n_i$ is the population of household i and $y_i$ is the calculated per capita income for household i ($y_i=Y_i/n_i$, where $Y_i$ is the household income). This ensured that the means were consistent with per capita summaries for each region as a whole.

The statistics expressed in this manner also allow us to test explicitly – using simple F-tests and t-tests – whether the per capita income distributions are the same across the survey regions. The t-test presumes, however, that the underlying variances behind the distributions are equal, and we must therefore first test whether these are indeed equal. Consider two samples having means $\mu_i$ and $\mu_j$, standard deviations $s_i$ and $s_j$, and observations $n_i$ and $n_j$, with the sub-samples chosen such that $s_i > s_j$. On the hypothesis that the population variances are the same, the statistic $F^{ij} = s_i^2/s_j^2$ is distributed as $F_{n_i-1;n_j-1}$ .

On the hypothesis that the population means are the same (presuming that the variances are the same), the statistic $t^{ij} = (\mu_i - \mu_j)/S_{ij}$ is distributed as t with $n_i+n_j-2$ degrees of freedom, where:

$$S_{ij}^2 = \left(\frac{1}{n_i} + \frac{1}{n_j}\right) \times \left(\frac{s_i^2(n_i-1)+s_j^2(n_j-1)}{n_i+n_j-2}\right) \qquad ...(5.8).$$

It can be calculated from Table 5.5 that, using a critical value of F=1.45 at the 2.5 percentile level, the variances on population are equal in all pair-wise comparisons of the EBZ, WBZ and KNP sub-samples ($F^{we}$=1.25, $F^{wk}$=1.07, $F^{ke}$=1.17). At the 5 per cent level of significance, one must reject the null hypothesis that the means of household population are the same in the EBZ and the KNP ($t^{ke}$=-3.15) and we hence conclude that household size in the park tends to be larger than that in the eastern buffer zone. Similarly, however, we accept the hypothesis ($t^{we}$=1.76) that mean household sizes in the WBZ and EBZ are the same.

If we go through a similar exercise with household incomes, it is readily calculated that the variances of the EBZ and WBZ are the same ($F^{ew}$=1.20) but that in the other cases the population variances are actually different ($F^{kw}$=1.83, $F^{ke}$=1.52). The t-test is therefore not applied in the latter two cases, but it can be demonstrated that, in the former case, $t^{ew}$=-1.08 and that we therefore accept the hypothesis that household incomes in the EBZ and WBZ are equal.

To conduct direct tests on whether the per capita incomes, distributed by *household*, differed between regions, test statistics were calculated as follows:[16]

$F^{ek} = 1.98$

$F^{ew} = 2.41$

$F^{kw} = 1.22$ $\quad t^{kw} = -1.10$

The t-test was only calculated when the variances of the two distributions were accepted as the same, hence from these tests we accept only the null hypothesis that the distributions of per capita income are the same inside the KNP and the WBZ, and the distribution in the EBZ is different from both of these.

Although the previous comments applied to all of the possible pair-wise comparisons between two sub-samples in the survey, the sample can also be split in a way that any particular sub-sample is compared to the rest of the survey. This lets us ask the question of whether per capita incomes are different in some region from those in the rest of the sample. Although the details of the calculations are omitted here, the procedure generates the test statistics shown in Table 5.6, where $F^i$ is the test statistic for testing whether the variance in sub-sample i is different from the rest of the sample and $t^i$ is the test statistic for testing whether the mean is different from the rest of the sample.

The test statistics for household income indicate that for KNP – and for the WBZ – we must reject the null hypothesis that the variance is the same as that in the rest of the sample, and hence no tests regarding the means are made. In the case of the EBZ, on the other hand, we can comfortably accept the hypotheses that both the variance and the mean of the household incomes are equal to those in the rest of the sample. A similar conclusion might have been drawn simply by observing that household incomes in the EBZ lie almost midway between those in the WBZ and KNP, so it is not necessarily surprising that this result should arise when the EBZ is compared to the aggregate of the KNP and WBZ.

The test statistics for household size again confirm that significant differences exist amongst the various sub-regions. Here the F-test statistics all indicate that we can comfortably accept the null hypotheses that the variance in household size in any one region is the same as that in the rest of the sample. The t-test statistics indicate that Korup National Park has a household size greater than the rest of the sample, and that the EBZ has an average household size less than the rest of the sample. As the WBZ has close to the

[16] The relevant data are (in CFAF/yr per capita, distributed by household):

| | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Mean | 85,858 | 52,165 | 65,830 | 68,643 |
| Standard Deviation | 137,605 | 88,593 | 97,905 | 112,109 |

Table 5.6
Significance Tests for Population and Income Measures (341 Households)

| | $F^i$ | $F_{crit}$ | $\|t^i\|$ |
|---|---|---|---|
| Household Income | | | |
| Korup National Park (i=k) | 1.65 | $F_{102,237}$=1.37 | 1.55 |
| Western Buffer Zone (i=w) | 1.48 | $F_{227,112}$=1.39 | 1.59 |
| Eastern Buffer Zone (i=e) | 1.17 | $F_{124,215}$=1.36 | 0.08 |
| Household Size | | | |
| Korup National Park (i=k) | 1.04 | $F_{102,237}$=1.37 | 2.55 |
| Western Buffer Zone (i=w) | 1.12 | $F_{112,227}$=1.36 | 0.37 |
| Eastern Buffer Zone (i=e) | 1.22 | $F_{215,124}$=1.37 | 2.79 |
| Per Capita Income | | | |
| Korup National Park (i=k) | 1.45 | $F_{237,102}$=1.40 | 0.30 |
| Western Buffer Zone (i=w) | 1.88 | $F_{227,112}$=1.39 | 1.92 |
| Eastern Buffer Zone (i=e) | 2.18 | $F_{124,215}$=1.36 | 2.17 |

* Critical $t_{339}$=1.97.

average household size, it is again not surprising that $t^w$=0.37 compels us to accept the hypothesis that households in the WBZ are on average the same size as those in the rest of the aggregated sample.

Finally, little can again be concluded from the per capita income statistics because, in all three cases, we must reject the null hypothesis that the variance of the per capita income in any of the sub-regions is equal to the variance in the rest of the sample. The t-statistics can therefore not be used to test whether the means are the same.

To summarise the major conclusions regarding means from these tests, there are few generalisations which can be made about differences in income distribution amongst the various areas surveyed. With respect to household size, we conclude only that they are on average largest in the KNP and smallest in the EBZ. With respect to average household incomes, formal tests will indicate only that those in the EBZ and WBZ are equal. With respect to per capita incomes, we can only state conclusively that – as distributed per *household* – they are the same inside the KNP and the WBZ; most formal tests are inconclusive. In short, while some differences in per capita incomes exist among regions, very little can be said from the simple summary statistics to determine how one can account for the underlying distributions in income. Simply trying to describe it on a regional basis is inadequate, and the following discussion hence centres on other descriptive statistics which allow us to account for any differences in income which exist within the sample.

While the previous analysis revealed statistics showing the variance in incomes, by itself it does not suggest any measure of income inequality which can be usefully compared to those calculated for other developing countries. Appropriately, the second approach shall now focus on two descriptive indices of income inequality:

a) the Gini coefficient; and,

b) the Atkinson index.

The Gini coefficient is defined as:

$$\text{Gini} = 1 + \frac{1}{n} - \frac{2}{n^2\bar{y}}\left[ny_1 + (n-1)y_2 + \ldots + 2y_{n-1} + y_n\right] \qquad \ldots(5.9);$$

where n is the number of individuals, $y_i$ is the income of individual in rank i (arranged such that $y_1 \leq y_2 \leq \ldots \leq y_{n-1} \leq y_n$), and $\bar{y}$ is the mean income. In a Lorenz curve such as that in Figure 5.3, the Gini coefficient represents the proportion of the area between the 45° line and the income locus to the area below the 45° line. In a Lorenz curve, any particular point (*a*,*b*) along the income locus indicates that the poorest *a*% of the population earns *b*% of the income. Perfect equality would thus have a Gini coefficient equal to zero, and with perfect inequality (with all the income in the hands of one person) the Gini coefficient approaches unity.

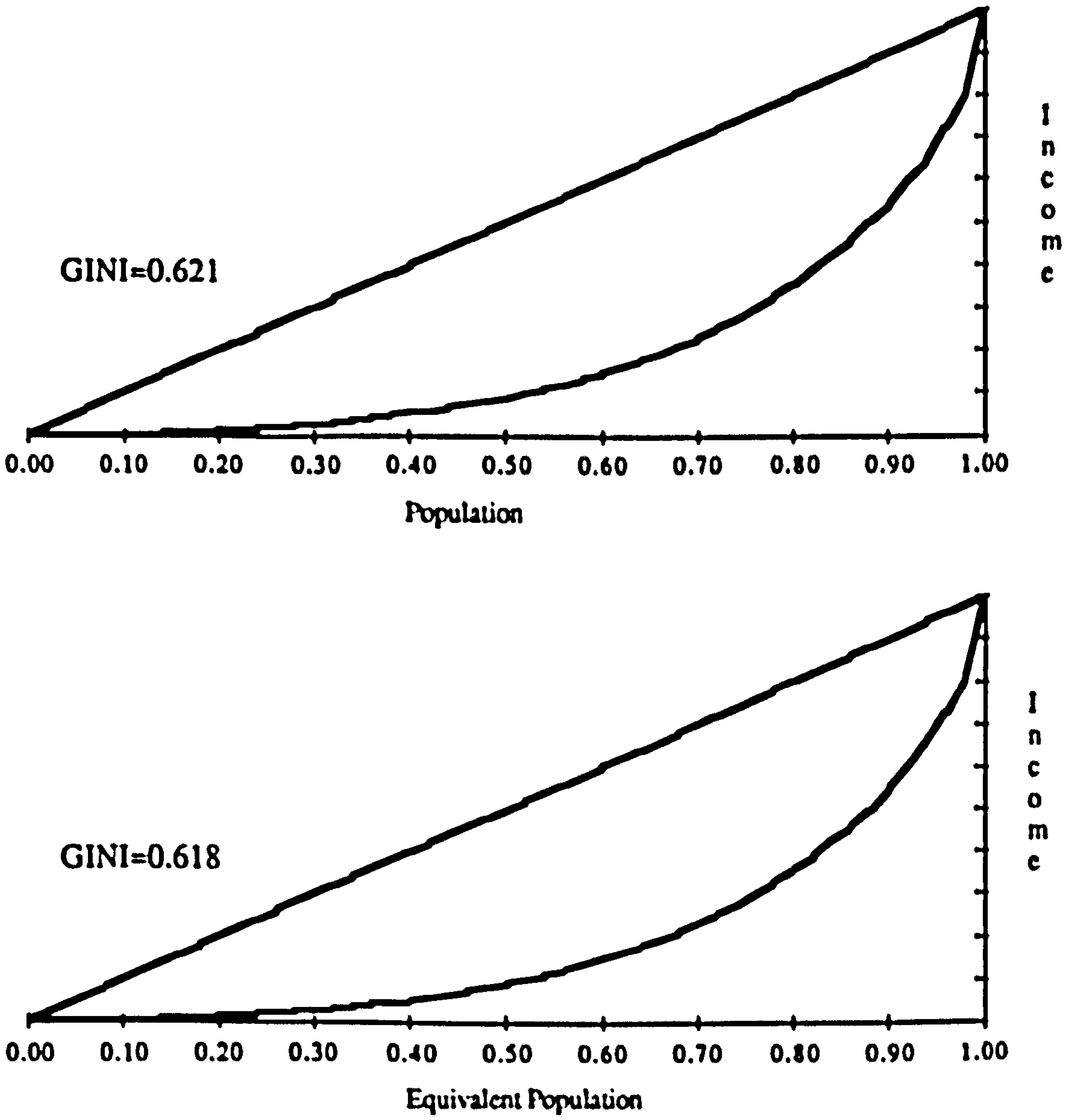
The Atkinson index of inequality explicitly incorporates a social valuation of income distribution, and is defined as $1-(\hat{y}/\bar{y})$, where $\hat{y}$ is the equally distributed equivalent income defined through:

$$n u(\hat{y}) = \sum_{i=1}^{n} u(y_i) \qquad \ldots(5.10);$$

where *u* (.) is a utility function. A distribution where every individual has an income level $\hat{y}$ is thus socially equivalent to the actual distribution of incomes. Although any one of a number of utility functions can be used, I shall use the isoelastic form $u(y)=y^{1-\varepsilon}/1-\varepsilon$, $\varepsilon \geq 0$; and $u(y)=\ln(y)$ when $\varepsilon=1$. When $\varepsilon=0$ we have $\hat{y}=\bar{y}$, and as $\varepsilon \rightarrow \infty$, $\hat{y}$ will tend towards the minimum income level in the sample. Atkinson (1970) discusses properties of both the Gini coefficient and the Atkinson index. Summaries of these indices for the entire survey sample are shown in Table 5.7.

Before discussing the results, some specific comments are in order. First, two sets of indices are shown: one for the set of all 341 households, and one for a set of households which excludes those households with zero incomes. As noted earlier, there were 15 households which had no cash income of any sort. While this does not affect the calculation of the Gini coefficient, it does complicate calculation of the Atkinson index for $\varepsilon \geq 1$, as the utility function is then undefined. To accommodate this in the first set any zero incomes were treated as a nominal income of 1 CFAF per year. This problem does not

Figure 5.3
Lorenz Curves of Income Distribution
(341 Households: Population = Present or at School)




arise in the second set – for which such households are excluded – but the Atkinson index in these cases will slightly understate income inequality.

The second comment relates to the basis of measuring incomes. If we use household income as a basis for the distribution calculations, the Gini coefficient is 0.653 for our sample. This may be compared with indices for the distribution of income of poor countries of about 0.4 to 0.5 as calculated by Anand (1978) and Atkinson (1970). This indicates that fairly high inequality exists in comparison to that in LDCs in general. But using the household as the unit for calculating income distribution may overstate inequality if larger incomes accrue to larger households. The reasons why larger households have higher incomes are varied. First, given that many of the activities still involve gathering tasks, the greater availability of household labour suggests that more would be gathered. Further, the phenomenon of an 'extended' family occurs here – as in other developing countries – whereby individuals with large incomes attract new additions to the family. This is especially a factor in this area where it is not uncommon for the household head to have more than one wife, and where the number of wives he has will depend to a degree on how many he can afford to keep. In any event, this suggests that it would be more appropriate to specify the individual as the basis for calculating income distributions. The second column in Table 5.7 provides such an estimate. It is based on per capita household income and calculated – for the 'all household' case – on the basis of the 2,233 individuals, with each individual being assigned the per capita income of the household in which they live.

A final adjustment was made to reflect the fact that even per capita income may not adequately reflect income inequality if there are substantial differences in household demographic structures. Very old and very young people will generally require less than adult males, so adjustments are at times made to reflect this. The usual method is to specify an 'equivalent' population for each individual: for example, an 8 year old girl is equivalent to only about 0.8 adult males in consumption requirements. The third column in Table 5.5 accommodates this adjustment.[17]

The results shown in Table 5.5 and Figure 5.3 confirm the existence of fairly high levels of inequality by most any measure, although it is noted that inequality measures based on individually distributed per capita incomes are lower than those based on household

[17] The actual conversion factors are provided in Appendix Table A.14. In calculating the Gini coefficient, it should be noted that Equation (5.9) can not be used as it applies to discrete individuals whereas in the formulation of equivalent incomes it is common to have a non-integer number as household population. The following algorithm was therefore used for a sample containing H households:

$$1 - \text{Gini} = \frac{\sum_{h=1}^{H} N_h \left(Y_h + 2\sum_{j=0}^{h-1} Y_j\right)}{\sum_{i=1}^{H} N_h \sum_{i=1}^{H} Y_h}$$

Where household of rank h has an equivalent population $N_h$, a household income $Y_h$, and the ranking is defined such that $(Y_h/N_h) \geq (Y_{h-1}/N_{h-1})$ for all $h>1$, and we have defined $Y_0=0$. It has a computational advantage as well in this application as it can be applied to the vector of households rather than the entire vector of individuals. It can be demonstrated, however, that this is equivalent to Equation (5.9) if all households have an integer number of members.

Table 5.7
Indices of Income Inequality (341 Households)

| | Based on Per Household Income | Based on Individually Distributed Per Capita Income | Based on Individually Distributed Per Capita Equivalent Income |
|---|---|---|---|
| All Households | | | |
| Gini Coefficient | 0.653 | 0.621 | 0.618 |
| Atkinson Index | | | |
| - ε=0 | 0 | 0 | 0 |
| - ε=0.25 | 0.193 | 0.173 | 0.171 |
| - ε=0.50 | 0.367 | 0.330 | 0.328 |
| - ε=0.75 | 0.537 | 0.479 | 0.477 |
| - ε=1.00* | 0.747 | 0.650 | 0.651 |
| - ε=1.25* | 0.967 | 0.891 | 0.896 |
| - ε=1.50* | 0.999 | 0.993 | 0.994 |
| - ε=2.00* | 1.000 | 1.000 | 1.000 |
| - ε=3.00* | 1.000 | 1.000 | 1.000 |
| - ε→∞ | 1.000 | 1.000 | 1.000 |
| Households with Income | | | |
| Gini Coefficient | 0.638 | 0.612 | 0.609 |
| Atkinson Index | | | |
| - ε=0 | 0 | 0 | 0 |
| - ε=0.25 | 0.180 | 0.166 | 0.164 |
| - ε=0.50 | 0.339 | 0.315 | 0.312 |
| - ε=0.75 | 0.475 | 0.446 | 0.442 |
| - ε=1.00 | 0.593 | 0.559 | 0.555 |
| - ε=1.25 | 0.696 | 0.658 | 0.653 |
| - ε=1.50 | 0.786 | 0.741 | 0.738 |
| - ε=2.00 | 0.914 | 0.868 | 0.866 |
| - ε=3.00 | 0.982 | 0.966 | 0.966 |
| - ε→∞ | 0.999 | 0.997 | 0.997 |

* Zero incomes treated as 1 CFAF/year.

incomes. This supports the earlier arguments that larger households will have larger incomes. Also, very little change occurs in the indices if an adjustment is made for equivalent consumption units. This reflects either that there is little variation in household structure as family size and incomes increase, or that any such variation does not effect the equivalent population of a small household differently than that of a larger household. Inspection of the Atkinson indices for the entire sample reveal that those based on per capita equivalent incomes are lower than those calculated on a strict per capita income basis at low values of ε, yet they are higher at high values of ε. In words, this suggests that the per capita income basis overstates inequality if one is not too averse to inequality, yet understates it if one is very averse to income inequality. As this 'anomaly' does not arise in the second set of data for which households with zero incomes are excluded, its appearance in the first set is attributed to the inclusion of such zero income households. Intuitively, what seems to be the case in this sample is that these households apparently have a somewhat higher average consumption 'requirement' per individual in the household than the rest of the sample. As a result, this would have a proportionately greater effect on the inequality if you were very concerned about the existence of low income groups.

While the indices provided in Table 5.7 describe the inequality in the population as a whole, they do not specifically account for it in any way. Table 5.8 explicitly decomposes the income inequality into its component parts.[18] It is calculated for all households on the basis of individually distributed per capita incomes. The decomposition allows calculation of the contribution $Gini_k$ for each income source k=1,...,K to the overall Gini coefficient:

$$Gini = \sum_{k=1}^{K} Gini_k \qquad ...(5.11);$$

where,

$$Gini_k = \frac{\bar{y}_k}{\bar{y}} G_k^* \qquad ...(5.12);$$

where $\bar{y}_k$ is the mean per capita income from source k, and $G_k^*$ is a 'pseudo-Gini' coefficient defined similarly to Equation (5.9) as:

$$G_k^* = 1 + \frac{1}{n} - \frac{2}{n^2 \bar{y}_k} [\, ny_{1,k} + (n-1)y_{2,k} + ... + 2y_{n-1,k} + y_{n,k} \,] \qquad ...(5.13);$$

where $y_{i,k}$ is the income to individual of rank i attributable to income source k. It is important to note that, for these formulae to be consistent with Equation (5.9), individuals must be ranked in terms of increasing *total* incomes ($y_1 \le y_2 \le ... \le y_{n-1} \le y_n$). Hence we refer to $G_k^*$ as a pseudo-Gini coefficient: the ranking is such that it could conceivably be negative (corresponding to an income locus in a 'pseudo-Lorenz' curve which went above the 45° line).

Interpretation of the decomposition is, however, quite straight forward. A high $G_k^*$ corresponds to an income source which is distributed preferentially towards the rich and a low $G_k^*$ corresponds to an income source distributed preferentially to the poor. Using the population Gini=0.62 as a benchmark and treating a difference of 0.04 from this as significant, it is clear that incomes from cocoa, hunting, trading and remittances all increase inequality in the sample. By contrast, incomes from food crop sales, trapping, and forest product gathering and manufacturing all decrease inequality in the sample to the extent that they contribute more relative income to the poor than to the rich. Inequality ascribed to

[18] This follows a procedure outlined by Shorrocks (1982) for decomposing the contributions of various factor components.

Table 5.8
Decomposition of per Capita Income Inequality by Income Source (341 Households)

| Source (k) | $\bar{y}_k$ | $\bar{y}_k/\bar{y}$ | $G^*_k$ | $Gini_k$ | $Gini_k/Gini$ |
|---|---|---|---|---|---|
| All Income Sources | 59,246 | 100.0% | 0.621 | 0.621 | 100.0% |
| Cash Crops | 20,291 | 34.2% | 0.649 | 0.222 | 35.7% |
| - Cocoa | 14,040 | 23.7% | 0.669 | 0.159 | 25.6% |
| - Coffee | 3,510 | 5.9% | 0.608 | 0.036 | 5.8% |
| - Other | 2,740 | 4.6% | 0.580 | 0.027 | 4.3% |
| Livestock | 798 | 1.3% | 0.369 | 0.005 | 0.8% |
| Hunting | 7,088 | 12.0% | 0.660 | 0.079 | 12.7% |
| Trapping | 5,724 | 9.7% | 0.567 | 0.055 | 8.9% |
| Fishing | 2,915 | 4.9% | 0.626 | 0.031 | 5.0% |
| Trading | 3,153 | 5.3% | 0.697 | 0.037 | 6.0% |
| Forest Products | 17,447 | 29.4% | 0.562 | 0.165 | 26.6% |
| - Gathering | 12,547 | 21.2% | 0.579 | 0.123 | 19.8% |
| - Manufacturing | 4,900 | 8.3% | 0.516 | 0.043 | 6.9% |
| Remittances | 1,828 | 3.1% | 0.879 | 0.027 | 4.3% |

fishing and coffee production are no different to that in the sample as a whole.

Values of $G^*_k$ should not be used in isolation to determine the total contribution of each source to the inequality in the sample. The fact that $G^*_k>0$ for all k indicates that each source does contribute to overall inequality to some degree,[19] and the total contribution to the Gini coefficient depends also on the share ($\bar{y}_k/\bar{y}$) of a particular income source in total income. As shown in Table 5.8, remittances by themselves are distributed very unequally, yet they are a small share of the income total (3.1%) and hence contribute little to the total inequality (4.3%). The distributions of both cash crop incomes and forest product incomes contribute most significantly to overall inequality: 36% and 27%, respectively.

Recall that we were most interested in conducting this exercise of describing income distribution to determine whether providing income support to either cash crop production or to forest product production would improve inequality in the region. Table 5.9 shows the results of simulations undertaken to illustrate the impacts of various types of income

[19] To an extent this is attributable to the inclusion of the zero income households.

Table 5.9
Impact of Income Support on Income Inequality
(341 Households - Based on Individually Distributed per Capita Income)

| | Gini | Atkinson Index | | |
|---|---|---|---|---|
| | | ε=0.5 | ε=1.0 | ε=1.5 |
| Base Case | 0.621 | 0.330 | 0.650 | 0.993 |
| 10% increase in Cocoa + Coffee | 0.622 | 0.331 | 0.652 | 0.993 |
| 10% increase in Forest Products | 0.619 | 0.328 | 0.648 | 0.993 |
| 30% increase in Cocoa + Coffee | 0.625 | 0.334 | 0.657 | 0.993 |
| 30% increase in Forest Products | 0.616 | 0.326 | 0.646 | 0.993 |
| 50% increase in Cocoa + Coffee | 0.628 | 0.338 | 0.662 | 0.994 |
| 50% increase in Forest Products | 0.615 | 0.324 | 0.644 | 0.994 |
| Changes from Base Case: | | | | |
| 10% increase in Cocoa + Coffee | +0.001 | +0.001 | +0.002 | 0.000 |
| 10% increase in Forest Products | -0.002 | -0.002 | -0.002 | 0.000 |
| 30% increase in Cocoa + Coffee | +0.004 | +0.004 | +0.007 | 0.000 |
| 30% increase in Forest Products | -0.005 | -0.004 | -0.004 | 0.000 |
| 50% increase in Cocoa + Coffee | +0.007 | +0.008 | +0.012 | +0.001 |
| 50% increase in Forest Products | -0.006 | -0.006 | -0.006 | +0.001 |

support on income inequality. Income support is, for illustrative purposes, in the form of price support for the particular income source. The simulations assume that there are no changes in income from the other sources. It should be noted that a 10% income support programme would have an annual cost of 3.92 million CFAF if applied to cocoa and coffee cash crops, and 3.90 million CFAF if applied to forest products. Hence it is fair to compare the two types of programme. In the particular case of Korup National Park, the project has annual funding of about 20 million CFAF available for such programmes, hence a simulation is also undertaken to show a 50% income support scheme which would use up this funding.

The results of these simulations confirm what was also revealed in the decomposition in Table 5.8: income support provided to conventional cash crops will tend to increase income inequality in the region, whereas support provided to forest product industries would assist the poorer households and improve income inequality. But the results also illustrate how one's degree of aversion to income inequality affects the results. In the case of ε=1.5, income support provided to either cash crops or forest products would increase inequality in the sample. Intuitively, what occurs is that the spread between those households with income and those without income increases – the income support mechanism used here fails to target the poorest – and therefore there is greater inequality. If however, one is not *too* averse to income inequality ($\varepsilon=1$), then it is better to support forest product based pursuits.

5.4.4 Summary

As the discussion has been quite detailed to this stage, I shall be brief in my summary comments. First, income from traditional hunting and gathering activities is found to be substantial in all areas of the survey – both inside and outside the primary forest zone. Second, there is a great deal of variation in incomes within the survey, but income distribution from traditional gathering activities benefits the poorer households more than does the income distribution from conventional cash crops such as cocoa and coffee. Appropriately, if one had to select between an income support policy which benefited cash crop producers, or one which benefited those involved in traditional forest based industries, the latter policy would normally be preferred if one were interested primarily in improving income distribution in the region.

While this section has characterised the income distribution, it has not made any attempt to explain how the current distribution actually evolved. While any such explanation is of interest in designing policies and, indeed, has been the subject of recent studies elsewhere (see Lanjouw and Stern [1989]) it is beyond the scope of this thesis to investigate it. More detailed panel data on input markets is usually required to investigate such problems and the survey data collected for this study were for only one period and did not contain information regarding production inputs.

## § 5.5 Income and Education

A striking feature which one can not help but notice when in the villages is that – in spite of the results of the previous section – there is very little conspicuous consumption. Although some villages and households seem to have more income than others, there is an apparent homogeneity in living standards which seems to contradict the assertion that substantial income inequality exists. Although this is not directly related to the problems addressed in the rest of this thesis, it is of interest to try to account for this discrepancy between incomes levels and apparent living standards and – in the process – learn something about how income is 'capitalised' in this part of the country.

The usual manner to account for such a discrepancy would be to address an expenditure survey for the region and to note explicitly how incomes were spent. Unfortunately, no such data are available for this sample. We must therefore revert to other observations which were made as a part of the demographic and income survey. In particular, it would seem natural to try to look at the actual assets held by various households: if no conspicuous consumption is occurring in spite of substantial income differences, one might presume that those with higher incomes have greater assets which would not be noticed by wandering around the villages. Items which might conceivably constitute assets would include: bank balances, farm land, farm implements, or consumer durables.

Although no statistics were gathered on bank balances, savings and loans, it was clear from informal discussions that credit institutions were not used in the region – primarily because of its isolation – and that any assets held in this form would account for only a handful of households at the most. With respect to farms, labour is the primary input other than land and seed, farm animals are not used, and there was no evidence of mechanisation. Ploughing and weeding are manual tasks, hence the only potential asset was the actual amount of farm land controlled by each household. This statistic, in terms of 'lope' (where 1 lope is about 0.75 ha) was gathered for each household. Finally, as noted earlier, there was no obvious consumption through consumer durables.

From discussions with individuals in the villages, it was clear that one of the greatest priorities for any household head was providing an education for his children. As noted earlier in this chapter, education must normally be paid for by a child's family in Cameroon, and individuals regularly complained that – because of income constraints – they had to make decisions as to which children could go to school and which had to stay home. Given these conditions, it seems natural to ask whether earnings are being 'capitalised' by educating children. If this is the case, then we should be able to detect this in the sample. To address this, two approaches are taken: the first approach involves the calculation of descriptive statistics for some of the potentially related income and education variables; the second approach is more detailed in that it investigates on an individual basis the conditions under which children in the sample are receiving an education.

The first approach taken in describing correlations between income, assets and education involves simply analysing the correlation matrix of the relevant variables. The variables used are described in Table 5.10, and the correlation matrix of the variables is presented in Table 5.11. To evaluate the significance of any correlation coefficient r, we use the result that, to test the hypothesis that r=0, the statistic t* is distributed as t with (n-2) degrees of freedom, where:

$$t^* = \left[(n-2)\frac{r^2}{1-r^2}\right]^{\frac{1}{2}} \qquad ...(5.14).$$

For 339 degrees of freedom, at a 5% significance level, the critical t value is 1.98 and the critical value of r is thus 0.107. If r is significant, then it indicates that a simple pair-wise regression of the two variables under consideration would also be significant. While this does not capture all of the results which might arise from more detailed multivariate analysis, it does provide an initial indicator of correlation between variables. Specific tests using multivariate analysis will be addressed later.

Using the result that any correlation coefficient greater than 0.107 indicates significance, we can now go to Table 5.11 to determine which pairs of variables would be correlated significantly. First, we note that all of the variables are significantly positively correlated to income. With respect to the education variables, the most significant correlation occurs between TOTED and INCOME, indicating that total years of education in the household increases as income increases. Although this result may not be surprising given that we had already noted that income and population were positively related (r=0.308), it is perhaps more striking that both the *maximum* level of education achieved by any household member, as well as the *average* level of education in the household, increases as income goes up. Similarly, the data suggest that households will tend to have higher incomes if the household head has a higher level of education.

Although the data clearly demonstrate that there is a positive correlation between income and education, one must take care in assigning any particular cause-effect relationship with these aggregate data. While the correlation is positive, it is not obvious whether the higher incomes are being used to purchase more education, or if the higher levels of education are themselves allowing individuals to earn more money. On this point, however, it is useful

Table 5.10
Definition of Income, Asset and Education Variables

| Variable | Definition | Mean | Standard Deviation | n |
|---|---|---|---|---|
| Subset: Households: All | | | | |
| INCOME | Annual HH income (CFAF) | 387,964 | 641,197 | 341 |
| TOTED | Total education of HH (years) | 14.46 | 11.81 | 341 |
| MAXED | Maximum education in HH (years) | 5.26 | 2.96 | 341 |
| AVERED | Average education in HH (years) | 2.16 | 1.53 | 341 |
| HHHSCHL | Education of HH head (years) | 2.19 | 2.79 | 341 |
| FARM | Farm land controlled by HH (lope) | 4.00 | 3.20 | 341 |
| HPOP01 | HH population normally present or absent at school | 6.55 | 3.97 | 341 |
| Subset: Individuals: Ages 4-14: Normally present or at school | | | | |
| ISEX | Individual's sex (0=F, 1=M) | 0.50 | 0.50 | 726 |
| IAGE | Individual's age (years) | 8.24 | 3.04 | 726 |
| ISCHL | Individual's schooling (years) | 2.25 | 2.02 | 726 |
| SCHOOLYN | =1 if ISCHL>0, else =0 | 0.70 | 0.46 | 726 |
| HSCHLV | =1 if there is a school in an individual's home village, else =0 | 0.56 | 0.50 | 726 |
| IHINCOME | HH income of individual (CFAF/year per capita) | 51,911 | 78,177 | 726 |
| ILOGINC | =ln(IHINCOME) | 9.84 | 2.02 | 726 |
| IHHHSCL | Schooling of head of HH in which individual lives (years) | 2.28 | 2.81 | 726 |
| DUMIWBZ | =1 if individual's HH in WBZ, else =0 | 0.34 | 0.47 | 726 |
| DUMIEBZ | =1 if individual's HH in EBZ, else =0 | 0.31 | 0.46 | 726 |
| DUMIBZ | =1 if individual's HH in WBZ or EBZ, else =0 | 0.65 | 0.48 | 726 |
| Subset: Individuals: Ages 5-14: Normally present or at school | | | | |
| ISEX | Individual's sex (0=F, 1=M) | 0.51 | 0.50 | 626 |
| IAGE | Individual's age (years) | 8.91 | 2.71 | 626 |
| ISCHL | Individual's schooling (years) | 2.61 | 1.96 | 626 |
| SCHOOLYN | =1 if ISCHL>0, else =0 | 0.81 | 0.40 | 626 |
| HSCHLV | =1 if there is a school in an individual's home village, else =0 | 0.56 | 0.50 | 626 |
| IHINCOME | HH income of individual (CFAF/year per capita) | 52,442 | 80,532 | 626 |
| ILOGINC | =ln(IHINCOME) | 9.85 | 1.97 | 626 |
| IHHHSCL | Schooling of head of HH in which individual lives (years) | 2.28 | 2.81 | 626 |
| DUMIWBZ | =1 if individual's HH in WBZ, else =0 | 0.34 | 0.47 | 626 |
| DUMIEBZ | =1 if individual's HH in EBZ, else =0 | 0.30 | 0.46 | 626 |
| DUMIBZ | =1 if individual's HH in WBZ or EBZ, else =0 | 0.64 | 0.48 | 626 |

Table 5.11
Correlation Matrix of Income, Asset and Education Variables (Households)

| | INCOME | TOTED | MAXED | AVERED | HHHSCHL | FARM | HPOP01 |
|---|---|---|---|---|---|---|---|
| INCOME | 1.000 | | | | | | |
| TOTED | 0.353 | 1.000 | | | | | |
| MAXED | 0.165 | 0.676 | 1.000 | | | | |
| AVERED | 0.149 | 0.591 | 0.780 | 1.000 | | | |
| HHHSCHL | 0.179 | 0.253 | 0.350 | 0.441 | 1.000 | | |
| FARM | 0.208 | 0.281 | 0.106 | 0.034 | -0.070 | 1.000 | |
| HPOP01 | 0.308 | 0.727 | 0.352 | 0.049 | 0.003 | 0.308 | 1.000 |

n=341

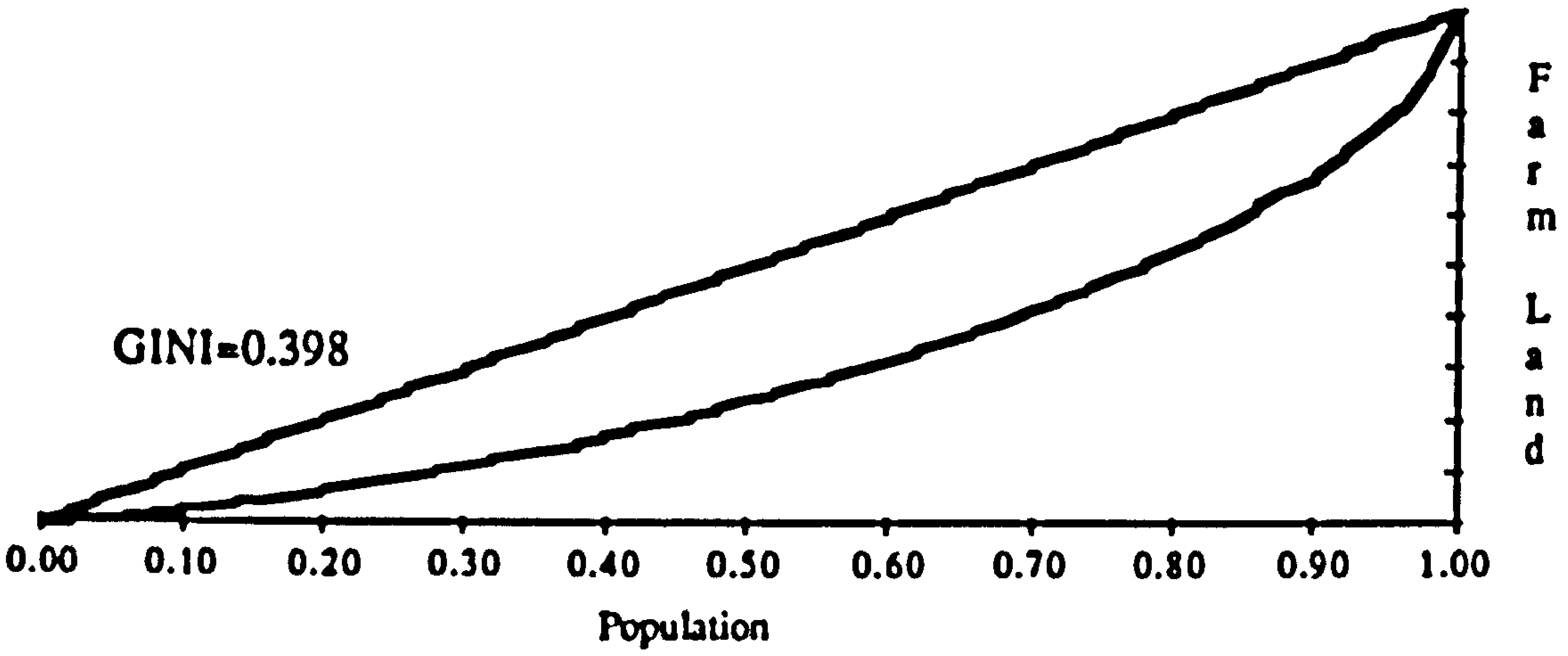
to remark that – in this sample – one would not normally expect the earnings level to depend that significantly on the level of formal education achieved within the household. Most of the traditional practices of gathering and hunting are learned in the home rather than in school, and only with cocoa and coffee farming might one expect *a priori* that agronomic standards would increase as the farms are being managed by better educated individuals. In addition, it seems less likely that younger family members currently receiving an education would be able to apply this education usefully to any current income earning activity for the household. Indeed, one might even argue that the income earning capacity of the household *decreases* when individuals are at school as they are then not available to assist in income earning activities. As such, it seems most likely that any positive correlation between incomes and education *does* reflect the fact that households must finance the education of their members.

With respect to tangible assets, the data suggest that farm land and incomes are correlated (r=0.21), although this correlation is primarily due to the actual household size: larger households will have more income and more farms. The correlation coefficient when calculated using per capita land holdings and per capita income suggested that the two were not strongly connected (r=0.10).

Given this apparently loose correlation, it is useful to look briefly at the variation in farm land. As with income, there is considerable variation in the amount of farm land controlled by individual households. It ranges from a minimum of zero to a maximum of 23 lope per household. The mean is 4.0 lope with a standard deviation of 3.2 lope. Calculation of an inequality index on farm land, based on individually distributed per capita land holding, indicated a Gini coefficient of about 0.4, as illustrated in Figure 5.4. There is no significant change in this coefficient if it is calculated on the basis of per capita equivalent land holding.

Although there is substantial inequality in both land holding and in income, it does not necessarily follow that one leads to the other. One might argue that those with less land will have less ability to generate income, but we have already seen that most of the income received by households is not associated with crops requiring land. Alternately, one might argue that larger incomes allow individuals to acquire more land, but in this case – as was noted earlier – land is essentially 'free' and low incomes will not exclude individuals from controlling land. Indeed, the empirical evidence suggests that land holding and income are largely unrelated. Figure 5.5 shows a distribution of land holding per capita ranked on the basis of individually distributed per capita *income*. It indicates that there is only moderate evidence for arguing that those with the lowest incomes control the least land.

Figure 5.4
Lorenz Curves of Farm Land Distribution
(341 Households: Population = Present or at School)



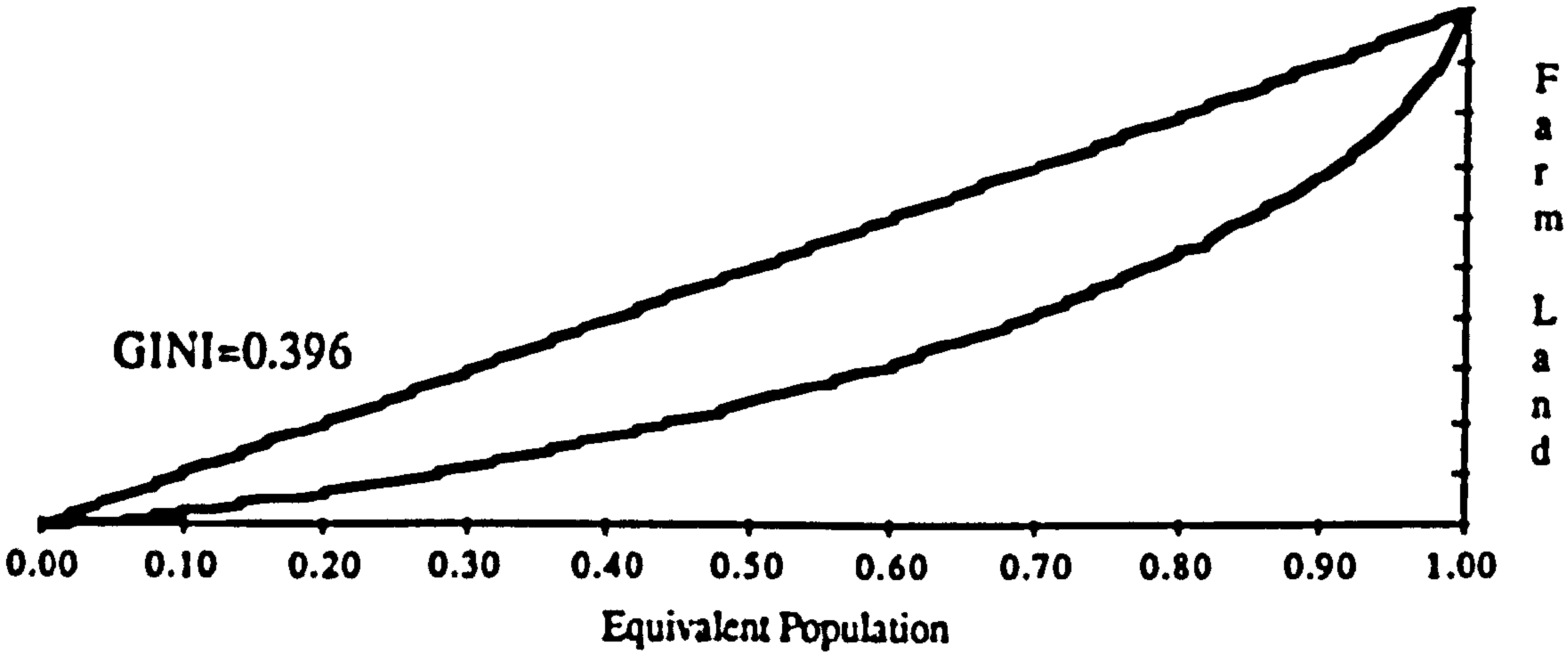
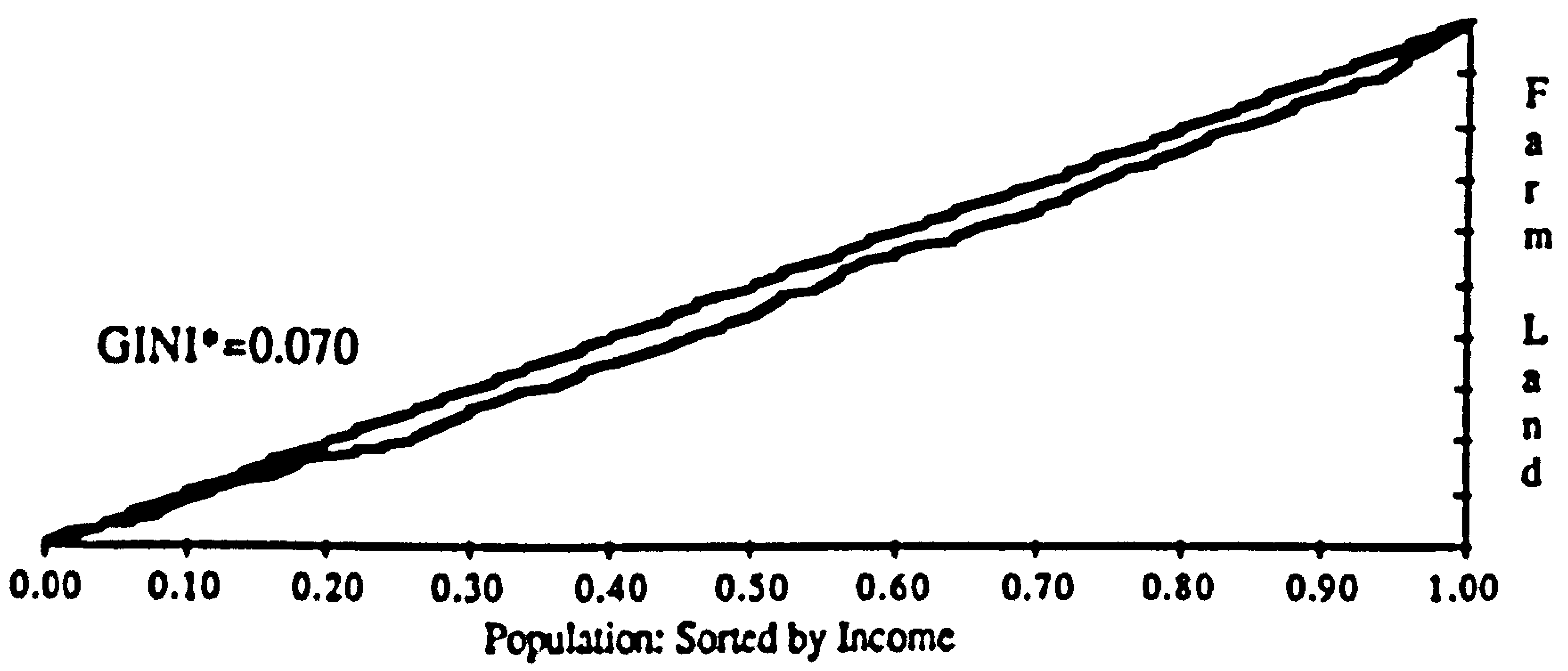




Figure 5.5
Distribution of Farm Land Sorted by Income
(341 Households: Population = Present or at School)



I now proceed to a more detailed analysis of the education levels of individual household members. A subset of the data was chosen which selected all family members of primary and secondary school age (4-14 years). The lower bound was chosen to correspond to the youngest which were in primary school attendance, and the upper bound for the sample was selected to exclude those individuals which were potentially economically active in some significant way. The upper bound is somewhat arbitrary, as there were individuals younger than this who were economically active, and some individuals older than this would still be attending primary school. Nonetheless, it is believed that this age group, consisting of 726 individuals, provides a realistic sample for conducting an analysis.

In formulating a model of whether any particular individual has formal schooling, I rely initially on some *a priori* presumptions of what factors might be relevant. Those chosen were:

a) the child's sex (ISEX);
b) the child's age (IAGE);
c) whether there is a school in the child's home village (HSCHLV);
d) the per capita income of the child's household (HINCOME; HLOGINC);
e) the level of schooling achieved by the household head (HHHHSCL); and,
f) the location of the child's village (DUMIBZ; DUMIWBZ; DUMIEBZ).

Descriptive statistics for the variables used in this sample are provided in Table 5.10.

Of the 726 individuals in the total sample, 511 had some schooling and 215 had no schooling. From an inspection of the data, it was determined that 100 individuals were in the youngest age class – 4 years of age – of which only 5 were in school. As it was believed that this group might bias the results, a second subset of 626 individuals was chosen which included only the 5-14 year age group. Results for both data sets are presented, although I shall normally concentrate on discussing the first subset (4-14 year group) in the text.

Two types of estimations were conducted: a Probit model; and a Tobit model. The Probit model uses the variable SCHOOLYN as the dependent variable, taking on the value of unity for a child with formal schooling and a value of zero for a child with no formal schooling. The data do not allow differentiation between those still at school and those having some education but no longer at school. Results from the Probit model are interpreted as how individual explanatory variables influence the probability of a child going to school. To understand how a particular model is diagnosed and interpreted, it is easiest to refer to a particular example.

Table 5.12a
Probit Results for Individual Education (4≤Age≤14)

| | |
|---|---|
| Dependent Variable: | SCHOOLYN |
| Total Observations: | 726 |
| Observations at 0: | 215 |
| Observations at 1: | 511 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (1a) | (2a) | (3a) | (4a) |
|---|---|---|---|---|
| ISEX | -0.038 | -0.023 | | |
| | (0.30) | (0.18) | | |
| IAGE | 0.443 | 0.466 | 0.438 | 0.463 |
| | (14.14) | (14.02) | (14.10) | (13.99) |
| IISCHLV | 0.958 | 1.115 | 0.984 | 1.160 |
| | (6.39) | (7.03) | (6.94) | (7.61) |
| IIINCOME | 0.183E-5 | | 0.206E-5 | |
| | (2.21) | | (2.53) | |
| IILOGINC | | 0.151 | | 0.158 |
| | | (4.53) | | (4.79) |
| IIHHHSCL | 0.038 | 0.039 | | |
| | (1.48) | (1.51) | | |
| DUMIWBZ | -0.464 | -0.390 | | |
| | (2.62) | (2.16) | | |
| DUMIEBZ | -0.365 | -0.357 | | |
| | (2.25) | (2.16) | | |
| DUMIBZ | | | -0.453 | -0.414 |
| | | | (3.15) | (2.83) |
| CONSTANT | -3.090 | -4.746 | -2.989 | -4.714 |
| | (11.06) | (9.51) | (11.36) | (9.60) |
| Log Likelihood (0) | -441.09 | -441.09 | -441.09 | -441.09 |
| Log Likelihood (Model) | -250.67 | -242.62 | -252.58 | -244.12 |
| L-R Test (Model) | 380.84 | 396.94 | 377.02 | 393.94 |
| Degrees of Freedom | 7 | 7 | 4 | 4 |
| Critical $\chi^2$ | 14.07 | 14.07 | 9.49 | 9.49 |
| Preferred Model: | | | | ******* |

$\chi^2$ (d.f.=3): 7.81

Table 5.12b
Probit Results for Individual Education (5≤Age≤14)

| | |
|---|---|
| Dependent Variable: | SCHOOLYN |
| Total Observations: | 626 |
| Observations at 0: | 120 |
| Observations at 1: | 506 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (1b) | (2b) | (3b) | (4b) |
|---|---|---|---|---|
| ISEX | -0.069<br>(0.50) | -0.047<br>(0.33) | | |
| IAGE | 0.340<br>(9.94) | 0.360<br>(9.97) | 0.332<br>(9.83) | 0.354<br>(9.88) |
| IISCHLV | 1.000<br>(6.29) | 1.143<br>(6.82) | 1.003<br>(6.67) | 1.166<br>(7.23) |
| IIINCOME | 0.177E-5<br>(1.97) | | 0.197E-5<br>(2.26) | |
| IILOGINC | | 0.142<br>(4.13) | | 0.151<br>(4.42) |
| IIHHHSCL | 0.045<br>(1.58) | 0.047<br>(1.63) | | |
| DUMIWBZ | -0.522<br>(2.74) | -0.448<br>(2.30) | | |
| DUMIEBZ | -0.339<br>(1.92) | -0.313<br>(1.75) | | |
| DUMIBZ | | | -0.467<br>(3.01) | -0.420<br>(2.66) |
| CONSTANT | -2.204<br>(6.89) | -3.761<br>(7.03) | -2.073<br>(6.91) | -3.714<br>(7.09) |
| Log Likelihood (0) | -305.91 | -305.91 | -305.91 | -305.91 |
| Log Likelihood (Model) | -214.46 | -208.06 | -217.33 | -210.45 |
| L-R Test (Model) | 182.90 | 194.62 | 177.16 | 190.92 |
| Degrees of Freedom | 7 | 7 | 4 | 4 |
| Critical $\chi^2$ | 14.07 | 14.07 | 9.49 | 9.49 |
| Preferred Model: | | | | ******* |

$\chi^2$ (d.f.=3): 7.81

Table 5.12a shows the results of the Probit estimations for the 4-14 year age group. Four separate models were run. The estimation coefficients are interpreted as the effect of a unit change of the independent variable on the probability index of a child going to school. This index is normally distributed with a mean of 0 and a variance of 1, and is hence readily converted to a probability conditional on a given set of characteristics. For example, at the means of all of the variables in the sample, the index is 0.99, which corresponds to a probability of 83.9% that a child will go to school. The particular t-ratio for any given coefficient is also presented, taken here as the absolute value of the ratio of the estimation coefficient to its standard error. At a 5% significance level, a t-ratio greater than 2 is regarded as statistically significant. It is clear that a child's sex, for example, is not statistically significant (t=0.30 in Model [1a]) in affecting education.

As Probit estimations involve procedures which maximise the likelihood function of a particular model, the usual test for determining whether a given model is meaningful involves a likelihood ratio (LR) test.[20] The test statistic LR = 2*[LL(Model) - LL(0)] is distributed as $\chi^2$ with $n_v$ degrees of freedom, where LL(Model) is the logarithm of the likelihood function of the model as estimated, LL(0) is the logarithm of the likelihood function of the model with only a constant term, and $n_v$ is the number of variables added to just the constant term. In essence, the LR statistic tests the hypothesis that the actual model is the same as taking a simple average of the dependent variable. If the LR statistic is greater than the critical value of $\chi^2$, then this hypothesis is rejected and the model is regarded as having some meaningful explanatory power. In our first example, for Model (1a), the LR statistic is 380.84, which given the critical $\chi^2$ of 14.07 at a 5% significance level, allows us to reject comfortably the hypothesis that the model is no different from a model with a constant term only.

In comparing any two model structures, models with the same dependent variable and the

[20] Although $R^2$ is used by some authors, it is not reported in these regressions as it is not believed to be a meaningful test for selecting models where the dependent variable is a qualitative variable. In the Probit model, for example, any given individual will either go to school or not go to school, hence the data are ones or zeros. But the estimator only purports to estimate the probability of any individual going to school. Even given a particular probability estimate, it would still be impossible to determine whether any given individual would or would not go to school. For large populations, however, any change in the explanatory variables would indicate the change in the probability of attendance and, hence, allow one to estimate how many more people would go to school, even though it would not be possible to decide which individuals would actually do so. Given that the estimator simply provides an estimated probability that a child will attend school, it is common for $R^2$ in these types of regressions to be low: the estimators are all between 0 and 1 whereas the observations are all at 0 and 1. Indeed, in our examples of schooling, the $R^2$ was typically of the order of 0.5. For additional discussion of the use of $R^2$ as a diagnostic statistic in such exercises, the reader is referred to Morrison (1972) who argues that it is not generally meaningful, and Goldberger (1973) who argues that it is meaningful in the sense that it describes the amount of the variation which is explained, but not necessarily in the sense that it should be used as a model selection statistic. For an excellent text on using quantitative variables in econometric regressions, and for discussions of different 'versions' of $R^2$ statistics, the reader is referred to Maddala (1983).

same $n_v$ are often compared directly through inspection of the LL(Model) value: those with a low (absolute) value are typically regarded as better. In Table 5.12a, therefore, Model (2a) is preferred over Model (1a) because $|LL(Model_2)|<|LL(Model_1)|$. The adjustment which was made in this specific case was to correct for potential heteroskedasticity by specifying income in a logarithmic form.

In comparing two models with different $n_v$, but with the same dependent variable, an LR test can also be conducted through the statistic $LR_{ij}=2*[LL(Model_i)-LL(Model_j)]$, which is distributed as $\chi^2$ with $n_{vi}-n_{vj}$ degrees of freedom. Effectively, $LR_{ij}$ basically tells us whether adding $n_{vi}-n_{vj}$ variables improved the model's descriptive powers. In the case of Table 5.12a, although $|LL(Model_2)|<|LL(Model_4)|$, Model (2a) is regarded as no better than Model (4a) because $LR_{24}=3.00$ and the critical $\chi^2=7.81$ at three degrees of freedom and a 5% significance level.[21]

Given the above criteria for selecting models and variables, it is clear from Table 5.12a that a child's sex seemed to have little to do with whether they received any schooling. Also, their schooling was independent of the level of education achieved by the head of their household. These variables were therefore dropped in Models (3a) and (4a). In addition, results from Models (1a) and (2a) revealed that the location of a child's village was significant: those in the Eastern or Western Buffer Zones were less likely to receive an education than those in Korup National Park villages. But the results also showed that one can accept the hypothesis that the coefficients to DUMIEBZ and DUMIWBZ are equal (t=11.1), hence in Models (3a) and (4a) they were constrained to be equal.

An inspection of the results suggests that Model (4a) is the preferred specification, and that the following conclusions can be made from it. The probability of a given child receiving some formal education is positively correlated to his or her age and per capita family income. Children living in a village with a school are more likely to receive an education than those living in a village without a school, but those living in the buffer zone are less likely to receive formal education than those living in the park; at the means of the other variables, a child in the park had a 90% probability of receiving an education and one outside had an 81% probability. While these results are not surprising in light of previous comments, the last result regarding village location merits further comment.

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[21] Strictly, the L-R test between two models requires that one is fully 'nested' within the other. This requires that all of the variables in the 'smaller' model are included in the 'larger', and the test then applies to the variables which appear only in the larger model. In the particular case, here, a number of intermediate models were estimated but are not shown here. The intermediate step was to exclude the explanatory variables ISEX and IIIHIHSCL. These models were nested within Models (1a) and (2a) and were found to be better, and were used as the next step to arriving at Models (3a) and (4a).

It might have *a priori* been expected that those villages which were most isolated would have lower access to education. If this were true, those in the WBZ should be less likely to receive an education than those in the KNP, and those in the KNP should be less likely to receive an education than those in the EBZ, all other things equal. But the data suggest that any such concept of 'isolation' does not – in this case – add anything to our understanding of whether an individual will receive any education.

Based on informal discussions in both Cameroon and Nigeria, there is one possible suggestion why this would occur. Many hunters indicated that one of the primary reasons that they hunted was to try to make a money windfall to pay for their children's education. While windfalls appear to be quite rare, it may nonetheless occur that hunting income was somehow treated separately from other income and dedicated to this purpose. To test this hypothesis, estimations were run using an additional variable – HUNTPROP – which represented the proportion of income received in a household from hunting. Results of these estimations suggested that this variable was insignificant when zonal variables were included, and that hunting income does not appear to be directed preferentially to education. In view of the significance of DUMIBZ, however, one can conclude only that there might exist some attitudinal differences which cause those living in the KNP villages to be more likely to send their children to school.

Models based on the smaller subset of age groups 5-14 years essentially confirmed the results obtained with the larger data set. Specific estimations are shown in Table 5.12b and the reader can verify that similar conclusions hold. Again, Model (4b) which specifies incomes in logarithmic form, excludes sex and the household head's education level, and aggregates the buffer zones, is selected as the preferred model.

While the Probit estimations indicate the probability of whether a child with certain attributes will or will not receive some education, the results do not indicate how much education a particular child will have. A standard OLS regression of the number of years of schooling (ISCHL) on the explanatory variables used for the Probit would not provide an efficient unbiased estimate because of the nature of the dependent variable: it takes on positive values for most of the sample but it takes on a zero value for a significant proportion of the sample. An appropriate technique in these circumstances is to use a Tobit estimation. The Tobit model is defined as follows:

$$y_i = \beta' x_i + u_i \quad \text{if} \quad \text{RHS}>0$$

$$y_i = 0 \quad \text{otherwise} \qquad ...(5.15);$$

where $\beta$ is a kx1 vector of unknown parameters, $x_i$ is a kx1 vector of known constants, and $u_i$ are independently and normally distributed residuals with mean zero.

Results for the Tobit estimations – with ISCHL the dependent variable – are shown in Table 5.13 for both age subsets. From inspection, it is clear that the logarithmic specification of incomes again provides a better model, and that sex and the education level of the household head are again not significant as explanatory variables. For the full set of 726 individuals, a number of simulations were conducted at the sample means using the coefficients of Model (4a) – which is selected as the preferred model. The probability of receiving an education was 90.5% and the expectation was that a child would get 1.93 years of education. With an increase of one year in age, he or she can expect to receive an additional 0.64 years of education.[22] As education is theoretically available to everyone in the sample, this implies that there is a fairly high drop out rate even if education is commenced. Also, simulations suggest that a child living in a village with a school can expect to get 2.4 years of education compared to 1.4 years received child living in a village without a school.

Finally, the amount of schooling which a child is expected to receive does depend positively on income, as the coefficient on the income variable is positive and significant. To illustrate the impacts of income an other variables, simulations were conducted at two income levels. Recalling that the mean per capita income in the sample is 60,000 CFAF, and that the median is 27,000 CFAF, we can calculate the following expected values for ISCHL (in years):

| | Probability of Schooling | | Expected Years of Schooling | |
|---|---|---|---|---|
| Income Level (CFAF): | 27,000 | 60,000 | 27,000 | 60,000 |
| School in village; living in park | 96.5% | 96.9% | 2.59 | 2.68 |
| School in village; living in buffer zone | 94.8% | 95.4% | 2.34 | 2.43 |
| No school in village; living in park | 84.5% | 86.0% | 1.56 | 1.64 |
| No school in village; living in buffer zone | 79.7% | 81.4% | 1.34 | 1.42 |

It is clear from these results that, the existence of a school locally has considerable bearing on a child's access to education. Those in villages where no such schools are locally available would normally expect to receive less schooling. Also, income does affect the amount of education received. Given that – at the time at which the survey was made – only 6 of the 24 villages surveyed did have schools, income constraints could be a major concern to a large portion of the households in the region. This also suggests that some of the 'hidden' consumption occurs through investing in education.

[22] These are the expected values of ISCHL and include the zeros.

Table 5.13a
Tobit Results for Individual Education Level (4≤Age≤14)

| Dependent Variable: | ISCHL |
|---|---|
| Total Observations: | 726 |
| Limit Observations (at 0): | 215 |
| Non-limit Observations: | 511 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (5a) | (6a) | (7a) | (8a) |
|---|---|---|---|---|
| ISEX | 0.078<br>(0.68) | 0.085<br>(0.74) | | |
| IAGE | 0.682<br>(25.69) | 0.682<br>(25.77) | 0.682<br>(25.81) | 0.682<br>(25.90) |
| IISCHLV | 1.024<br>(7.71) | 1.107<br>(8.22) | 1.043<br>(8.23) | 1.129<br>(8.73) |
| IIINCOME | 0.131E-5<br>(1.73) | | 0.143E-5<br>(1.93) | |
| IILOGINC | | 0.111<br>(3.59) | | 0.113<br>(3.66) |
| IIHHHSCL | 0.015<br>(0.68) | 0.017<br>(0.77) | | |
| DUMIWBZ | -0.284<br>(1.82) | -0.226<br>(1.45) | | |
| DUMIEBZ | -0.291<br>(2.03) | -0.261<br>(1.83) | | |
| DUMIBZ | | | -0.304<br>(2.42) | -0.263<br>(2.09) |
| CONSTANT | -4.283<br>(17.28) | -5.395<br>(12.79) | -4.213<br>(17.94) | -5.327<br>(12.81) |
| Standard error of estimate ($\sigma$) | 1.4338 | 1.4235 | 1.4346 | 1.4243 |
| Log Likelihood (0) | -1438.95 | -1438.95 | -1438.95 | -1438.95 |
| Log Likelihood (Model) | -1046.05 | -1040.97 | -1046.49 | -1041.51 |
| L-R Test (Model) | 785.80 | 795.96 | 784.92 | 794.88 |
| Degrees of Freedom | 7 | 7 | 4 | 4 |
| Critical $\chi^2$ | 14.07 | 14.07 | 9.49 | 9.49 |
| Preferred Model: | | | | ******* |

$\chi^2$ (d.f.=3): 7.81

Table 5.13b
Tobit Results for Individual Education Level (5≤Age≤14)

| | |
|---|---|
| Dependent Variable: | ISCHL |
| Total Observations: | 626 |
| Limit Observations (at 0): | 120 |
| Non-limit Observations: | 506 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (5b) | (6b) | (7b) | (8b) |
|---|---|---|---|---|
| ISEX | 0.090<br>(0.75) | 0.098<br>(0.83) | | |
| IAGE | 0.625<br>(21.89) | 0.626<br>(22.00) | 0.626<br>(22.06) | 0.626<br>(22.17) |
| IISCHLV | 1.035<br>(7.58) | 1.115<br>(8.05) | 1.038<br>(7.95) | 1.121<br>(8.42) |
| IIINCOME | 0.116E-5<br>(1.51) | | 0.129E-5<br>(1.70) | |
| IILOGINC | | 0.107<br>(3.32) | | 0.109<br>(3.39) |
| IIHHHSCL | 0.012<br>(0.50) | 0.013<br>(0.57) | | |
| DUMIWBZ | -0.320<br>(1.98) | -0.264<br>(1.64) | | |
| DUMIEBZ | -0.274<br>(1.84) | -0.239<br>(1.61) | | |
| DUMIBZ | | | -0.308<br>(2.37) | -0.265<br>(2.04) |
| CONSTANT | -3.672<br>(13.45) | -4.752<br>(10.61) | -3.606<br>(13.91) | -4.690<br>(10.64) |
| Standard error of estimate (σ) | 1.4300 | 1.4204 | 1.4311 | 1.4215 |
| Log Likelihood (0) | -1279.17 | -1279.17 | -1279.17 | -1279.17 |
| Log Likelihood (Model) | -1004.38 | -999.96 | -1004.86 | -1000.49 |
| L-R Test (Model) | 549.58 | 558.42 | 548.62 | 557.36 |
| Degrees of Freedom | 7 | 7 | 4 | 4 |
| Critical $\chi^2$ | 14.07 | 14.07 | 9.49 | 9.49 |
| Preferred Model: | | | | ******* |

$\chi^2$ (d.f.=3): 7.81

While the foregoing discussion of the Tobit results concentrated on the 4-14 year age group, similar conclusions can be drawn from the smaller subset of individuals which excludes the 4-year old children. Results for the Tobit estimations on this smaller subset are presented in Table 5.13b. The conclusions are consistent with those for the larger data set.

## § 5.6 Empirical Evidence: Migratory Adjustment in Korup

### 5.6.1 Methodology

The purpose of this section is to characterise the migratory adjustment process in the survey area, and to describe what factors have caused people to move away from their home villages. This is important because – in designing policies which attempt to induce people to migrate – we need to know those factors to which people appear to react. It is normally presumed that people are induced to migrate to higher income areas, but the theory discussed in Section 5.2 indicated that this was not necessarily the case. Income may be a requisite to financing a move or – as was illustrated in the previous section – income may be important for financing education which might subsequently increase an individual's mobility. This section therefore attempts to quantify more precisely how various factors influence an individual's decision to migrate. While a number of demographic factors are of interest, we are particularly concerned with how education levels and income levels influence this decision. Before proceeding with the formal analysis, however, some additional comments regarding methodology are in order.

First, the models described in this section all concentrate on the *individual* migration decision. All models are specified as Probit estimations where the individual either decides to leave (1) or stay (0). This contrasts sharply with most models of migration which attempt to estimate the *flows* of migrants from one area to another. These flow models have the advantage that they require very little detailed data, but they have a disadvantage in that they do not allow one to separate individual characteristics (such as household income) from regional characteristics (such as regional income). The models used here, by focussing on the individual, allow us to isolate the effects of household characteristics in the migration decision. The disadvantage of the individual-based model, however, is that one requires information not only on those individuals which migrated, but also on those which did *not* migrate. The data gathering and management task is thus compounded many-fold, as non-migrants normally far outnumber the migrants. Nonetheless, the survey undertaken for this study does provide such data and – given that the survey approached 100% coverage in those villages where observations were made – meaningful analyses can potentially be undertaken.

While we gain some information about how people respond to individual circumstances, however, we do lose information regarding the factors which *pull* people away from their home villages. It is usually asserted that low income levels at home push people away, whereas high income levels elsewhere pull people away. Many of the empirical studies cited in Section 5.2 found that income differentials paid an important role in describing migrant flows. Such analysis is not available to us with such a Probit specification for two reasons: one practical and one theoretical. The practical reason has to do with migrant tracing: information was gathered on individuals which had left a household some time in the previous five years. But the type of information gathered concentrated on their individual characteristics and the characteristics of the household and village from which they left. Only in 10 out of 407 cases was it possible to trace these migrants to obtain information on the conditions to which they migrated.[23] In any event, even if such data were available for all of the migrants in the sample, a conceptual problem still exists as to how to treat the majority of people who did not migrate.

To see how this conceptual problem arises, suppose, that an individual's decision is based on some decision process depending on a vector of individual characteristics $C_i$, a vector of household characteristics $H_i$, and some opportunity to which he or she would be migrating designated by $Y_i$. Then we can characterise the migration decision for individual i as:

Migrate if and only if $\mathcal{M}_i > 0$, where $\mathcal{M}_i = \mathcal{M}_i(C_i, H_i, Y_i)$ ...(5.16);

where $\mathcal{M}_i$ might be regarded as the marginal utility of migrating. Formulated this way, it is clear that $Y_i$ must include the costs of migrating as well as the returns from migrating. In a Probit specification we observe only an individual's migration decision, $MD_i$, where,

$MD_i = 1$ if $\mathcal{M}_i > 0$;

$MD_i = 0$ if $\mathcal{M}_i \leq 0$ ...(5.17).

The probability $PM_i$ that an individual i will migrate is then given by $P[\mathcal{M}_i > 0 \mid C_i, H_i, Y_i]$, and we estimate by maximum likelihood the model,

$$\mathcal{M}_i = \alpha + \beta_C C_i + \beta_H H_i + \beta_Y Y_i + \varepsilon_i \qquad ...(5.18);$$

where $\varepsilon_i$ is normally distributed with zero mean and unit variance.

The conceptual problem is perhaps now more obvious: although detailed migrant tracing

[23] Of 407 individuals which left their home villages for reasons other than schooling, migrant tracing allowed the identification of the target villages for 53 of them. Income data on the household which they *left* were available for 46 of these, and income data on the household to which they *went* were available for 10 of these 46. Of the 10 migrants which were individually traced, 5 went to higher income households and 5 went to lower income households. Of the 46 for which only village data were available, 24 went to villages with higher per capita incomes, and 22 went to villages with lower per capita incomes.

might yield information regarding $Y_i$ for those who did migrate, it is normally impossible to find out what – if any – opportunity an individual turned down by not migrating. At best we can define some common opportunity $\bar{Y}$ which everyone in the sample has, including those who actually did migrate. We thus address this problem in the following estimations by assuming that $Y_i = \bar{Y}$ for all observations.

It should be noted, however, that some 'opportunities' can be isolated in terms of a household characteristic. In particular, the estimations attempt to take account of household location by introducing dummy variables for location within the sample. These dummy variables allow separation of the WBZ, EBZ, and KNP only, where it is supposed that WBZ is the most isolated and that individuals might have the fewest opportunities (or larger costs in gaining access to those opportunities). Similarly, EBZ is the least isolated and KNP is somewhere in between. While it might seem to have been more desirable to define a distance variable for every village, this option was rejected for a number of reasons. First, there exists a complex tangle of trails throughout the survey area and the trails which are actually used vary considerably depending on time of year, weather conditions, purpose of travel, and general condition of the trail. Second, distance in itself is not necessarily a good measure of isolation as some villages which are quite isolated during high water periods on the major rivers have excellent access during the dry season. Also, actual trail conditions depend a lot on how often they are used, which seems to depend in turn on how much hunting and trading is going on in any given area. Third, there is no obvious central reference point to which distance would be measured as migrants were found to travel in all directions: Nigeria to the west; Nguti to the northeast; and Douala, Limbe or Kumba to the southeast. While using dummy variables as a locational variable does not offer the same resolution as a distance variable, dummy variables have the advantage that they assume no a priori relationship between location and opportunity. For example, given the proximity of the WBZ to Nigeria, it might equally well be argued that the KNP is the most isolated area. Through the dummy variables, such hypotheses can be tested explicitly.

Another major point concerning the methodology is that the procedures here model only the *emigration* decision. In some cases this would be a major weakness, although, for reasons soon to be elaborated, this limitation should not restrict the relevance of the results which are obtained. Many empirical migration models which concentrate on modelling flows actually measure net flows from one region to another. In the context of our problem, assuming that people go to high income areas, an increase in buffer zone incomes might have two direct effects on migration: (i) more people will migrate to the buffer zone; and, (ii) fewer people will emigrate from the buffer zone. By concentrating only on the second effect, we are in a sense understating the impact of any income increase in the buffer zone.

But a number of factors indicate that the first effect will be relatively small; evidence suggests that there is little migration into the region.

First, of the households surveyed, the household head was born in the village in which he or she was currently resident in 85% of the cases, 5% originated from a village within the survey area, and 4% did not say. The remaining 6% – only 21 of the 357 household heads – had actually come from outside the region. Second, migrant tracing suggested that when people left their village, they normally left the region altogether rather than staying in close neighbouring villages. Of 407 people leaving their home village, 87% left the region. Both of these observations are consistent with traditions of land tenure and tribal custom. As was discussed earlier, land is freely available if one stays in one's own village, but must be paid for if one goes to another village. Given that there is little land scarcity in the region, it is not surprising that few people come to this area. Further, although the people have a common background dating back some 300 years, a number of distinct tribal groups exist and definite rifts exist between some groups. While this has not generally developed into aggressive behaviour, individuals tend to stay with their own 'people' in small clusters of villages rather than moving around the region. These institutions highlight the fact that people in the region are not, as a rule, very mobile. If they actually leave, it will normally be to somewhere far enough away that contact is made only sporadically with their home villages.

Finally, although we are investigating the 'event' of an individual migration, it is worth asking whether this event is actually an individual decision – as we have characterised it – or whether it is a household decision. There are two issues of potential empirical interest which I will address here. The first is the actually *decision* which leads to a single household member moving away. One can imagine circumstances in which a household head might decide that one of the household members should go to the city in search of a job, in the hopes that he or she will send money back or open doors for other household members. This decision would probably depend upon a range of household characteristics, opportunity variables, and consideration of the characteristics of each of the household members. Should the smartest ones leave because they have the best chance of finding work? Should the laziest ones leave because they are a drain on the household? How many should go and how many should stay? While it is clear that the household might have different decision criteria than individuals, many of these factors will be captured in the approach which we are using as both household and individual characteristics are included as explanatory variables.

The second issue of household decision-making involves cases where the entire household has moved. Where this occurs to a large extent, there is a serious risk of underestimating emigration because of the lack of information available on the migrants. In the Korup survey, this was not believed to be a problem because the villages were relatively small and the chief or some other elder could normally provide some relevant information in the cases where it did arise.[24]

### 5.6.2 Determinants of Emigration

In conducting the actual estimations of whether any given individual would migrate, the sample of 2619 individuals[25] was split into three separate data sets which were intended to address the following issues:

a) what factors influenced the emigration of young people aged less than 15 years;
b) what factors influenced the emigration of people aged 15 years and over; and,
c) of those 364 individuals aged 15 years and over who did emigrate, did those who moved to urban centres have different characteristics to those who moved to another rural location.

The first two issues were isolated because it was believed that the emigration of those of school age, many of whom were indeed leaving for schooling, would be governed by a different set of factors than those which influenced the rest of the population. While the choice of splitting the data at the 15 year age level was somewhat subjective, it was chosen to correspond to the upper age level of those individuals for which access to education was explicitly modelled in the previous section. The third issue, which relates to the urban-rural split, explores whether the subset of individuals who did decide to migrate had any particular tendency – based on personal or household characteristics – to go to another rural area or to an urban centre.

A definition of the variables used in the migration models, showing as well the means and standard deviation for each subset of data, is provided in Table 5.14. In addition to the explanatory variables which were used in describing access to education, a variable HVINC

[24] In addition, it is noted that the interviewers, during the survey process, also made detailed maps of the villages which located all vacant and abandoned building sites: there were a total of 76 such sites identified. In most cases these sites had belonged to someone else in the village who had chosen to build a bigger house elsewhere in the village. Some sites had been abandoned – according to the village elders – for a period longer than the five-year time horizon set by the survey. Only in 6 cases were the sites actually 'unaccounted for'. Using the average household size of the survey suggests that these sites might account for an additional 30 migrants which were missed: about 7% of the total emigration which was recorded.

[25] This is somewhat less than the total population of 2718 because income characteristics, which were included in the explanatory variables, were available for only 341 of the 357 households surveyed.

Table 5.14
Definition of Migration Variables

| Variable | Definition | Mean | Standard Deviation | n |
|---|---|---|---|---|
| Subset: Individuals: Age ≤ 14 | | | | |
| MIG123 | =1 if individual is normally absent else=0 | 0.16 | 0.37 | 1041 |
| ISEX | Individual's sex (0=F, 1=M) | 0.51 | 0.50 | 1041 |
| IAGE | Individual's age (years) | 6.72 | 3.87 | 1041 |
| IISCHLV | =1 if there is a school in an individual's home village, else =0 | 0.55 | 0.50 | 1041 |
| HINCOME | HH income of individual (CFAF/year per capita) | | | |
| HLOGINC | =ln(HINCOME) | 9.86 | 2.11 | 1041 |
| HVINC | Village income of individual (CFAF/year per capita) | | | |
| LOGVINC | =ln(HVINC) | 10.78 | 0.67 | 1041 |
| HHHHSCL | Schooling of head of HH in which individual lives (years) | 2.29 | 2.83 | 1041 |
| DUMHWBZ | =1 if individual's HH in WBZ else =0 | 0.34 | 0.47 | 1041 |
| DUMHEBZ | =1 if individual's HH in EBZ else =0 | 0.32 | 0.47 | 1041 |
| Subset: Individuals: Age ≥ 15 | | | | |
| MIG123 | =1 if individual is normally absent else=0 | 0.23 | 0.42 | 1578 |
| ISEX | Individual's sex (0=F, 1=M) | 0.49 | 0.50 | 1578 |
| IAGE | Individual's age (years) | 32.69 | 14.58 | 1578 |
| ISCHL | Individual's schooling (years) | 3.10 | 3.36 | 1578 |
| HINCOME | HH income of individual (CFAF/year per capita) | | | |
| HLOGINC | =ln(HINCOME) | 10.07 | 2.16 | 1578 |
| HVINC | Village income of individual (CFAF/year per capita) | | | |
| LOGVINC | =ln(HVINC) | 10.82 | 0.67 | 1578 |
| DUMHWBZ | =1 if individual's HH in WBZ else =0 | 0.28 | 0.45 | 1578 |
| DUMHEBZ | =1 if individual's HH in EBZ else =0 | 0.40 | 0.49 | 1578 |
| Subset: Individual Migrants: Age ≥ 15 | | | | |
| MIGURBAN | =1 if individual left to urban area else=0 | 0.28 | 0.45 | 364 |
| ISEX | Individual's sex (0=F, 1=M) | 0.54 | 0.49 | 364 |
| IAGE | Individual's age (years) | 26.70 | 10.25 | 364 |
| ISCHL | Individual's schooling (years) | 5.40 | 3.83 | 364 |
| HINCOME | HH income of individual (CFAF/year per capita) | | | |
| HLOGINC | =ln(HINCOME) | 10.10 | 2.36 | 364 |
| HVINC | Village income of individual (CFAF/year per capita) | | | |
| LOGVINC | =ln(HVINC) | 10.90 | 0.70 | 364 |
| DUMHWBZ | =1 if individual's HH in WBZ else =0 | 0.11 | 0.32 | 364 |
| DUMHEBZ | =1 if individual's HH in EBZ else =0 | 0.64 | 0.48 | 364 |

has been included in these estimates to represent the average level of per capita income in any particular village. For each of the 24 villages in the sample, a mean village income was calculated and was then specified in the variable HVINC which had dimensions consistent with the particular data subset which was being investigated. In this manner, each individual was assigned a value of HVINC which corresponded to that in the village in which the head of their household lived.

The reasoning behind specifying an additional income variable was to allow the separation of effects which might influence the financing of a move (through household income HINCOME) and effects which might reflect the overall profitability of living in a given village (through village income HVINC). As before, all income variables are specified in logarithmic form,[26] as estimations conducted using the linear form often seemed to suffer from some heteroskedasticity. The reader will note from Table 5.14 that, although the means of the LOGVINC and HLOGINC variables are typically similar, the standard deviations of LOGVINC are considerably smaller than those of HLOGINC. This is because LOGVINC takes on one of 24 values corresponding to the 24 villages, whereas HLOGINC takes on one of 341 values corresponding to the number of households in the survey. Although there clearly exists some collinearity between LOGVINC and HLOGINC,[27] they were nevertheless both introduced in the estimations to investigate whether they had any independent effects on migration.

Results of the first set of estimations relating to individual migration of those of school age are presented in Table 5.15. Using the same coefficient and model selection criteria as those applied in Section 5.5, it is clear that Model (1) is statistically an improvement (at the 5% significance level) over taking a simple mean of the data to decide whether any given individual would emigrate. In this estimation, however, the variables ISEX, HHHHSCL, and DUMIWBZ were all found to be insignificant, and were dropped to arrive finally at Model (3) which was the preferred model of those reported here. The results of this exercise indicate that, for those of school age, an individual will be more likely to leave home if he or she: has no school in their village; has high family income; comes from a village with a low income; or lives in the Eastern Buffer Zone. Furthermore, older children are more likely to emigrate than younger children. In light of previous comments, all of these conclusions seem reasonable.

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[26] For those few households with zero income, HLOGINC was set to zero. Given that non-zero incomes were expressed in CFAF and were generally of the order of many thousands of CFAF, this adjustment was judged to be reasonable.

[27] The correlation coefficient r for these two variables took on values of 0.388, 0.370, and 0.400 for the three data sets used. At a 5% significance level, this would indicate that a pair-wise regression of one variable on the other would prove to be significant.

It seems obvious that a child would be less likely to leave for any reason if there were a school in their home village and, indeed, the presence of such a school decreases the probability from 27.8% to 8.9% (calculated at the means of other variables). But it is clear that children in this age group would not normally be expected to leave unless accompanied by another family member. This would explain why children living in the Eastern Buffer Zone are about three times more likely to leave than those living elsewhere in the region (31% vs 10.7% at the means). We shall see later that this pattern exists for the older age groups as well, and that we might therefore attribute the significance of location here as reflecting this 'accompanied' emigration.

The results also show that we were justified in using the two income variables: they are both significant yet of opposite sign. High family income increases the probability that a given child will emigrate, whereas high village income reduces this probability. Intuitively this makes sense in light of the analysis in Section 5.5 which suggested that children are more likely to get an education with higher family income. In cases where there is no school available this would suggest that they would have to emigrate. With respect to village income, however, it reflects the fact that children from villages with high incomes are less likely to have someone available to accompany them as most of the older generations will be happy staying where they are.[28] The data also suggest that changes in village income would have a much greater effect on mobility than would changes in household income. To see the impact of changes in income, the following simulation results are relevant for those under 15 years of age:

| Case | Probability of Emigrating |
|---|---|
| Base Case (Sample Means) | 15.7% |
| Double Household Income | 17.1% |
| Double Entire Village Income (incl. HH) | 10.8% |

The 'pull' effect of higher local incomes in this case clearly offsets any of the 'push' effects which higher incomes might contribute to a household's ability to finance a move.

[28] Alternately, it might reflect a 'friends and relatives' effect. Low village incomes mean (as will be demonstrated later) that more people will leave and, as such, it is perhaps more likely that a child can be sent away to school or to live with someone outside of the village. To test this hypothesis, estimations were conducted with two additional explanatory variables: IFRIENDH – to reflect the number of 'other' household members which had left; and IFRIENDV – to reflect the number of 'other' village members which had left. These were used for all three general cases (<15 years; >14 years; urban) and were found to be insignificant in all of them with the exception that IFRIENDH was positive and *almost* significant (t=1.9) when added to the >14 case. In that case, however, it probably reflects the fact that people tend to leave home in the company of another family member.

Table 5.15
Probit Results for Individual Migration (Age≤14)

| | |
|---|---|
| Dependent Variable: | MIG123 |
| Total Observations: | 1041 |
| Observations at 0: | 874 |
| Observations at 1: | 167 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (1) | (2) | (3) |
|---|---|---|---|
| ISEX | 0.037<br>(0.36) | 0.040<br>(0.39) | |
| IAGE | 0.113<br>(7.86) | 0.114<br>(7.97) | 0.114<br>(7.98) |
| IISCHLV | -0.744<br>(6.39) | -0.758<br>(6.69) | -0.755<br>(6.87) |
| IILOGINC | 0.079<br>(2.50) | 0.076<br>(2.45) | 0.076<br>(2.45) |
| LOGVINC | -0.419<br>(4.75) | -0.414<br>(4.72) | -0.412<br>(4.75) |
| IIHHHSCL | -0.011<br>(0.55) | | |
| DUMIWBZ | -0.006<br>(0.04) | -0.013<br>(0.09) | |
| DUMIEBZ | 0.758<br>(6.23) | 0.754<br>(6.21) | 0.748<br>(7.07) |
| CONSTANT | -3.090<br>(11.06) | 2.085<br>(2.21) | 2.097<br>(2.23) |
| Log Likelihood (0) | -458.43 | -458.43 | -458.43 |
| Log Likelihood (Model) | -367.36 | -367.51 | -367.59 |
| L-R Test (Model) | 182.14 | 181.84 | 181.68 |
| Degrees of Freedom | 8 | 7 | 5 |
| Critical $\chi^2$ | 15.51 | 14.07 | 11.07 |
| Preferred Model: | | | ******* |

$\chi^2$ (d.f.=1): 3.84
$\chi^2$ (d.f.=2): 5.99
$\chi^2$ (d.f.=3): 7.81

Table 5.16
Probit Results for Individual Migration (Age≥15)

| | |
|---|---|
| Dependent Variable: | MIG123 |
| Total Observations: | 1578 |
| Observations at 0: | 1214 |
| Observations at 1: | 364 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable | (4) | (5) |
|---|---|---|
| ISEX | -0.072 | |
| | (0.87) | |
| IAGE | -0.016 | -0.016 |
| | (4.53) | (4.88) |
| IISCHL | 0.119 | 0.114 |
| | (8.57) | (8.96) |
| IILOGINC | 0.028 | 0.027 |
| | (2.41) | (2.38) |
| LOGVINC | -0.116 | -0.115 |
| | (2.92) | (2.90) |
| DUMIWBZ | -0.359 | -0.362 |
| | (3.15) | (3.18) |
| DUMIEBZ | 0.500 | 0.506 |
| | (5.55) | (5.62) |
| CONSTANT | 0.251 | 0.256 |
| | (2.91) | (2.90) |
| Log Likelihood (0) | -852.26 | -852.26 |
| Log Likelihood (Model) | -694.05 | -694.43 |
| L-R Test (Model) | 316.42 | 315.66 |
| Degrees of Freedom | 7 | 6 |
| Critical $\chi^2$ | 14.07 | 12.59 |
| Preferred Model: | | ******* |

$\chi^2$ (d.f.=1): 3.84

The next set of estimation results deals with the 1578 people in the survey sample aged 15 or over for whom income and demographic data were available. Of these, 364 had made the decision to emigrate. As indicated in Table 5.16, the individual's sex was found to be insignificant as an explanatory variable, and Model (5) was selected as the preferred model of those tested. It has an LR test statistic of 315.66 which allows us to reject comfortably the null hypothesis (critical $\chi^2$=12.59) that the estimation is the same as using a simple constant (which in this case would be 0.23) for the probability of emigrating. The decision to emigrate is influenced by individual and household characteristics.

With respect to personal characteristics, the results show that individuals with more schooling are more likely to emigrate. At the sample means, the probability that an individual will migrate is 21.6%; increasing schooling by one year will increase that probability to 25.1%. These results confirm other empirical studies which suggest that education does increase mobility. Also consistent with other empirical studies, the data confirm that young folk are more likely to emigrate than their elders.

With respect to income, both income variables again test significant, and village income again has a greater influence on mobility than does household income. The coefficients are again of opposite sign, suggesting that household income does actually appear to be a barrier to leaving, although individuals in low income villages are more likely to emigrate. We can again see the impact of changes in income through the following simulation results for those at least 15 years of age:

| Case | Probability of Emigrating |
|---|---|
| Base Case (Sample Means) | 21.6% |
| Double Household Income | 22.2% |
| Double Entire Village Income (incl. HH) | 19.9% |

Finally, the location dummy variables suggest that those in the Eastern Buffer Zone are the most mobile and those in the Western Buffer Zone are the least mobile. Any of a number of conditions might generate this result. Possible reasons, however, for the higher mobility of people in the EBZ include better access to information, lower real costs of moving, or better access to home support groups if they do move. Unfortunately, the data do not allow us to test any of these hypotheses explicitly.

The final Probit estimations which were undertaken were on the subset of 364 individuals in the previous group who actually did move. In all of these cases, the survey determined to where they had moved and it was thus possible to categorise this migration as either rural-rural or rural-urban. The raw statistic that only 28% of the migration was to cities or major towns is in itself of interest empirically, as it is often assumed that most people leave to the cities when they leave the country-side. This assumption is in this case not true, as most of the emigration was rural-rural.

The hypotheses which we wish to test at this stage again involve the significance of various individual and household characteristics on whether an individual moves to the city or to another rural area. Results of the estimations are shown in Table 5.17. While the LR statistics are not very high in any of these models, they do nonetheless indicate that they are better than taking a simple average. Model (7) is better than model Model (6), however, as the LR test for adding the 2 variables of age and DUMIWBZ provides a test statistic of $LR_{67}$=0.32 and (with a critical $\chi^2$=5.99) we would accept the null hypothesis that these two variables add no additional explanatory power. Similarly, we accept the hypotheses that the two income variables add no explanatory power to Model (8), and we are left with Model (8) as the preferred structure of those tested.

The results are quite interesting, in that they again support the idea that those with more education are more likely to migrate to the city rather than to another rural location. Also, in this sample, women were more likely to migrate to the cities and towns and men were more likely to migrate to another rural area. Again, this is consistent with fears (and at times pride) expressed by the household heads that young women would leave and were leaving for the cities and towns to become prostitutes. Finally, the empirical results also show that those in the EBZ were more likely to move to the city than those in either the WBZ or the KNP.[29]

[29] Results of simulations at the sample means which reflect these statements are:

| Case | Probability of Emigrating |
|---|---|
| Base Case (sample means) | 26.8% |
| Base Case plus 1 Year Education | 29.7% |
| Base Case (Women) | 34.7% |
| Base Case (Men) | 20.9% |
| Base Case (EBZ) | 34.7% |
| Base Case (WBZ or KNP) | 15.5% |

Table 5.17
Probit Results for Individual Migration to Urban Centres (Age≥15)

| | |
|---|---|
| Dependent Variable: | MIGURBAN |
| Total Observations: | 364 |
| Observations at 0: | 263 |
| Observations at 1: | 101 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable | (6) | (7) | (8) |
|---|---|---|---|
| ISEX | -0.407 | -0.419 | -0.416 |
| | (2.51) | (2.63) | (2.62) |
| IAGE | -0.003 | | |
| | (0.33) | | |
| IISCHL | 0.082 | 0.083 | 0.081 |
| | (3.75) | (3.93) | (3.86) |
| IILOGINC | -0.026 | -0.027 | |
| | (0.77) | (0.79) | |
| LOGVINC | 0.094 | 0.092 | |
| | (0.81) | (0.79) | |
| DUMIIWBZ | -0.141 | | |
| | (0.46) | | |
| DUMIEBZ | 0.562 | 0.598 | 0.622 |
| | (2.94) | (3.58) | (3.76) |
| CONSTANT | -1.907 | -1.994 | -1.261 |
| | (1.61) | (1.70) | (7.13) |
| Log Likelihood (0) | -214.96 | -214.96 | -214.96 |
| Log Likelihood (Model) | -194.65 | -194.81 | -195.25 |
| L-R Test (Model) | 40.62 | 40.30 | 39.42 |
| Degrees of Freedom | 7 | 5 | 3 |
| Critical $\chi^2$ | 14.07 | 11.07 | 7.81 |
| Preferred Model: | | | ******* |

$\chi^2$ (d.f.=2): 5.99
$\chi^2$ (d.f.=4): 9.49

### 5.6.3 Effects of Incentive Programmes

The impetus behind conducting the analysis of migratory behaviour was ultimately to determine if increasing incomes in the buffer zone would indeed decrease pressures on the forest. The general results from the empirical work suggest that an increase in buffer zone incomes would – other things equal – decrease the probability that any given individual will leave the region. Given as well that people in the buffer zone are to some extent responsible for some of the non-sustainable forest uses, one would expect that income increases in the buffer zone would *increase* pressures on the forest. To provide some quantitative estimate of the connection between income and forest use, we shall conduct some simulations using the model results derived in this chapter.

First, however, it is useful to outline the theoretical basis of such simulations. Recall from Table 5.1 that any changes in pressure on the forest can be represented as:

$$\Delta F = \Delta N_b \left(\theta_b Y_b - \psi\theta_p Y_p - [1-\psi]\theta_c Y_c\right) \qquad \text{...(5.19)},$$

where we have defined $\psi$ – the proportion of the migrants coming from the protected area – as $\psi = -\Delta N_p / \Delta N_b$. While one can go into considerable detail analysing this, I shall limit myself here to a simple illustrative analysis.

First, we note that an increase in buffer zone incomes (region b) should not affect population exchange between the other two regions (p and c). In addition, because of institutional constraints and traditional systems of land tenure, it was observed that there was very little opportunity for intra-regional migration. This implies that $\Delta N_p = 0$ and, therefore, $\psi = 0$. If we note further that those outside the park and buffer zone do not hunt in Korup, then $\theta_c = 0$, and Equation (5.19) simplifies to:

$$\Delta F = \Delta N_b (\theta_b Y_b) \qquad \text{...(5.20)}.$$

If we now assume further that income support will be for non-hunting activities and that per capita hunting income ($\theta_b Y_b$) remains constant,[30] then – within the buffer zone – we can estimate the elasticity of forest use to changes in income as:

$$\varepsilon_{FY} = \frac{\Delta F/F}{\Delta Y_b/Y_b} = \frac{\Delta N_b/N_b}{\Delta Y_b/Y_b} \qquad \text{...(5.21)}.$$

Next, we decompose the population change in the buffer zone into the following components:

$$\Delta N_b = -M_{bc} + M_{cb} - M_{bp} + M_{pb} \qquad \text{...(5.22)};$$

where $M_{ij}$ is the flow from region i to region j. We have already noted the lack of intra-

[30] It should be emphasised that $\theta_b Y_b$ is held constant so when $Y_b$ goes up $\theta_b$ goes down proportionately. See also footnote 2 of this chapter.

regional migration, implying that $M_{bp}=M_{pb}=0$. In addition, however, these same constraints generally prevent individuals from entering the buffer zone from the outside so that we can safely assume that $M_{cb}=0$ in response to any change in income in the buffer zone region. This implies that Equation (5.22) reduces to:

$$\Delta N_b = -M_{bc} \qquad ...(5.23),$$

which reflects the fact that (apart from births and deaths) population will fall only through higher emigration or increase through reduced emigration to the outside world. But the reader will note that the individual migration 'events' which were being modeled in this chapter were those which contribute to $M_{bc}$. If we can link these migration decisions to the actual population levels, then we have a means of estimating the changes on forest use.

To address this, we shall abstract from the time period over which changes in population occur and simply estimate the extent of the comparative static shift in population in response to a change in income. Consider, for example, some total source population $N_t$ which has a probability P of being absent from the buffer zone at income level Y, and a probability P+ΔP of being absent at income level Y+ΔY. As the actual population 'present' in the buffer zone is $N_b=(1-P)N_t$, we can approximate the change in population as,

$$\Delta N_b = -\Delta P N_t = \frac{-\Delta P N_b}{(1-P)} \qquad ...(5.24);$$

and Equation (5.21) now becomes:

$$\varepsilon_{FY} = \frac{-\Delta P/(1-P)}{\Delta Y_b/Y_b} \qquad ...(5.25).$$

Using the models in this chapter to simulate changes in incomes, this elasticity can readily be approximated.[31] The results of these simulations are presented in Table 5.18.

In conducting the simulations, we concentrate on household and income characteristics in the Eastern Buffer Zone, as it is assumed that most of the development incentives will be targeted to this area. We separately model the effects of a 30% income change on the two age groups (≤14 and ≥15) and aggregate the results by noting that about one-third of the population in the EBZ is 14 or under.

Case I reflects the impacts of increasing incomes by 30% to all households in the EBZ. Results indicate that the probability of being absent falls by 1.7%, which implies in turn that the elasticity of forest use to income, $\varepsilon_{FY}$, is just under +0.1 if one assumes that the only adjustments which occur are through changes in migration behaviour.

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31 Given that P has been defined as the probability of being *absent*, it is clear that an equivalent interpretation of this is the income elasticity of the probability of being present:

$$\varepsilon_{FY} = \frac{\Delta P'/P'}{\Delta Y_b/Y_b}$$

where $P'=1-P$.

Pearce, D. and R.K. Turner. (1990) *Economics of Natural Resources and the Environment*, Hertfordshire: Harvester Wheatsheaf, 378 pp.

Pearsall, S. (1984) "In Absentia Benefits of Natural Preserves: A Review", *Environmental Conservation*, **11**, no 1, pp. 3-10.

Pearson, P.J.G. and P. Stevens. (1989) "The Fuelwood Crisis and the Environment: Problems, Policies and Instruments", *Energy Policy*, Special Issue, **17**:2, April, pp. 132-137.

Perrings, C.A. (1988) "An Optimal Path to Extinction? Poverty and Resource Degradation in the Open Agrarian Economy", *Journal of Development Economics*.

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Peterson, George L and Alan Randall. (1984) *Valuation of Wildland Resource Benefits*, Boulder, Colorado: Westview Press, 258 pp.

Pigou, A.C. (1947) *A Study in Public Finance*, London: McMillan.

Pisias, N.G. and N.J. Shackleton. (1984) "Modelling the Global Climate Response", *Nature*, **310**, pp. 757-759.

Pister, E.P. (1979) "Endangered Species: Costs and Benefits", *Environmental Ethics*, **1**, pp. 341-352.

Porter, R.C. (1982) "The New Approach to Wilderness Preservation through Benefit-Cost Analysis", *Journal of Environmental Economics and Management*, **9**, pp. 59-80.

Prance, Ghillean T. (1985) "The Pollination of Amazonian Plants", in G.T. Prance and T.E. Lovejoy (eds.) *Key Environments: Amazonia*, Oxford: Pergamon Press, pp. 166-191.

Prance, Ghillean T. (ed.) (1986) *Tropical Rainforests and the World Atmosphere*, New York: American Association for the Advancement of Science, 105 pp.

Praween, P., T. Tavatchai, and R.J. Dobias. (1988) *Using Economic Incentives to Integrate Park Conservation and Rural Development in Thailand*, Paper presented at Workshop on Economics, IUCN General Assembly, 4-5 February, Costa Rica.

Prescott-Allen, Robert and Christine Prescott-Allen. (1982) *What's Wildlife Worth?*, Nottingham: Earthscan, 92 pp.

Prescott-Allen, Robert and Christine Prescott-Allen. (1983) *Genes from the Wild: Using Wild Genetic Resources for Food and Raw Materials*, Nottingham: Earthscan, 101 pp.

Price, Colin and C.T.S. Nair. (1984) "Cost-Benefit Analysis and the Consideration of Forestry Alternatives", *Journal of World Forest Resource Management*, **1**, pp. 81-104.

Principe, Peter P. (1988a) *The Economic Value of Biological Diversity among Medicinal Plants*, Paris: OECD.

A second simulation was conducted which provides some indication of the effects of education on forest use. Empirical results suggested that an increase in incomes would lead to higher levels of schooling. But the migration model indicated that higher levels of education increased the probability that an individual would leave the region. One might therefore expect some long-term effect which links current access to education to future levels of migration. The simulation in Case II provides a rough calculation of the potential order of magnitude of such effects, assuming essentially that the increased education levels of the current 'young' generation are translated into a similar increase in future older

Table 5.18
Effects of Increasing Buffer Zone Incomes

**Base Case**
Eastern Buffer Zone
Initial Income ($Y_b$) = 32,000 CFAF per Capita (EBZ Median)
Other Variables at Sample Means as in Tables 5.10 and 5.14

| | Age Group ≤14 | Age Group ≥15 | All |
|---|---|---|---|
| Proportion of Individuals in Age Group | 0.35 | 0.65 | 1.00 |
| **Impact Case I: Increase Incomes by 30% Excluding Education Response** | | | |
| Base Case Probability of Being Absent ($P_o$) | 38.6%[1] | 37.4%[2] | 37.8% |
| Impact Case Probability of Being Absent ($P_1$) | 35.3%[1] | 36.5%[2] | 36.1% |
| Change in Probability of Being Absent ($\Delta P = P_1 - P_o$) | -3.3% | -0.9% | -1.7% |
| Elasticity of Forest Use to Income $\left(\frac{-\Delta P/[1-P_o]}{\Delta Y/Y}\right)$ | +0.180 | +0.047 | +0.093 |
| **Impact Case II: Increase Incomes by 30% Including Education Response** | | | |
| Base Case Expected Education (years) | 1.900[3] | 3.100[4] | |
| Impact Case Expected Education (years) | 1.927[3] | 3.127 ⇑ | |
| Change in Expected Education (years) | +0.027 ⇒ | +0.027 | |
| Base Case Probability of Being Absent ($P_o$) | 38.6%[1] | 37.4%[2] | 37.8% |
| Impact Case Probability of Being Absent ($P_2$) | 35.3%[1] | 36.7%[2] | 36.2% |
| Change in Probability of Being Absent ($\Delta P = P_2 - P_o$) | -3.3% | -0.7% | -1.6% |
| Elasticity of Forest Use to Income $\left(\frac{-\Delta P/[1-P_o]}{\Delta Y/Y}\right)$ | +0.180 | +0.040 | +0.089 |

Notes:
(1) Uses Model (3) in Table 5.15.
(2) Uses Model (5) in Table 5.16.
(3) Uses Model (8a) in Table 5.13a.
(4) Based on Sample Mean in Table 5.14.

the region. While households in the park were more reliant on hunting than those outside the park, substantial hunting activity still occurred by individuals living outside of the park. Given the management goals of the park, it is contemplated that some regional development programme be initiated in the buffer zone to induce individuals out of the park and to give them something better to do than hunt. This chapter concentrated on what effect an income support policy might have in the area.

Income support policies were available in the first instance through mechanisms which supported either conventional cash crop activities or traditional forest gathering activities. A study of income distribution indicated that there is a large amount of inequality in the region. A decomposition of income distribution suggests that supporting traditional forest gathering activities will decrease income inequality in the region, and that supporting conventional coffee and cocoa cash crops will increase income inequality.

Supplementary analyses were undertaken to determine what, if any, relationship existed between incomes and education. In spite of the unequal income distribution, observations made during the survey process did not suggest large differences in consumption patterns. One suggestion for this discrepancy was that income was being capitalised in less visible assets. Although there was some correlation between income and farm land, this was not believed to account for the discrepancy as farm land is for most purposes a free good in the survey area. A study was hence made of education levels as, in Cameroon, families are required to pay most of the current expenses of their children's education. These studies confirmed that those children from higher income households were generally more likely to get an education, and that the amount of schooling which they eventually received was also positively dependent on their household income.

Migratory behaviour was modeled to determine if individuals with certain types of characteristics were more likely to migrate than others. School aged children were most likely to emigrate if they came from high income households, low income villages, or lived in a village without a school. Other individuals in the sample were most likely to emigrate if they had an education, came from high income households, or came from low income villages.

The effect of incomes on mobility is often discussed in the literature and there is no *a priori* reason for believing that increased income in a region will decrease emigration from that area. The model used in this study – which focuses on individual and household characteristics – allows us to separate potential effects from increasing income in the region. First, higher incomes in a region will make it easier for individual households to move – perhaps either to cover costs or to provide income security. Second, higher incomes in a region will create an incentive to stay. Both of these effects were measured in the sample and were found to be significant, although the incentive effect which holds people in a high income region exceeds the effect of higher incomes on increased labour mobility. Thus, any increase in regional income will tend to hold people there more strongly. A third effect also occurs, however, which in principle increases long-term mobility. This relates to a response through the education mechanism. Increased incomes would improve access to education for children, which would in turn make them more likely to emigrate in the future. Simulation results suggest, however, that this effect is small in relation to the direct effects of higher incomes.

An analysis of the specific data for migratory adjustment around Korup National Park suggested that an income support programme in the Eastern Buffer Zone would actually increase net pressures on the park if one relied purely on the migratory adjustment process. Increased income will have the effect of decreasing emigration from the area and the added population will thus increase non-sustainable pressures such as hunting. This result presumes that there is no switching of activities from hunting to other activities, which will be the subject of study in Chapter 6.

In addition to the empirical results arising from this study, a number of comments can also be made regarding the methodologies employed.

First, the chapter demonstrates the feasibility and usefulness of using household survey data for analysing problems relating to conservation and economic development. Surveys of the type used in this analysis are often conducted as an integral part of a socio-economic study process aimed at describing some baseline conditions before the implementation of a conservation or development programme. Such studies are not usually analysed in detail because they are often thought to be too noisy to be of any use. While reducing the data into a manageable format is by no means trivial, the task seems to be worthwhile given that important insights can be generated which will assist in policy design.

Second, although the concept of a buffer zone was designed primarily as a management tool to facilitate policy design and implementation around a conservation programme, it has also proven to be a useful analytical concept. Because physical conditions are often different outside a primary rainforest than they are inside the forest, activities which are pursued outside the rainforest may be constrained inside, or vice versa. Through disaggregating and analysing data on the basis of various physical zones, insights can be gained which would not be obvious from an aggregated data set. It was noted, for example, that residents in the Eastern Buffer Zone area of Korup would – all other things equal – be more likely to emigrate than those in the rest of the sample and, if they were to emigrate, they were more likely to go to an urban area than were those in the rest of the sample.

Finally, the process of using *individual and household characteristics* as a basis for modelling migratory behaviour was particularly fruitful. In addition to its theoretical appeal – that decisions are ultimately made at the individual or household level – the empirical results which were generated could be reconciled intuitively through a knowledge of existing institutional structures in the region. Further, the results were often consistent with those generated by aggregate analyses of migratory flows – for example, that people are more likely to migrate if they are young and educated. More significantly, however, modelling the migration process at this level allowed us to isolate the two potential effects of income on migration. Whereas aggregated analyses of flows allows us only to investigate the effects of regional income levels, the use of household survey data sheds light as well on how household income influences emigration decisions.

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# CHAPTER 6
# DEVELOPMENT INCENTIVES AND HUMAN INTERACTION WITH THE FOREST: HUNTING IN KORUP

## § 6.1 Introduction

Much of received economic theory is based on ideas that individual agents somehow make choices in a fashion that maximise their utility. It requires little intuition to conclude that, all other things equal, individuals might prefer high income jobs over low income jobs. It should come as little surprise, therefore, that a common approach suggested for stopping people from working in activities which hurt the rainforest biome – such as hunting – is to give them something better to do which generates higher incomes in an alternative activity which does not hurt the rainforest. This straightforward logic is so compelling that planners seem to give little second thought to whether the provision of an alternative source of income might not increase pressures on the biome.

Nonetheless, economic theory is ambiguous over how changes in compensation affect activity. A simple formulation for the Slutsky equation for labour supplied to a particular activity suggests this ambiguity. For example, where h are the number of hours of activity, w is the hourly wage, and y is the income level, we know that for a utility maximising individual:

$$\frac{dh}{dw} = \left.\frac{\partial h}{\partial w}\right|_{u=0} + h\frac{\partial h}{\partial y} \qquad \text{...(6.1)},$$

where the first term on the right hand side measures a substitution effect and the second is the income effect. As labour is supplied while leisure is demanded, the sign of the substitution effect is positive and, if leisure is a normal good, the sign of the income effect is negative. The net effect of any change in wages on the effort dedicated to the activity is hence indeterminate. While this can arise even where there is only one productive activity (labour) and one unproductive activity (leisure), extending the problem to cases where multiple potential productive activities exist – such as in the rainforest area of Korup – does little to simplify the issue.

If we concentrate more specifically on hunting activity, we might expect the time ($h_H$) which an individual dedicates to hunting will depend on the hunting 'wage' ($w_H$), the wages from other sources ($w_O$), the household income ($y$), and a range of individual and household characteristics ($C_i$):

$$h_H = h_H\{w_H; w_O; y; C_1, C_2, \ldots, C_n\} \qquad \text{...(6.2)}.$$

The intuitive argument contained in the first paragraph focuses on the assertion that increases in $w_O$ will lead to decreases in $h_{H}$. But there is no *a priori* reason for believing that individuals will actually decrease their hunting activities just because we give them something better to do; a change in $w_O$ could affect one of the other variables in a manner which will increase $h_{H}$. If, for example, hunting is regarded as complementary with leisure, then increases in other income sources might in fact increase hunting effort: implying that hunting was a normal good in demand with a positive income elasticity. This might apply even if hunting yielded no financial return (i.e., $w_H$=0). Once again, although the theory provides a useful framework for discussing the problem, some empirical research is required to verify any presumption that increasing household incomes will in fact promote conservation.

An additional ambiguity arising from the economic theory has more to do with the basic assumption that individuals or households are maximising utility. In the case of hunting, it is worth asking whether people indeed try to maximise anything, and whether what they are maximising can be expressed by some profit or utility function.[1] Some observers (Anandu, et. al. (1988), Hart and Hart (1986), Martin (1983)) point out that in many cases hunting has certain spiritual or cultural elements which go beyond the apparent economic or physical needs of a society. In West African rainforest areas, those in the Korup area included, ancestors' spirits are believed to reside in the animals of the forest and hunting certain animals is often regarded as a show of reverence for these ancestors. Further, as hunting is generally regarded as a skill which must be learned over a considerable length of time, as well as something which must be practised on an on-going basis to maintain one's proficiency, models which rely on short-term utility maximisation might not adequately explain observed behaviour.

Irrespective of the economic theory, however, experience suggests (Child [1988]; McNeely [1988]) that hunters in traditional cultures do react to economic incentives or disincentives in regulating the level of their hunting activity. Informal interviews with hunters undertaken for this research, as well as by Infield (1988) in independent work, revealed a number of reasons for why people hunted. Hunting provides both cash income and meat for the household, and many hunters regard it as an activity which elevated their stature in the village. Although some complained that it was hard work which kept them away from home, others claimed that it was an enjoyable activity and seemed to relish the time spent

[1] A related empirical question is whether the behaviour which is observed can be reconciled with the maximisation of a particular utility function. In practice this is referred to as the 'integrability problem' and it involves deriving a utility function from some given functional specification. The economic literature addresses this issue at length (see, for example, Stern [1986] for a review of the attributes of a number of functional specifications), but the general thrust of it is that one can use whichever of the supply function, indirect utility function, or direct utility function is most convenient; the others can be imputed as long as certain conditions apply (primarily, as shown by Hurwicz and Uzawa [1971], that the Slutzky matrix is negative semi-definite and symmetric).

away. Further, many believed that it assisted in controlling animal pests on their farms, and that they therefore generated some benefits to themselves as well as to fellow farmers by controlling such pests. While such information does not specifically give us direction as to what policies would be optimal to control hunting behaviour, it does provide a basis for more rigourous investigations into why individuals hunt.

Given that hunters often expressed some economic motivation (cash, food, pest control) for hunting, a multivariate analysis can provide some important insights into how hunters might react to conservation incentives. Also, in the particular case of Korup, we are interested in knowing whether policies which increase people's incomes are likely to increase or decrease hunting pressures on the forest. Accordingly, the purpose of this chapter is to investigate – using the household survey data – whether and how incentives can induce individuals to pursue activities which promote rainforest conservation.

To this end, Section 6.2 provides an analysis of the forest use and income data for the Korup National Park area in Cameroon. The results in this section rely solely on an estimation of a model using a single equation probit specification. A closer look at the hunting activity and income linkages is provided in Section 6.3 using a tobit model and a double hurdle model. The purpose of this section is both to evaluate the robustness of the results from the simple probit specification and to compare the effectiveness and usefulness of various applied econometric techniques for our problem. Conclusions relating to the theory and the individual empirical findings are presented in 6.4.

## § 6.2 Korup National Park Revisited

### 6.2.1 Hunting in Korup

Results from the household survey indicated that one third of the households surveyed in 1988 in the Korup National Park area were involved in hunting, and that hunting represented some 12% of household cash income. As such, it was the third most important single activity in terms of its contribution to household income, after cocoa production and bush mango gathering. Given the seasonality of cocoa harvesting, and given further that traditional forest gathering activities are undertaken primarily by women and children, hunting ranks high as a year-round activity for adult males.

Hunting is of policy concern because, as noted in Chapter 5, it is the only activity which is apparently being conducted non-sustainably and which directly threatens the existence of currently endangered species. Policies involving taxation of inputs or output are not feasible as most of the inputs are smuggled in from Nigeria and, similarly, about 90% of the meat from the hunting is exported illegally to Nigeria. The effectiveness of policing is limited by the availability of qualified personnel. Other mechanisms often used to control hunting – such as tags or quotas – provide considerable management problems in this instance: most of the animals hunted are too small to tag, and quotas can normally only be established once accurate population estimates are available. Matters are complicated by the fact that some of the primates and deer being hunted are endangered whereas others are in apparent abundance, yet identification of a particular species is normally possible only after a kill is made. To reduce pressure on the endangered species hence requires a reduction in the total hunting effort. As noted in Chapter 5, the provision of alternative income sources is often regarded as a potential means for reducing hunting pressures.

If we are interested in knowing how much time any individual is going to spend hunting, a natural question we might ask is "what is the production function for hunting?" To answer this question fully, however, would require fairly exact accounting of all of the inputs and output from hunting. The most rigourous investigation of such a type was conducted by Infield (1988), and based on observations conducted during about half a year of hunting parties, he found that the activity could probably best be defined as a constant returns to scale activity in the short run, requiring variable inputs of carbide, cartridges and labour. Hunters typically travelled in groups, although smaller groups were proportionately no more or less successful than larger groups. Similarly, short trips were proportionately no more or less successful than long trips. The only fixed requirements were guns, and trips could be extended to almost any length by using young boys to shuttle meat and provisions between the hunting parties and their home villages. On this basis, one would, formally, expect that an individual would keep on hunting until the marginal disutility of his effort exceeded the marginal utility of the net income from hunting. Chayanov (1966) argued that individuals are more likely to maximise their own utility rather than profits from a given exercise. This argument is particularly relevant here where the expected marginal profit remains positive for any apparently feasible level of activity. As simple observation indicates that not everybody hunts all of the time, it is clear that there is some process (or set of processes) occurring which limits hunting to current levels.

In addition to the supposed marginal disutility which is eventually involved with hunting[2], there do exist barriers to participation. First, each village has traditional hunting areas which, although they often overlap each other, are respected throughout the region. As

[2] Many hunters complained that they did not enjoy hunting because it was hard work and they were away from home nine or more months of the year, yet they acknowledged that they also enjoyed the life and that, without it, they would probably have to help on the family farm.

such, these hunting areas are perhaps more properly described as 'common property' rather than 'open access' resources. Second, hunting is a skill which is acquired over many years which commence in a boy's childhood. The passing on of these skills between generations is acquired through an apprenticeship which includes teaching the hunter a number of 'magical' feats which improve his abilities.[3] Finally, there is some potential financial barrier to entry in that one needs a gun to hunt, and these are normally purchased from Nigerian traders.

### 6.2.2 Data and Methodology

The data on which the analyses are based were taken from the household survey discussed in Chapter 5 and in the Appendix. The single equation models were applied to households rather than individuals. This is both because there was no information available on individual hunting efforts, and the observation that household income was at times aggregated for the general use of the entire household. It is important to note that – for a number of reasons – the hunting data addressed in this chapter excludes trapping activities. First, almost everybody having a farm would also do some trapping to control pests near the farm. Second, these pests were rodents such as moles or the African Grasscutter (locally called a 'cutting grass'), and the level of trapping being conducted is not regarded as being detrimental to the forest. As the conservation concern focused on non-sustainable activities, exclusion of the trapping activities allowed a finer focus.

The dependent hunting variable takes on a number of forms. The original raw data contained three potential types of information. It identified those households where nobody hunted with a 'zero', it identified those households which hunted a small amount for their own purposes only with a 'one', and it identified all active hunting households with a figure representing the net income (in CFAF) from hunting.

[3] The most obvious example of this is that people claim that good hunters can draw on the animistic spirits of their ancestors to turn themselves into the animals which they are stalking. A hunter stalking a duiker can thus turn *himself* into a duiker, approach his prey without distressing it, and then turn back to human form to kill it at close range. As might be expected, however, hunters sometimes end up mistakenly shooting other hunters with this alleged ability and therefore, in most cases, accidental shootings are not punished as the party responsible could not reasonably be expected to distinguish between a fellow hunter in duiker form and a real duiker. This tradition also automatically implies that any hunter accidentally wounded or killed must have been a 'good' hunter, as he must have been transformed into an animal at the time!

most people in the region contend that Erat is well known for its hunting prowess.

Income from the household, in the estimations contained in this chapter, included net income from all sources *excluding hunting*. This approach was taken as a simple expedient to removing potential simultaneity. It is noted that, in the usual structural models of labour supply, it is the outside wage rate ($w_0$) rather than income which is exogenous to the hunting decision; the absence of $w_0$ from the specification merits some remarks. Although the lack of data was a relevant constraint,[5] its exclusion is not necessarily serious. First, if the other income accrues primarily to household members who could not hunt – which is certainly the case for the forest product gathering and manufacturing tasks pursued by children and women – then such income is exogenous to the problem (faced by men) of how much time to spend hunting. Second, as we are dealing with a relatively small area, it might not be unreasonable to assume that – when a hunter hunts – the wage rate foregone, whatever it is, is common across households. In the cross-sectional analyses undertaken here, $w_0$ could then be left out of the specification.[6] While this precludes explicit investigation of the substitution effects between activities, we are still in a position to address the important policy question of how households react to changes in *incomes*.

We have no particular expectation of the connection between income and hunting activity. If strong substitution effects occur, we might expect hunting activity to go down with increases in income from other sources. If income from other activities somehow facilitates hunting, however, then we might expect a positive relationship between hunting and other income.

Other demographic variables were also investigated (including education and the number of other household members) but they were found to be insignificant. The role of village income levels is discussed in further detail in Section 6.2.4.

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[5] The area around Korup is characterised by very little wage income. While good detail was available on the household income by source, there was little basis for estimating the actual physical labour required to obtain that income and hence no effective wage could be imputed.

[6] One indirect test was conducted to test if differences existed between sub-regions. As noted, location variables DUMHBZ and DERAT were specified and interpreted as 'opportunity' variables. An alternate interpretation of these is that they reflect the foregone opportunity $w_0$ – or perhaps more precisely some 'relative' opportunity such as $w_H/w_0$ – which might be different in the various sub-regions. To test this, and in line with the specifications presented in Chapter 5, four sub-regions were defined using dummy variables DUMHEBZ, DUMHWBZ, and DERAT. Consistent with results presented later in this chapter (for just DUMHBZ and DERAT), the preferred specifications included only the variable DERAT and found that the other variables did not contribute significantly to the estimations.

Table 6.1
Definition of Hunting Activity Variables

| Variable | Definition | Mean | Standard Deviation |
|---|---|---|---|
| HUNT | Annual HH Hunting Income (CFAF) | 46,416 | 157,420 |
| HDHUNT | Dummy Variable for Hunting Participation | 0.314 | 0.465 |
| INCOME | Annual HH Income (CFAF) | 387,964 | 641,197 |
| CASHALL | Annual HH Cashcrop Income (CFAF) | 132,870 | 306,010 |
| INCXHUNT | Annual HH Non-hunting Income (CFAF) | 341,550 | 566,690 |
| VINC | Per Capita Income in Village (CFAF) | 58,478 | 34,100 |
| LOGHUNT | = ln(HUNT+1) | 3.096 | 5.046 |
| LOGCASHA | = ln(CASHALL) | 6.616 | 5.791 |
| LOGIXH | = ln(INCXHUNT) | 11.395 | 2.795 |
| LOGVINC | = ln(VINC) | 10.790 | 0.409 |
| HPESTO | Huntable Animal Pests in HH | 0.205 | 0.405 |
| ADMALE | Number of Adult Males in HH | 1.704 | 1.123 |
| HPRESNOM | Number of Persons in HH excluding Adult Males | 4.422 | 3.386 |
| DERAT | Dummy for Erat | 0.103 | 0.304 |
| DUMHBZ | Dummy for Buffer Zone | 0.698 | 0.460 |

n=341

### 6.2.3 A First Look at the Empirical Evidence: The Probit Model

The first estimation conducted involved a probit specification for hunting. The probit model uses the variable HDHUNT as the dependent variable, taking on the value of unity for a household which hunts and a value of zero for a household which does not hunt. Results from the probit model are interpreted as how individual explanatory variables influence the probability index[7] of a household being involved in hunting activity.

Descriptive statistics for the variables used in these estimations are shown in Table 6.1. Table 6.2 shows the results of the probit estimations for the 341 households in the sample. Four separate models were specified. The estimation coefficients are interpreted as the effect of a unit change of the independent variable on the probability index of a household hunting. The models were tested with two nestings: the first was simply against a specification comparing a simple constant term with the explanatory variables excluding any income variables (Model 1a). The results indicate that the model does provide a significant improvement over a simple constant term. The LR test statistic for the model is 39.28 and the critical value for $\chi^2$ (at a 5% level of significance) is 7.81.

The second nesting involved adding a single income variable to this. The specification of the income variable took two basic forms: a logarithmic and a linear specification. In all the cases tested, the addition of the income variable provided a significant improvement to Model (1a). On the basis of selecting the model with the greatest incremental improvement

[7] Recall that the index is normally distributed with mean 0 and variance 1.

to the log-likelihood function, the logarithmic specification using all non-hunting income was better. This corresponds to Model (4a) in Table 6.2, and I shall confine my comments regarding specific results to this model.

### 6.2.4 Interpretation of the Results

First, it was clear that the number of males in the household had an important impact on whether the household would be involved in hunting. Calculations of elasticities at the means of the sample indicated that an increase of 10% in the number of potential hunters available would increase the probability of hunting by 5.6%.[8] The elasticity of less than unity illustrates that effort does not increase proportionately with the number of men in the household, although an increase in hunting activity does occur with more men in the household. To investigate whether activity was correlated to household size, estimates were also conducted using non-males as an explanatory variable and no additional explanatory power was generated by adding this variable. Although the detailed results are not presented here, adding the variable HPRESNOM to designate the number of household members normally present who were not adult males, yielded a test statistic LR=0.44. Given that the critical $\chi^2$=3.84 for the additional degree of freedom, it suggests that the level of hunting activity is not driven by household 'needs', or that this 'need' factor is already captured by the ADMALE variable.

Second, the results indicate that those households with farms being bothered by huntable animal pests will have a higher propensity to hunt. Calculations of elasticities at the means indicated that a 10% increase in such pests increased the probability that a given household would hunt by 1.5% (i.e., $\Delta P/\bar{P}$=0.015). Again, this coincides with accounts given by some hunters that they do hunt in part to protect their farms.

Results indicated that the coefficients for the 'opportunity' variables DERAT and DUMHBZ were of the expected sign, but when both were included in the estimates, the incremental improvement was not significantly larger than if only one of the two variables were included. The greatest improvement occurred when only DERAT was kept in the estimation procedure and, given that locals normally acknowledged that those in Erat had the best hunting territory, and that those in the buffer zone had hunting opportunities which

[8] This should be interpreted as $\Delta P/\bar{P}$=0.056, where $\bar{P}$ is the probability of hunting, evaluated at the means of all the explanatory variable. In this instance it represents an increase in the probability of hunting from 27.3% to 28.9%.

Table 6.3
Probit Results for Hunting Activity Including Village Income Variables

| | |
|---|---|
| Dependent Variable: | HDHUNT |
| Total Observations: | 341 |
| Observations at 0: | 234 |
| Observations at 1: | 107 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (4a) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|
| CONSTANT | -3.394<br>(5.51) | -3.333<br>(5.48) | -3.693<br>(2.25) | -1.620<br>(7.50) | -4.180<br>(2.62) |
| ADMALE | 0.270<br>(3.78) | 0.272<br>(3.78) | 0.270<br>(3.78) | 0.313<br>(4.45) | 0.315<br>(4.53) |
| LOGIXH | 0.187<br>(3.75) | 0.169<br>(3.21) | 0.184<br>(3.44) | | |
| VINC | | 0.262E-5<br>(0.99) | | 0.622E-5<br>(2.57) | |
| LOGVINC | | | -0.032<br>(0.20) | | 0.270<br>(1.85) |
| HPEST0 | 0.587<br>(3.15) | 0.557<br>(2.95) | 0.580<br>(3.08) | 0.504<br>(2.74) | 0.519<br>(2.83) |
| DERAT | 0.720<br>(3.02) | 0.828<br>(3.16) | 0.756<br>(2.52) | 0.891<br>(3.44) | 0.931<br>(3.18) |
| Log Likelihood (0) | -212.13 | -212.13 | -212.13 | -212.13 | -212.13 |
| Log Likelihood (Model) | -182.61 | -182.12 | -182.59 | -189.18 | -190.76 |
| LR Test (Model) | 59.04 | 60.02 | 59.08 | 45.90 | 42.74 |
| Degrees of Freedom | 4 | 5 | 5 | 4 | 4 |
| Critical $\chi^2$ | 9.49 | 11.07 | 11.07 | 9.49 | 9.49 |
| LR Test | | 0.98 | 0.04 | | |
| Compared to Model | | (4a) | (4a) | | |
| Degrees of Freedom | | 1 | 1 | | |
| Critical $\chi^2$ | | 3.84 | 3.84 | | |
| Preferred Model: | ******* | | | | |

therefore reject the hypothesis that village income levels are responsible for the hunting activity.

A third possible set of explanations is related to the financial requirements of hunting. Two possible connections can be made here. First, as noted by Infield (1988), hunting requires relatively expensive purchased inputs and other income facilitates the purchase of guns, carbide and shells to undertake hunting expeditions. If credit were available for hunting, these costs would not be a constraint given that hunting is expected to generate positive returns. With some exceptions,[10] credit is not formally available for this illegal activity. Second, given that the hunter's time is also a necessary input to hunting, it is possible that farmers who are also good hunters will hire labour to work on their farms while they go hunting. The ability to hire such labour will increase with higher household income levels. While this appeared, from informal interviews, to occur in Nigeria, it would seem to be less of a factor in Cameroon given that income data for the survey area showed that very little wage labour was being earned.

The causal connection, if there is indeed any causality, could of course be the other way around: high hunting income leads to higher non-hunting income. This could arise, for example, if the hunting income were used to finance necessary inputs for other activities. An example of this would be fertilisers or pesticides: these inputs are expensive and formal credit mechanisms are not available to small-holders. Income from hunting could potentially finance the purchase of such inputs which, in turn, would increase cashcrop income. The weakness of this argument, however, is that farmers in the area generally did not use purchased inputs for the major cashcrops: cocoa and coffee treecrops would be tended and harvested using family labour.

In summary, there is no obvious single factor which would account for the observed relationship between non-hunting income and hunting activity. Based on the preceding cursory review, however, the most likely contributory factors are that: (i) people like hunting and it is a normal good having a positive income elasticity of demand; and, (ii) increases in non-hunting income help to overcome some of the financial barriers to hunting.

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[10] Hunters indicated that at times traders would come from Nigeria and 'loan' guns and provide shells and carbide to hunters in Cameroon on condition that anything which was bagged would be sold preferentially to that trader at market prices less the cost of the inputs and some amount as rental payment for the gun.

## § 6.3 Hunting and Income: A Closer Look

### 6.3.1 Overview of Methods

The probit specification explored in the previous section has the advantage that it is robust to reporting errors in measuring the dependent variable: hunting. As it relies basically on a simple yes or no response, the respondent is not required to give a great deal of thought to how much hunting is actually undertaken. But therein lies a disadvantage as well: ideally we are interested not just in whether a household is hunting, but also *how much* hunting activity it engages in if it does hunt. The simple probit specification does not explicitly address this problem and, in this section, I shall investigate the usefulness of some other econometric techniques which can be applied to the data. The two models which I shall use are:

a) a tobit model; and,
b) a double hurdle model.

The tobit model approach was discussed in detail in Chapter 5. In the context of conservation, we are particularly interested in knowing what the actual physical capture is from the hunting activity and in knowing what influences the amount captured. If we assume, as before, that prices are constant throughout the sample and that hunting capture is proportional to effort, then the income generated by hunting activity serves as a proxy for both the level of capture and the level of effort applied. By using hunting income as the dependent variable, we can therefore get an idea of what influences the levels taken. The independent variables identified for the probit studies apply here as well.

Two specifications of dependent variable in the tobit model were used. The first, HUNT, was simply the hunting income earned by the household in a given year, as estimated by the respondent. To address potential heteroskedasticity, LOGHUNT was used as a dependent variable as well, and it was defined as the natural logarithm of (HUNT+1). It is noted that such a normalisation process was required as the logarithm of HUNT was not defined for those households which did not hunt. Because HUNT was generally large and positive for non-zero values, the LOGHUNT variable as defined in this manner would operationalise the data without creating overt distortions.

The second modelling approach used was a double hurdle specification. Discussion of the estimating procedure applicable to double hurdle models can be found in Cragg (1971), and Atkinson, Gomulka and Stern (1984; 1989). I am in particular grateful to Dr. Joanna Gomulka for having run my data through her model to generate the estimated equations presented in this chapter. In the context of this study, the basic idea in a double hurdle model is that there is some proportion of the population which will not hunt no matter what economic incentives might exist to encourage – or discourage – hunting. An obvious example in this study would be Household 60, consisting of a lame old lady who is supported entirely by those in the village. While this is clearly an extreme case, one can nonetheless postulate that one set of characteristics will determine whether or not a given household falls into that proportion of the population which would hunt. This is the first hurdle. The second hurdle corresponds to the truncation which exists in a standard tobit specification. Another way of looking at it is that, in the data, zeros will arise (for households which do not hunt) for two reasons. First, households may lack the physical ability to hunt and would, therefore, under all conceivable conditions register a 'zero'. Second, some households with the ability may choose to hunt but at certain levels of income or other variables their level of hunting effort falls to zero. Because of the large number of zeros in the data (234 out of 341 households did not hunt), it is particularly important from a policy perspective to determine what factors contribute to these zeros.

Formally, the double hurdle model can be defined as follows. A household will potentially hunt if $u_h > 0$ where,

$$u_h = \sum_j \alpha_j \cdot Z_{h:j} + \eta_h \qquad \text{...(6.3);}$$

where attributes $Z_1, Z_2, ..., Z_j$ are those which correspond to the first hurdle, and that, as a potential hunting household, the amount of effort actually expended is $\text{Max}[0, y_h]$, where

$$y_h = \sum_k \beta_k \cdot X_{h:k} + \varepsilon_h \qquad \text{...(6.4);}$$

and the set of variables $\{X_1, X_2, ..., X_k\}$ does not necessarily exclude any of the attributes $Z_j$. In the specifications undertaken in this chapter it is assumed that the disturbance terms $\eta_h$ and $\varepsilon_h$ are normally distributed and are independent, implying a covariance matrix $\begin{bmatrix} 1 & 0 \\ 0 & \sigma^2 \end{bmatrix}$.

Our observations of hunting effort, $y_h^*$, then indicate that

$$y_h^* = y_h \text{ if } y_h > 0 \text{ and } u_h > 0 \qquad \text{...(6.5);}$$
$$= 0 \text{ otherwise.}$$

In selecting which specification best describes the data, it is noted that the tobit is a special case – and is thus nested within – the double hurdle model. This allows us to investigate whether the double hurdle specification does indeed provide any improvements over the tobit.

As with the tobit model, results from the double hurdle model can, for any set of household characteristics, be translated into two indicators which are of potential policy interest: the probability that the household will hunt; and the expected level of hunting of any given household. These are independent of the stochastic terms ($\eta$ and $\varepsilon$) and are calculated using the following formulae:

Probability of falling at first hurdle $= P_1 = \Phi(\alpha \cdot Z)$ ...(6.6a);

Probability of falling at second hurdle $= P_2 = \Phi\left(\frac{\beta \cdot X}{\sigma}\right)$ ...(6.6b);

Probability of a household not hunting $= P_0 = P_1 + P_2{*}(1-P_1)$ ...(6.6c);

Expected Level of Hunting $= \left[\beta \cdot X \cdot P_2 + \sigma\phi\left(\frac{\beta \cdot X}{\sigma}\right)\right] \cdot P_1$ ...(6.6d);

where $\Phi$ is the distribution function for the standardised normal distribution and $\phi$ is its density function. The reader will recognise the term in square brackets in Equation (6.6d) to be the expected value function (conditional on X) for a standard tobit model.

Also, I shall be investigating whether the tobit model itself is a good specification by comparing it to the probit: in the limit the tobit and probit specifications should give the same (relative) estimated coefficients. If these coefficients diverge, it suggests that the tobit specification may not be appropriate and that alternative models may be better.

### 6.3.2 Results: Tobit Model

As with the probit estimates, the tobit models were estimated using SHAZAM econometric software. Results presented in this section refer to adjusted estimation coefficients: the normalised coefficients for calculating the appropriate indices can be extracted by dividing these coefficients by the standard error, $\sigma$. I concentrate here on the models with and without the household income terms; the conclusions drawn in the probit analysis regarding the significance of demographic variables (education and non-males) and village incomes applies here as well. This section presents the results of various tobit specifications and addresses the selection of a 'preferred' model. Explicit interpretation of the model will be deferred until later when it will be compared in greater detail with the double hurdle model.

Table 6.4 summarises Models (1b) and (4b) for the linear dependent variable HUNT. Both models represent improvements over the case where only a constant is used to estimate behaviour. Through the inclusion of a household income variable, Model (4b) also represents an improvement over Model (1b). The LR test statistic for adding the single variable LOGIXH is 27.68 which, at the 5% significance level, indicates that income is a significant explanatory variable in the estimation. Through including this term, the variance fell by 11.6%; although there is still a substantial residual variance not explained by the model.

Table 6.4 also provides an indication of whether the tobit model approaches, at the limit, the probit results. If the tobit model is a correct specification, then the relative values of the estimation coefficients should be the same as those in the probit model having the same set of explanatory variables. The third column in Table 6.4 shows the ratio of the coefficients in Model (4b) to those in Model (4a), normalised such that the ratio for the constant is exactly unity. In a well-specified model, the ratios for all of the coefficients should approach unity. While these ratios are close to unity for some variables, there is some divergence for others – notably for DERAT. Given, however, that the variable DERAT is not highly significant in the estimation (with a t statistic of 1.82) one might not consider this divergence to be too serious, yet it suggests that other specifications might be more appropriate.

One such alternate specification is to use a logarithmic specification for the dependent variable, as shown in Table 6.5. In this specification, the ratio of the estimation coefficients to those for the probit specification is improved somewhat, with the greatest divergence arising from the variable ADMALE. In the logarithmic specification there is again a significant improvement in the likelihood function from adding the income variable. The variance fell by 13.8% and the LR statistic of 28.20 for adding one variable is significant at the 5% level.

The choice between the linear model and the logarithmic model is, admittedly, somewhat judgmental. There are, however, some indicators which can guide us. First, all of the coefficients which were individually significant in the probit model are also individually significant in the logarithmic model; this is not the case with the linear model. This is also reflected in the ratio of the relative coefficients. Second, one often presupposes the existence of heteroskedasticity in these observations, and adjusts for it by taking logarithms. A more direct test is suggested by White (1980), which requires comparing the conventional t statistics with 'robust' t statistics. As the robust t statistics were available on the software used for the double hurdle models, they were calculated for the tobit Models (4b) and (4c). The results suggested that heteroskedasticity did exist in the linear

Table 6.4
Tobit Results for Hunting Activity – Linear Dependent Variable

| | |
|---|---|
| Dependent Variable: | HUNT |
| Total Observations: | 341 |
| Limit Observations (at 0): | 234 |
| Non-limit Observations: | 107 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (1b) | (4b) | Ratio* [4b:4a] |
|---|---|---|---|
| CONSTANT | -419,400<br>(10.33) | -1,113,030<br>(6.69) | 1.000 |
| ADMALE | 115,130<br>(6.71) | 94,444<br>(5.70) | 1.07 |
| LOGIXH | | 63,293<br>(4.61) | 1.03 |
| HPESTO | 144,490<br>(3.02) | 140,670<br>(3.06) | 0.73 |
| DERAT | 71,738<br>(1.15) | 109,750<br>(1.82) | 0.46 |
| Standard error of estimate ($\sigma$) | 291,810 | 274,310 | |
| Log Likelihood (0) | -1622.95 | -1622.95 | |
| Log Likelihood (Model) | -1594.53 | -1580.69 | |
| LR Test (Model) | 56.84 | 84.52 | |
| Degrees of Freedom | 3 | 4 | |
| Critical $\chi^2$ | 7.81 | 9.49 | |
| LR Test | | 27.68 | |
| Compared to Model | | (1b) | |
| Degrees of Freedom | | 1 | |
| Critical $\chi^2$ | | 3.84 | |
| Preferred Model: | | ******* | |

* For variable i, coefficient estimate $\alpha_i$, the ratio is defined as the ratio of $\alpha_i$(Tobit)/$\alpha_i$(Probit) to $\alpha_i$(Tobit)/$\alpha_i$(Probit) where $\alpha_0$ is the coefficient of the estimate for the constant term.

Table 6.3
Tobit Results for Hunting Activity – Logarithmic Dependent Variable

| | |
|---|---|
| Dependent Variable: | LOGHUNT |
| Total Observations: | 341 |
| Limit Observations (at 0): | 234 |
| Non-limit Observations: | 107 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (1c) | (4c) | Ratio* [4c:4a] |
|---|---|---|---|
| CONSTANT | -12.632<br>(8.03) | -38.505<br>(6.11) | 1.000 |
| ADMALE | 3.166<br>(4.76) | 2.276<br>(3.58) | 0.74 |
| LOGDXH | | 2.355<br>(4.53) | 1.11 |
| HPESTO | 5.513<br>(2.90) | 5.207<br>(2.91) | 0.78 |
| DERAT | 6.862<br>(2.81) | 8.050<br>(3.46) | 0.99 |

| | (1c) | (4c) |
|---|---|---|
| Standard error of estimate (σ) | 11.820 | 10.970 |
| Log Likelihood (0) | -547.84 | -547.84 |
| Log Likelihood (Model) | -528.77 | -514.67 |
| LR Test (Model) | 38.14 | 66.34 |
| Degrees of Freedom | 3 | 4 |
| Critical $\chi^2$ | 7.81 | 9.49 |
| LR Test Compared to Model | | 28.20 (1c) |
| Degrees of Freedom | | 1 |
| Critical $\chi^2$ | | 3.84 |
| Preferred Model: | | ******* |

* For variable i, coefficient estimate $\alpha_i$, the ratio is defined as the ratio of $\alpha_i(\text{Tobit})/\alpha_i(\text{Probit})$ to $\alpha_0(\text{Tobit})/\alpha_0(\text{Probit})$ where $\alpha_0$ is the coefficient of the estimate for the constant term.

specification and that using a logarithmic specification did provide an improvement.[11] For this reason, Model (4c) was selected as the preferred tobit model and was used as the basis for nesting the double hurdle models.

### 6.3.3 Results: Double Hurdle Model

Results for the double hurdle model are presented in Table 6.6. In addition to allowing a heteroskedasticity check, the tobit model was run using the double hurdle software to ensure that the results were consistent with those done using Shazam. The results for the estimation coefficients agreed in all cases to three significant figures. As before, the results presented in this table are for the estimation coefficients and normalised coefficients can be deduced by dividing through by $\sigma$.

The first double hurdle model investigated involved adding a constant term and the number of adult males as explanatory variables for whether a household was potentially a hunter. This differs from an approach taken by Deaton and Irish (1982) who rely on a 'p-tobit' model which is equivalent to the double hurdle model with only a constant in the first hurdle. The 'p-tobit' would capture the effect of a fixed probability of not hunting, whereas Model (9) is somewhat richer in that it allows other variables to have an effect on the propensity of the household to hunt. As the variable ADMALE had the largest divergence in the tobit:probit ratios, and as it seems *a priori* to be an important indicator for a household's propensity to hunt, it was placed in the first hurdle.

The result of adding a first hurdle to the basic tobit model is striking and highly significant. The standard error of the estimate falls from 10.97 to 3.46, implying a reduction in the variance of 90%. The logarithm of the likelihood function increases by 38.16, implying a LR test statistic of 76.32, and one would accept the hypothesis that the additional two variables added significantly to the model (critical $\chi^2$ is 5.99 at a 5% significance level). Further improvements in the double hurdle model were tested by adding income, pest and opportunity variables to the first hurdle as shown in Models (10) to (12). Results indicated that no improvement arose by adding the opportunity variable, a marginal improvement was achieved by adding the pest variable, and an unambiguous improvement was achieved

[11] A comparison of the t statistics for the variables follows:

| | Linear Model (HUNT) | | Logarithmic Model (LOGHUNT) | |
|---|---|---|---|---|
| | conventional | robust | conventional | robust |
| CONSTANT | 6.69 | 3.50 | 6.11 | 4.59 |
| ADMALE | 5.70 | 2.87 | 3.58 | 3.73 |
| LOGIXH | 4.61 | 2.78 | 4.53 | 3.30 |
| HPESTO | 3.06 | 3.37 | 2.91 | 3.18 |
| DERAT | 1.82 | 2.29 | 3.46 | 3.68 |

Table 6.6
Double Hurdle Results for Hunting Activity

| | |
|---|---|
| Dependent Variable: | LOGHUNT |
| Total Observations: | 341 |
| Limit Observations (at 0): | 234 |
| Non-limit Observations: | 107 |

Estimation coefficients with asymptotic t-ratios in parentheses:

| Variable : Model | (4c) [TOBIT] | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|
| **First Hurdle** | | | | | |
| CONSTANT | | -0.994 | -2.75 | -1.04 | -1.10 |
| | | (5.7) | (3.3) | (5.8) | (5.8) |
| ADMALE | | 0.311 | 0.281 | 0.306 | 0.312 |
| | | (3.9) | (3.3) | (3.8) | (3.8) |
| LOGIXH | | | 0.151 | | |
| | | | (2.1) | | |
| HPEST0 | | | | | 0.470 |
| | | | | | (2.1) |
| DERAT | | | | 0.423 | |
| | | | | (1.4) | |
| **Truncated Regression** | | | | | |
| CONSTANT | -38.505 | -5.72 | -4.08 | -5.60 | -5.74 |
| | (6.11) | (2.3) | (1.4) | (2.2) | (2.3) |
| ADMALE | 2.276 | 0.104 | 0.109 | 0.103 | 0.109 |
| | (3.58) | (0.39) | (0.41) | (0.39) | (0.41) |
| LOGIXH | 2.355 | 1.21 | 1.09 | 1.20 | 1.21 |
| | (4.53) | (6.2) | (4.8) | (6.1) | (6.1) |
| HPEST0 | 5.207 | -0.128 | -0.161 | -0.133 | -0.209 |
| | (2.91) | (0.16) | (0.21) | (0.17) | (0.26) |
| DERAT | 8.050 | 1.98 | 1.79 | 1.94 | 1.96 |
| | (3.46) | (2.0) | (1.8) | (2.0) | (2.0) |
| Standard error of estimate ($\sigma$) | 10.97 | 3.46 | 3.43 | 3.45 | 3.46 |
| Log Likelihood (0) | -547.84 | -547.84 | -547.84 | -547.84 | -547.84 |
| Log Likelihood (Model) | -514.67 | -476.51 | -471.83 | -474.80 | -473.11 |
| LR Test (Model) | 66.34 | 142.66 | 152.02 | 146.08 | 149.46 |
| Degrees of Freedom | 4 | 6 | 7 | 7 | 7 |
| Critical $\chi^2$ | 9.49 | 12.59 | 14.07 | 14.07 | 14.07 |
| LR Test | | 76.32 | 9.36 | 3.42 | 6.80 |
| Compared to Model | | (4c) | (9) | (9) | (9) |
| Degrees of Freedom | | 2 | 1 | 1 | 1 |
| Critical $\chi^2$ | | 5.99 | 3.84 | 3.84 | 3.84 |
| Preferred Model: | | | ******* | | |

by adding the income variable to the first hurdle. While other models were tested, including the use of an education variable in the first hurdle, none provided significant improvements to Model (10) which was hence designated as the preferred double hurdle model.

Apart from the fact that the double hurdle model is a notable improvement to the simple tobit model, the nature of the preferred model is quite interesting. The coefficients in the first hurdle imply that a household will be more likely to be a 'potential hunter' if there are more males and there are higher income levels in the household. At the sample means (ADMALE=1.7; LOGIXH=11.4), the probability of being a 'potential hunter' is 43.6% (corresponding to a normalised index of -0.16). An increase in the household composition by one male would increase the household's probability of being a potential hunter to 46.8% (corresponding to a normalised index of -0.08). A doubling in the non-hunting income would increase the household's probability of being a potential hunter to 45.5%. That these two variables are significant confirms earlier suggestions that hunting is an enjoyable pursuit with a positive income elasticity of demand, or that 'barriers' to entry might exist corresponding to the availability of skilled men or the availability of adequate capital to finance hunting trips.

The fact that the ADMALE variable is significant in the first hurdle and, one will note, not in the truncated regression, suggests that the number of males is important in determining whether or not a household will hunt but not, ultimately, how much it will 'conditionally' hunt. Two explanations would be consistent with this observation. First, if only a certain proportion of males were trained as hunters and if these hunters would always hunt, then this would be reflected in this model. Alternately, perhaps all males are potential hunters but other household tasks preferentially require males: the first hurdle might then reflect the idea that some minimum number of males are required by the household to meet its other basic needs before it can 'afford' to send surplus males out on hunting expeditions. Such circumstances might, for example, arise if households need a male around for protection. Based on what we know about the population, however, the first reason seems more plausible.

Unlike the adult male variable, the income variable is significant and positive both in the first hurdle and in the truncated regression. Households with higher income will have a higher probability of hunting and, if they hunt, they will tend to hunt more. While this would support the argument that hunting is a leisure activity with a positive income elasticity of demand, it is also consistent with observations that the financial barriers to hunting might be both capital in nature (gun purchases) and current (for carbide and shells).

It is notable that the pest variable becomes insignificant in the double hurdle model. This might be attributable to a mis-specification in the tobit which causes the effects of the pest variable to be captured partially by other variables in the double hurdle model. For example, the income variable – to the extent that it reflects cash crop income – could act as a proxy for 'value of crops at risk to pests' and further reinforce the positive relation between hunting and other income.

### 6.3.4 Comparison of Results

The most revealing way to show the differences in the models and at the same time show some of the potential policy implications is through simple simulations using the model coefficients. As a base case we use a typical household to compare the 'preferred tobit' Model (4c) with the 'preferred double hurdle' Model (10). The typical household is one with one adult male; it is located outside of Erat, has animal pests on its farm, and has an income level falling at the top of the first quartile. The results for these simulations are shown in Table 6.7. Note that the expected hunting activity level is normalised to a level of 1000 for the base case.

Table 6.7
Comparison of Probit, Tobit and Double Hurdle Models
(Base Case Predicted at First Quartile income; 1 male; animal pests; not in Erat)

| Model: | Probit (4a) | Tobit (4c) | | Double Hurdle (10) | | | |
|---|---|---|---|---|---|---|---|
| Case | %'age Hunters | %'age Hunters | Expected Hunting | $P_1$ (%) | $P_2$ (%) | %'age Hunters | Expected Hunting |
| Base Case | 16.8 | 15.3 | 1000 | 63.7 | 7.2 | 33.7 | 1000 |
| One More Male | 24.4 | 20.7 | 1502 | 60.6 | 6.7 | 36.8 | 1221 |
| Double Income | 20.2 | 19.0 | 1323 | 62.5 | 4.6 | 35.7 | 1385 |
| One More Male +Double Income | 28.6 | 25.2 | 2183 | 59.4 | 4.3 | 38.9 | 1736 |
| HH in Erat | 40.4 | 38.5 | 8095 | 63.7 | 2.4 | 35.5 | 1861 |

Notes:
$P_1$ = Probability of falling at first hurdle
$P_2$ = Probability of falling at second hurdle

Results are illustrated for the probit, tobit, and double hurdle specifications. Note that in the base case the predicted number of hunters is highest with the double hurdle model: the household would normally not hunt because it failed to overcome the first hurdle, and the model predicts that the probability of the household actually hunting is 33.7%. The impacts of adding a single male to the household are more pronounced in the tobit and probit models than they are in the double hurdle model. The tobit model would predict a 52% increase in hunting capture over the base case; the probit model – assuming that there was a constant level of off-take for anyone hunting – would predict a 44% increase. By contrast, the hunting off-take in the double hurdle specification would increase by only about 22%. If the double hurdle model is regarded as the preferred model for estimating hunting effort, it is clear that the tobit specification would overestimate the impact of additional males in the household.

The tobit and double hurdle models agree fairly well, however, on the impact of increased incomes on hunting activity. Taking into account the zeros, Table 6.7 shows that a doubling in incomes implied an increase in hunting activity of about 32% (tobit) to 39% (double hurdle). Note that if one relied simply on the probit model to predict hunting off-take and assumed that there was a constant level of hunting for anyone that did hunt, then a doubling of income would lead to only a 20% increase in off-take. In this case the tobit and double hurdle models make an important contribution by identifying both the increased participation and the increased effort which arises at higher income levels.

## § 6.4 Conclusions: When are Development Incentives Effective?

The impetus behind undertaking the investigations in this chapter was ultimately to determine whether increasing incomes in the Korup National Park area would indeed decrease pressures on the forest. Hunting was singled out for detailed investigation as it is regarded to be the primary non-sustainable forest use currently being pursued in the region. Empirical studies were regarded as important because the theory is ambiguous about how people respond to increases in income. While it is often assumed that the provision of alternate income sources would stop individuals from hunting, a case can also be made that the higher incomes will lead to higher hunting effort.

The investigations support the hypothesis that hunting activity and household income from other sources are positively related. Simulations suggest that the elasticity of hunting effort to non-hunting income is of the order of +0.4. There are a number of potential reasons for this. One possible explanation is that hunting is regarded as an enjoyable activity with a positive income elasticity of demand. A second possible explanation is that some type of financial barrier exists both to entering into the hunting activity and to actually conducting it. A similar barrier exists in terms of the number of potential hunters in the household: all of the modelling results clearly identified that a household will be more likely to hunt if it has more adult males.

The policy implications of these results indicate that one must be very careful in providing alternative income opportunities in this area. Untargeted transfers would, for example, be expected to increase hunting pressures and the case illustrates that development and conservation goals might conflict in this instance. One might assert that a carefully targeted development programme might be able to skirt the connection between income and hunting activity. For example, promoting projects with a high intensity of male labour may enforce what (if any) substitution effect exists in the income:hunting relationship. It is, however, perhaps more effective not to look in this case to development incentives to promote conservation. Other policies associated with directly controlling hunting probably deserve a closer look, even though they might have been originally rejected on the assumption that the development incentives would do the job. One should perhaps not even overlook the obvious answer of overtly depressing incomes in an area to induce both emigration and hunting pressures; while this may have little political appeal, one might imagine cases where it could be justified if conservation priorities are high.

In closing, it is useful to add some caveats to these results. Although there is an apparent correlation between income and hunting activity, there are a number of possible interpretations which give rise to this. Those interpretations that can be tested with the data at hand have already been discussed, but it is also recognised that such a correlation would arise if there was a consistent misreporting in income levels. The tobit and double hurdle models relied on hunting income estimates to estimate hunting effort. If individuals consistently mis-estimated all income levels from all sources, then one would expect a positive relation between hunting and income. In this respect, however, the probit results provide an important contribution: they are generally regarded as more robust because they do not attempt to estimate actual levels of activity.

Finally, it is also appropriate to comment on the cross-sectional nature of the data. As noted earlier, the factors which influence hunting activity are not just current in nature. Only men trained to hunt can actually participate, and the specifications which were made in this section looked at a cross-section of activity at a single point in time. If development activity somehow effects – over the longer term – the number of men trained as hunters, then this development activity might eventually assist in decreasing hunting. Chapter 5 illustrated, for example, that higher incomes increased the propensity of households to send their children to school, and children would often leave the local village for this schooling. One would presume that this would isolate the child from hunting opportunities at an early age and – although the traditional structures might be threatened – conservation goals would likely be supported. In short, this illustrates that a more critical analysis would require panel data to allow identification of longer term trends between hunting and income. Nonetheless, the results suggested by the cross-section analysis provide an important contribution to understanding some of the potential short-term responses to development incentives.

# CHAPTER 7
# INDIRECT TAXES TO REDUCE EXTERNALITIES: THE CASE OF FUELWOOD DEMAND IN INDIA

## § 7.1 Introduction

As described in earlier chapters, primary tropical rainforest exploitation and depletion in the developing world has received increased international attention over the past decade with rising environmental consciousness. While timber exploitation has traditionally been an important source of export earnings to LDCs, international aid and funding agencies have more recently begun to recognise the importance of the resource in other economic sectors. In addition to the potential "passive" roles which tropical rainforests play as mechanisms for controlling soil stability, water catchment integrity, and regional climates, they have also provided a traditional and important source of energy to developing nations: fuelwood.

The overall scope of this chapter is to explore some of the fundamental issues relating to fuelwood demand in a formal framework, highlighting the policy choices which are often seen to arise from this framework. In particular, the paper concentrates on interfuel substitution possibilities through describing and demonstrating the application of a methodology for analysing substitution possibilities. It should be noted that the methodology prescribed is not a new approach; it has been used extensively in developed countries to establish demand relationships between fuels. Its application in this context, however, is less developed and introduces certain challenges: particularly in relation to data availability. As such, one of the objectives of this chapter is simply to demonstrate the viability of the approach as an applied tool for analysis in LDCs.

As always, when focusing on a particular issue, related yet equally important issues must be overlooked. As this study concentrates on demand relationships, many fuelwood supply-side issues are not addressed. In particular, the overall question of supply from an open access resource does not enter into the formal analysis here. Similarly, management and intervention in the fuelwood "crisis" will have substantial distributional effects within a country. For example, many individuals currently derive income from gathering and selling scarce fuelwood at fairly high prices. While the distributional implications of intervention should enter into ultimate decisions regarding "optimal intervention" policies, they are beyond the scope of this study.

The primary motivation behind investigating interfuel substitution policies here has to do with evaluating taxation policy. Intuitively, when commodity consumption causes negative externalities, it seems plausible that one could levy appropriate indirect taxes on that consumption to internalise any such externalities. Indeed, this is the basic idea behind the "Pigovian" tax. Where it is not feasible – for whatever reasons – to tax the commodity causing the externality, one normally attempts to identify complementary goods (for taxation) or substitutes (for subsidies).[1] The identification of such goods essentially reduces the problem to one of identifying the demand functions for the goods, but the straight-forward logic of the intuitive argument has caused many to presume that fuelwood consumption can be decreased by subsidising kerosene.

The formal analytical framework used in this chapter relies on two demand-side modelling approaches:

a) a multi-fuel trans-log cost share model; and,
b) a simple single fuel residuals model.

Although a complete description of the approaches is presented in Section 7.3, a brief outline of the methodology is given here.

The trans-log model provides a framework for modelling interfuel demand relationships between substitute (or complementary) products. The framework has been used extensively in analysing both time-series and cross-sectional demand data for electrical energy, oil, natural gas, and coal in developed economies. The same principles can, however, be extended to analysing fuelwood demand in developing countries. The advantages of the trans-log approach are that it: (i) is very data efficient; (ii) does not require price deflators which are often notoriously difficult to use consistently in LDCs; (iii) allows separability from the supply questions; (iv) is based on an explicit theory of utility maximisation; and, (v) has no *a priori* restrictions on the demand elasticities. Although the model is amenable to any number of fuels in any sector, this chapter addresses only fuelwood and kerosene in the household sector.

The disadvantage of the trans-log modelling approach is that its application is restricted to estimating demand elasticities. It cannot be used to forecast explicitly total demand, nor can it capture the effects of lagged responses to exogenous changes in capital stocks. Specifically, it is incapable of capturing trends in increased cooker efficiency arising from

[1] The appropriate indirect "tax" may, in fact, be a subsidy depending on the relative contributions and directions of the income and substitution effects. In the discussions here, however, we shall for the moment assume that taxing complements and subsidising substitutes will reduce total consumption of the good which causes the negative externality. For early discussions of using taxation to offset externalities, see Pigou (1947). Green and Sheshinski (1976) review the use of direct and indirect mechanisms in reducing externalities; Sandmo (1975; 1976) discusses optimal taxation in the presence of externalities, highlighting how one might target complementary or substitute goods when the good causing the externality is not taxable.

changes in prices. Hence, a simple single fuel residuals model is used for this task. This model is essentially a simple econometric multivariate specification of fuelwood demand as a function of fuel prices and population. The residuals from this model are regressed against lagged parameters or through time-series analysis to extract information respecting factors not captured by the cost share model. The advantage of this approach is that it allows exploration of hypotheses regarding these exogenous factors. The disadvantage is that the model specification is largely arbitrary and has only a weak theoretical basis. As such, it should be regarded as a *secondary* tool to cross-check the results of the trans-log model. Indeed, one check of the residuals model is that it generates the same own- and cross-price elasticities suggested by the cost-share model.

In all modelling exercises in LDCs, data are often a constraint. India was one country for which the minimum required data were available. Government of India statistics were used for monthly fuelwood and kerosene prices, and annual forestry data relating to fuelwood consumption. The United Nations Food and Agriculture Organisation provided supplementary fuelwood statistics, and the International Energy Agency provided kerosene consumption by household. Selected data were available from 1949 to 1988 but, due to data reliability, the estimations were conducted over the period 1962 to 1982.

This chapter continues in Section 7.2 with a description of the international fuelwood situation and a more detailed description of the links in the conceptual framework. Section 7.3 presents the formal economic models: the trans-log cost share model and the simple residuals model. A complete discussion of the data and related problems is also provided in Section 7.3. Empirical results from the modelling exercise and their interpretation are presented in Section 7.4. Finally, Section 7.5 summarises the findings of this chapter and presents some conclusions.

## § 7.2 An Overview of Fuelwood Issues

### 7.2.1 International Fuelwood Situation

The pressures which fuelwood gathering have had on moist forest exploitation are significant. Myers (1984) suggests that some 12% of tropical deforestation can be directly linked to the process of fuelwood gathering. The problem of decreasing fuelwood availability is often exacerbated by increasing population pressures, common property access, and non-sustainable rates of harvesting. Indeed, whereas developed countries have experienced a number of energy crises over the past two decades relating to fossil fuel supplies, growing fuelwood scarcity in the developing world is often characterised as *the* energy crisis faced by many LDCs: it is as persistent as it is threatening.

In fairness to planners, the situation has not gone unnoticed and considerable efforts have been made on numerous fronts in an attempt to mitigate the effects of this crisis.[2] Programmes established to increase wood supplies or to create incentives to shift to kerosene or bottled gas have been implemented with various degrees of success. With international real oil prices in recent decline, some suggest (Krapels [1987]) that households will find a real economic incentive to shift towards refined products. The process of interfuel substitution may take some of the pressures off of fuelwood scarcity.

The largely empirical question of whether households will switch from fuelwood to kerosene has implications reaching far beyond simple fuel choices and the rate of forest exploitation. If a switch is made to kerosene, it will in many cases increase a nation's import requirements or, for oil producing countries, decrease their export earnings. Conversely, however, if households simply cut back on fuelwood with no substitution, then legitimate concerns arise that they will be consuming less cooked food and suffer itinerant health problems. An intermediate choice – using agricultural residues or animal manure as a fuel substitute – raises concerns that these products might be better left on the land as natural fertilisers. Clearly, while normally only energy economists have held an interest in interfuel substitution possibilities, planners and analysts concerned with external trade balances, agricultural productivity, and community health conditions would also be wise to lend an ear to the issues raised here.

Fuelwood is, with few exceptions, the fuel used for household cooking and heating requirements in the developing world. Table 7.1 illustrates the use of fuelwood in the total energy mix of selected developing countries. Even where severe deforestation or desertification has occurred – such as in Nepal, Ethiopia, and Upper Volta – wood still accounts for over 90% of the energy consumption. As noted in Chapter 2, many countries find themselves in situations of relative fuelwood 'scarcity'.

The pressures exerted by such scarcity have invariably increased fuelwood prices relative to other goods. Where no formal markets exist, there are clear cases indicating that individual efforts must increase to gather fuelwood. Eckholm et. al. (1984) documents cases in Papua New Guinea of individuals travelling 30 kilometres daily to gather fuelwood. Evans (1984) notes that in parts of Mexico it has become a full time task of one of the children in

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[2] See, for example, Teplitz-Sembitzky and Schramm (1989), Pearson and Stevens (1989), and Leach et. al. (1986).

Table 7.1
Fuelwood Consumption Estimates

| Country | Wood as % of Total Energy Consumed | Country | Wood as % of Total Energy Consumed |
|---|---|---|---|
| Nepal | 98 | Mozambique | 74 |
| Mali | 97 | Kenya | 70 |
| Rwanda | 96 | Senegal | 63 |
| Chad | 94 | Thailand | 63 |
| Tanzania | 94 | Sri Lanka | 55 |
| Upper Volta | 94 | Liberia | 53 |
| Ethiopia | 93 | Ivory Coast | 46 |
| Central African Republic | 91 | Honduras | 45 |
| Somalia | 90 | Tunisia | 42 |
| Burundi | 89 | Papua New Guinea | 39 |
| Niger | 87 | El Salvador | 37 |
| Benin | 86 | Pakistan | 37 |
| Cameroon | 82 | India | 36 |
| Nigeria | 82 | Zambia | 35 |
| Sudan | 81 | Brazil | 33 |
| Madagascar | 80 | Zimbabwe | 28 |
| Sierra Leone | 76 | Nicaragua | 25 |
| Angola | 74 | Morocco | 17 |
| Ghana | 74 | Chile | 16 |
| Guinea | 74 | Malaysia | 8 |

Source: Eckholm. et. al. (1984)

the household to gather fuelwood. As a ballpark estimate (Myers [1984]), it is not unusual for individuals to spend up to 40% of their incomes or their time to meet their fuelwood needs. The increase in prices or effort required to gather fuelwood potentially diverts income or effort from meeting other subsistence requirements: notably food.

### 7.2.2 Interfuel Substitution

The question of what people do as fuelwood prices increase is important and is open to debate. One expects that fuelwood and kerosene ought to be fairly good substitutes, and that individuals would arrange their consumption to allow for interfuel substitution. The evidence of such substitution is, however, inconclusive and studies are not always complete in providing empirical evidence one way or another. Foley (1986), in fact, generalises that the available evidence suggests that relative changes in the prices of wood-fuels and conventional fuels have little effect on consumer behaviour.

Kamara (1986) finds, for example, that fuelwood consumption in Sierra Leone has a positive income elasticity and that the income elasticity is lower for other fuels. In addition, he notes that people will tend to do less gathering on their own behalf as their incomes rise, In most cases it is difficult to assess at the outset whether interfuel substitution will occur as relative fuel prices shift. It comes, in the end, to an empirical question which must be investigated on a country by country – if not region by region – basis. Indeed, the conclusions of such investigations have marked impacts on policy choices which might be pursued.

### 7.2.3 Use of Empirical Evidence

In selecting the policy choices, empirical evidence relating to interfuel substitution can make some important contributions to selected policy considerations. We summarise these in terms of:

a) pricing issues;
b) taxation reform issues;
c) distributional issues; and,
d) resource management issues.

First, regulating prices through intervention had become a popular policy in the 1970s for countries with large oil import requirements. The justification was often that individuals should be shielded from the price shocks. This nonetheless has a substantial foreign exchange cost, and analysts (Krapels [1987]) continue to advise that "efficiency" dictates that domestic prices be aligned with international prices. If, however, such a policy leads to increased substitution towards fuelwood and accelerated fuelwood scarcity, then a government might still conclude that it is "optimal" to provide some degree of implicit fossil fuel subsidy.[3] But such conclusions could only be drawn if the substitution effects are known.

Second, many developing countries are currently rationalising their taxation systems through the introduction of major reforms designed – ostensibly – to improve economic welfare. The reforms often include changes in indirect taxes or subsidies, and fuels are often singled out as strategic goods. The linkages are similar to those arising from price controls discussed above, as the response to taxes or subsidies will depend critically on the structure of demand for potential substitutes.

Third, distributional issues arise frequently in fuelwood use situations, and governments often purport to pursue policies promoting more egalitarian distribution of income. In the

[3] A related pricing issue is, of course, what effects a fossil fuel subsidy might have in fossil fuel markets. Where products have a variety of uses, subsidies targeted to correct one specific market externality might create distortions in other markets. For example, kerosene subsidies in cooking fuel markets will normally spill over into markets where kerosene is being used in small electric generator sets.

of cooked food. In that event, however, we might be more concerned with the effects it has on real incomes of households and the availability of income for other goods.

If, however, it turns out that fuelwood consumption does fall as its price increases, then the next problem is to explore how in fact households accommodate their consumption. The four possibilities outlined in Q2 are regarded, in most practical cases, to represent an exhaustive list of the possible outcomes. If evidence suggests that fossil fuel substitution occurs, then an LDC can expect the increased wood prices to influence its external trade balance through increased oil imports or reduced exports.[5] If, however, fossil fuels are not adopted, then households may substitute agricultural residues. By agricultural residues we include both animal residue in the form of dung, as well as crop residues. This possibility begs another line of questioning addressed in Q3: whether the use of the agricultural residues has some effect on productivity. Such residues normally have been used to return nutrients to the soil, and burning them effectively robs the land of these nutrients. Even so, however, some argue that the optimal use of residues may be as fuel even if some agricultural productivity is lost.[6] Or, in other instances, leaving the residues on the land might *decrease* the productivity of the next crop if it increased the incidence of crop pests or diseases.[7] Again, these are empirical problems which can be investigated.

If options (a) and (b) are not undertaken, then one option is still for households to change their capital stock and use cookers with higher efficiencies. Indeed, many efforts in policy intervention have simply involved distributing pots and stoves which have higher energy efficiencies. Eckholm et.al. (1984) observe quite rightly, however, that fuel efficiency is notoriously difficult to measure and that great variance exists in the efficiencies of traditional methods: which usually rely on open fires. They also observe that peasants tend to conserve fuel when it is scarce by controlling the fire and recovering unburnt wood. Formally, this provides a problem for the economist bent on distinguishing between conservation from changes in the capital stock and conservation from changes in the mode of operating existing stock. Capital stock changes are normally easier to detect, as will be discussed later, whereas when households simply conserve using existing technologies, they may still ultimately achieve the same end-use value from their decreased consumption.

[5] Strictly speaking, it may have no impact on oil exporters if low cost incremental production is possible and if exports are somehow constrained by quotas. This situation occurred with Nigeria, and provided a useful rationale for subsidising domestic kerosene consumption to alleviate the fuelwood problem.
[6] Eckholm et. al. (1984) cite a case in India in which a researcher calculated that a tonne of cow dung could displace 268 Rp worth of firewood in the local market. The same amount of dung, when applied to the land as fertiliser, would result in increased grain production of only 80 Rp.
[7] This point came up during informal discussions with farmers in the Korup National Park Household Survey in Cameroon (see Appendix). The farmers generally managed more than one crop of maize in one season; but the maize invariably suffered from insect pests. When the residues were left on the land between crops, these pests seemed to flourish and affect the productivity of the second crop more adversely than they did the first crop.

This issue actually is reflected as well in Q4 above, which asks whether health indeed suffers if fuelwood use declines. A logical argument can be made that decreased fuelwood use leads to decreased cooking times, which in turn leads to decreased consumption of cooked foods and increased incidence of parasites or malnutrition. However, each of the links in this argument must be empirically demonstrated and if, indeed, households can conserve fuel with no detrimental effects on health, then increasing fuel prices may not have severe detrimental welfare impacts. Some suggest that decreasing the number of fires will improve health conditions as high smoke densities in traditional conditions contribute to respiratory ailments. The East-West Centre in Honolulu[8] observes that "the women cooks are inhaling as much benzopyrene as if they had smoked 20 packs of cigarettes a day."

So even with a conceptual framework in which to ask questions and develop our arguments, it is not always clear what effect increased fuelwood prices will have in a society. Nonetheless, the framework allows us to address the issues in a coherent fashion.

The methodology adopted in this study is capable of addressing only some of the questions enumerated here. The interfuel substitution model certainly allows us to address Q1 and Q2a, relating to the own-price and cross-price elasticities of demand for fossil fuels and fuelwood. In theory, the model could also be used to address Q2b, as agricultural residues are technically substitutes. In practice, however, price and consumption data for this class of commodity will not normally be available.

Problem Q2c (whether increases in cooker efficiency occur) can be explored with the residuals model, although the model can detect only such increases when they are induced by changes in the capital stock or by exogenous trends in cooking techniques. Any direct efficiency increase (through conservation) arising from increased prices is indistinguishable from a simple reduction in use with no efficiency changes.

The two models together, therefore, allow us to explore Q1, Q2a and Q2c. Problems Q2b and Q2d can not be addressed directly, although one can draw conclusions depending on the outcome of Q2a and Q2c. Finally, the problem of whether increased use of agricultural residues results in lower productivity, and whether decreased uncompensated fuelwood consumption is actually a bad thing, are not addressed by our models or by our study.

[8] Quoted in Eckholm et. al. (1984), p. 92.

### 7.2.5 A Comment Regarding Empirical Problems

On a note of definition, all of the consumption data used in this chapter have aggregated charcoal and fuelwood. This was primarily because forestry production statistics were used as a basis for estimating consumption, and no reliable and consistent means could be found for separating the amount used for fuel and the amount used for charcoal manufacture. Prices, however, were strictly fuelwood prices. The potential errors introduced by this procedure are thought to be small, as Government of India Forest Statistics in the 1960s typically estimated that less than 5% of the fuelwood harvest was converted to charcoal.

Although some of the analytical steps are clear, often difficult challenges arise in dealing with the data which are available. Many countries do not have well developed markets for fuelwood, and proxies must be found for fuelwood prices and consumption. Further, fuelwood, even when measured, is normally reported in terms of volume or weight. As anyone who has ever built a fire knows, the value to the user of a kilogram or cubic meter of wood can vary tremendously depending on what type of wood it is, how wet it is, and how densely it is packaged. The need for developing consistent means of measurement is far from trivial and, ultimately, completely necessary to determine fuelwood demand relationships. At this juncture we therefore provide the common lament of the development economist: that being the need for reliable data in this area.

## § 7.3 Measuring Fuelwood Demand Response in India

### 7.3.1 Methodology

Energy demand modelling in developing countries is as much an exercise in developing systems which efficiently use the sparse data as it is an exercise in developing theoretically sound models. Although simple single equation models are popular because they allow the analyst to look for correlations between variables, their theoretical basis is often suspect and their specification is arbitrary. Conversely, however, models which have a defensible theoretical basis – by being founded on some utility maximising principle, for example – often require estimating systems of equations which lose their significance in measurement noise.

The approach adopted here attempts to use the advantages of each of these two approaches.[9] A trans-log cost share model is specified which is founded in a theory of utility maximisation. The model allows us to extract estimates of the interfuel elasticities of substitution, but captures only responses to single period price changes. A single equation residuals model is then specified which explores any lagged responses arising from changes in the exogenous capital stock. The specification of the residuals model is somewhat arbitrary, and is to a degree an exploratory exercise. Specific hypotheses can be tested, however, as described later.

Although the actual models are relatively straight-forward, their validity relies on a number of underlying assumptions about individuals' behaviour. Potentially serious objections to the approach arise if:

a) no formal markets exist for the goods; or,
b) unmeasurable quantities of potential substitutes (agricultural residues) are known to be consumed.

Each of these objections will be addressed in some detail in Section 7.3.5.

### 7.3.2 The Trans-Log Model

The use of the trans-log model has been well developed for analysing energy demand in developed countries using only time-series data (Berndt and Watkins [1978]) or time-series and cross-sectional data (Halvorsen [1975]; Chern [1976]; Uri [1982]). In general the model can be used for any number of substitute or complementary goods. It is based on the premise that individuals attempt to maximise utility by minimising the cost of satisfying any given level of energy demand. The existence of an energy cost function is thus hypothesised which sets an aggregate energy price, $P_E$, as some function of the prices of n individual fuels:

$$P_E = F(P_1,\ldots,P_i,\ldots,P_n) \qquad \ldots(7.1).$$

The transcendental logarithmic functional form of this relationship allows considerable generality since it places no restrictions on the partial elasticities of substitution and is shown by Christensen et.al. (1973) to be a good second-order approximation of any arbitrary twice-differentiable price possibility frontier. For any number of fuels, the trans-log specification is as follows:

$$\log P_E = \beta_0 + \sum_i \beta_i \log P_i + \frac{1}{2}\sum_i\sum_j \gamma_{ij} \log P_i \log P_j \qquad \ldots(7.2).$$

[9] A third approach to demand modelling in LDCs is demonstrated by de Lucia and Tabors (1982), which consists essentially of a detailed accounting of the energy intensities of various sectors. While this is a revealing exercise, it does not in itself provide information about demand elasticities.

Here the ß's and γs are unknown parameters. Some further restrictions must apply for the function to be homogeneous. In order that total energy expenditures increase proportionately with proportionate increases in prices, we must have:

$$\sum_i \beta_i = 1 \qquad \text{...(7.3);}$$

and,

$$\sum_i \gamma_{ij} = 0 \qquad \text{...(7.4).}$$

One feature of the price possibility frontier approach is that the derived demand $X_i$ for any fuel can be obtained by partially differentiating Equation (7.2) with respect to prices. This gives, generally, $\partial P_E / \partial P_i = X_i$, and, in the case of the trans-log specification:

$$\frac{\partial \log P_E}{\partial \log P_i} = \frac{P_i X_i}{\sum_j P_j X_j} = S_i \qquad \text{...(7.5);}$$

which is better known as Shephard's lemma (after Shephard [1963]). Here $S_i$ is the cost share of fuel i.

This derivation now allows us to express a system of cost share equations for any number of fuels. In our case, we will restrict the model to two fuels: fuelwood and kerosene, having subscripts W and K respectively. The share equations are:

Model I

$$S_W = \beta_W + \gamma_{WW} \log P_W + \gamma_{WK} \log P_K \qquad \text{...(7.6a);}$$
$$S_K = \beta_K + \gamma_{KW} \log P_W + \gamma_{KK} \log P_K \qquad \text{...(7.6b).}$$

From the restrictions imposed by Equations (7.3) and (7.4), it is clear that the cost shares must sum to unity. Further, these restrictions imply that for any system with n fuels, we can estimate any (n-1) of the equations and then the last will be uniquely defined. Indeed, Barten (1969) shows that the system is invariant to which of the equations is dropped.

Once the cost share equations are estimated, one can derive conventional own- and cross-price elasticities either through simulation or, after Allen (1938) and Uzawa (1962), we can

### 7.3.3 The Residuals Model

An alternate approach to describing fuelwood demand is to specify the quantity demanded as a function of numerous explanatory variables. An example of this approach is that used by Bryant (1986) in estimating the U.S. residential demand for fuelwood. Using a weighted least squares approach, he estimates the amount of wood burned in homes as a function of wood price, alternate fuel price, household income, weather, age of the head of the household, the number of individuals in the household, and some 14 dummy variables relating to demographic and aesthetic factors. This approach has the advantage that it allows the analyst to isolate those variables which are apparently significant in explaining fuelwood demand.

Our residuals model is based on such an approach. The approach is further divided into two steps: the first to confirm the cost share model; and the second step to evaluate the residuals.

The first step involves estimating fuelwood consumption as a function of prices only, although an added term (POP) is specified to capture growth in the population. Also, rather than using nominal prices, real fuelwood and kerosene prices are used, and are designated as $P'_W$ and $P'_K$ respectively. Adding the time period subscript explicitly, the single equation model is then estimated as:

Model IIa

$$X_{W_t} = b_0 + b_1 POP_t + b_2 P'_{W_t} + b_3 P'_{K_t} + e_t \qquad ...(7.8).$$

Using this specification, it is possible to test whether the own- and cross-price elasticities generated here are equal to those estimated by the cost share model. This is an important step because, as noted, the cost share model is based on some form of utility maximisation and it is desirable to obtain a specification for this model which generates results which are consistent with such an assumption.

The second step involves attempting to extract explicitly further information from the residuals, $e_T$. There are numerous techniques available for obtaining information from such residuals. For time series data, one useful approach is to develop an auto-regressive or ARIMA[11] type of model to provide information about the underlying time series. Such

[11] This refers to an auto-regressive integrated moving average estimation procedure, often called the Box-

If a distributed lag of the form $a_k = \lambda a_{k-1}$ for k>1 is further assumed, then as $T \to \infty$, we derive:

Model IIb

$$e_t = a_0(1-\lambda) + (1-\lambda)e_{t-1} + a_1 P_{t-1} \quad ...(7.11).$$

This is what we refer to as the simple single equation residuals model. If significant estimators are found, it is concluded that evidence exists supporting the hypothesis that new capital is adopted in response to fuelwood price changes.

7.3.4 Data Sources

While the procedures can be applied for any country for which data are available, India was selected in this study as it provided a sufficiently long time-series of consistent data and thus allows a demonstration of the approach.

Prices for kerosene and fuelwood were based on monthly statistics reported by the Government of India Department of Statistics under the series "All India Average Rural Retail Prices of Some Selected Commodities/Services". The particular series for both fuelwood and kerosene prices were available from August 1969 to December 1986. From January 1963 to July 1969, kerosene and fuelwood price data for Bangalore were used and were normalised such that they coincided to the "rural" series in July, 1970. Bangalore data[12] were used as they were found to have the smallest variance from the "rural" statistics over the one year period (August 1969 to July 1970) during which both were reported. Monthly prices were then averaged on a calendar year basis to generate the average annual nominal prices on which the estimations were based.

Kerosene consumption data were available from 1967 to 1985 from assorted series published by the International Energy Agency (1979; 1984) and the United Nations (1983; 1984; 1987). For India there are basically two sources of fuelwood statistics. The India Department of Agriculture prepares estimates of annual wood production for fuelwood and charcoal. These data are available from 1949 to 1982. The second source is the Food and Agricultural Organisation which estimates fuelwood and charcoal consumption in the developing countries. The FAO data are available to 1988. The disadvantage of using the

[12] This was based on the series "Retail Prices of Essential Commodities at Selected Centres". A discontinuity occurs not only in the market location here but also in the commodity sold. Prices prior to August, 1969 are reported in terms of Rp/40 kg whereas thereafter they are reported in terms of Rp/100 kg. Hence the 'normalisation' procedure captured both locational differences as well as any potential non-linearities in the relationship between price and bundle weight.

approaches would, for example, reveal whether or not there existed any exogenous trend towards increased fuel efficiency which was unrelated to prices. The problem with such approaches is that, first, they assume that the underlying time series is stationary and, second, they require very long time series to extract useful information. Series stationarity can often be achieved through differencing techniques – albeit at the expense of data – but seldom are sufficiently long time-series available in developing countries. A more tractable approach, and the one adopted here, is to regress explicitly the residuals on lagged variables.

Specifically, we are interested in testing the hypothesis that increased fuelwood prices cause the adoption of capital equipment which is more energy efficient. Because we have no information on the vintage or nature of the capital equipment in use at any time, we must explore the data for signals that this adoption occurs. In order to do this, we are testing the following hypothesis:

> H0: Increased fuelwood prices in year t lead to the adoption of new more efficient capital equipment $E_t$ in year t,

and we assume further that:

> A1: The useful life of the new equipment is T years such that T>1;

which provides us with the corollary:

> C1: An increase in fuelwood prices in year t will lead to a decrease in fuelwood use in years t, t+1, ..., t+T-1.

This gives us the testable implication that $X_{W_t}$ must also be a function of historical prices if some new capital stock is adopted in response to price changes. In terms of our residuals, it implies that:

$$e_t = e_t ( P_{t-1},\dots,P_{t-T+1} ) \qquad \dots(7.9).$$

Note that the $P_t$ term does not appear here because all of its effects will have been captured by Model IIa in estimating $X_{W_t}$.

Although numerous functional forms can be specified, we choose an obvious lag function of the form:

$$e_t = a_0 + a_1 P_{t-1} + a_2 P_{t-2} + \dots + a_{T-1} P_{t-T+1} \qquad \dots(7.10).$$

Jenkins method (after Box and Jenkins [1976]).

If a distributed lag of the form $a_k = \lambda a_{k-1}$ for k>1 is further assumed, then as $T \rightarrow \infty$, we derive:

Model IIb

$$e_t = a_0(1-\lambda) + (1-\lambda)e_{t-1} + a_1 P_{t-1} \quad ...(7.11).$$

This is what we refer to as the simple single equation residuals model. If significant estimators are found, it is concluded that evidence exists supporting the hypothesis that new capital is adopted in response to fuelwood price changes.

### 7.3.4 Data Sources

While the procedures can be applied for any country for which data are available, India was selected in this study as it provided a sufficiently long time-series of consistent data and thus allows a demonstration of the approach.

Prices for kerosene and fuelwood were based on monthly statistics reported by the Government of India Department of Statistics under the series "All India Average Rural Retail Prices of Some Selected Commodities/Services". The particular series for both fuelwood and kerosene prices were available from August 1969 to December 1986. From January 1963 to July 1969, kerosene and fuelwood price data for Bangalore were used and were normalised such that they coincided to the "rural" series in July, 1970. Bangalore data[12] were used as they were found to have the smallest variance from the "rural" statistics over the one year period (August 1969 to July 1970) during which both were reported. Monthly prices were then averaged on a calendar year basis to generate the average annual nominal prices on which the estimations were based.

Kerosene consumption data were available from 1967 to 1985 from assorted series published by the International Energy Agency (1979; 1984) and the United Nations (1983; 1984; 1987). For India there are basically two sources of fuelwood statistics. The India Department of Agriculture prepares estimates of annual wood production for fuelwood and charcoal. These data are available from 1949 to 1982. The second source is the Food and Agricultural Organisation which estimates fuelwood and charcoal consumption in the developing countries. The FAO data are available to 1988. The disadvantage of using the

[12] This was based on the series "Retail Prices of Essential Commodities at Selected Centres". A discontinuity occurs not only in the market location here but also in the commodity sold. Prices prior to August, 1969 are reported in terms of Rp/40 kg whereas thereafter they are reported in terms of Rp/100 kg. Hence the 'normalisation' procedure captured both locational differences as well as any potential non-linearities in the relationship between price and bundle weight.

FAO data are that they are simply estimates derived by multiplying population by per capita fuelwood requirements, and their estimate for per capita requirements remained unchanged from 1974 to 1985. No rationale for this assumption is given, although it should be borne in mind that the concern of the FAO was to forecast gross global fuelwood demands and price responses would not likely change the thrust of their conclusion. Therefore, for this study, the India forestry production estimates were used. It should be noted that this has the added advantage in that it also includes fuelwood which would not have passed through normal markets, as they were trying to determine the total resource use.

The residuals model also requires miscellaneous population and price deflator statistics which were based on annual data presented by the India Department of Statistics. The specific price deflator used was the "All India Food Index for Agricultural Labour". These data were available from 1960 to 1988.

Because of the data limitations, therefore, various constraints were imposed on the estimations. Model I was constrained by the absence of reliable kerosene consumption data prior to 1967. Model II, however, which did not require these data, was constrained by the availability of reliable price series prior to 1963. Both models were constrained by the lack of recent forestry production estimates, as the FAO data were deemed inappropriate for the reasons discussed earlier. In summary, therefore, the cost share model was based on an estimation period of 1967 to 1982 and the residuals model was based on an estimation period of 1963 to 1982.

### 7.3.5 Discussion of Underlying Assumptions

#### Product Prices

One of the potential objections to the overall approach adopted here is that much of the activity in the fuelwood sector never passes through formal markets. The cost share model requires that individuals have opportunities to interact and trade in a market, responding to price changes. While in developed countries this assumption is valid, it can be questioned in LDCs where much of the activity is not observed. The objection basically relates to product pricing: that many products are gathered 'free' and are consumed individually without ever entering the market.

In response to this objection, it is important to realise what the cost share model is doing. It allows individuals to minimise some aggregate price by selecting various mixes of commodity inputs. The prices used in the model must reflect, in effect, the marginal utility to the user of consumption and the quantity consumed must reflect their total consumption and not necessarily what passes through the market. It is argued, therefore, that as long as prices reflect marginal utilities to the consumers and as long as total (traded + untraded) consumption is used, the approach is valid.

In terms of consumption, our empirical study has, in fact, used total production data as a proxy for consumption. This is believed to approximate total consumption more closely than something which measures traded goods. Second, in terms of product prices, this may be a valid objection in some instances. In the case of India, however, a fairly good private market is developed in most centres because of the existence of plantation forestry which aims to provide fuelwood (Gupta [1982]; FAO [1981]). But the market is open, and anyone can gather fuelwood and sell into the market or choose not to gather fuelwood and purchase from woodlots or private individuals. Hence, although not all goods are traded, the existence of the *opportunity* suggests that, at the margin, non-traded goods must have the same value as traded goods.[13] This may not, however, generally be the case and researchers should establish what market conditions in fact exist before proceeding with this approach.

Alternate Fuels

A second potential objection relates to the fact that unknown quantities of an untraded good, in this case agricultural residues, are known to be consumed. Strictly, one should consider three goods: fuelwood, kerosene, and agricultural residues. While in theory the cost share model can be recast to accommodate all three fuels, data limitations prevent explicit incorporation of the agricultural residue share. Even though it has no formal market price, its cost share can not be regarded as zero as one must consider its value to the user (as discussed above).

Although the only rationale for excluding agricultural residues is the lack of data, we can identify the conditions sufficient to validate our approach. Basically, the evaluation of just fuelwood and kerosene implies that the fuelwood/kerosene mix is separable in the utility function from the agricultural residues. In practice, this requires that any change in agricultural residue 'prices' can affect all of the cost shares $S_W$, $S_K$, and $S_R$, but that the ratio $S_W/S_K$ must remain unchanged.

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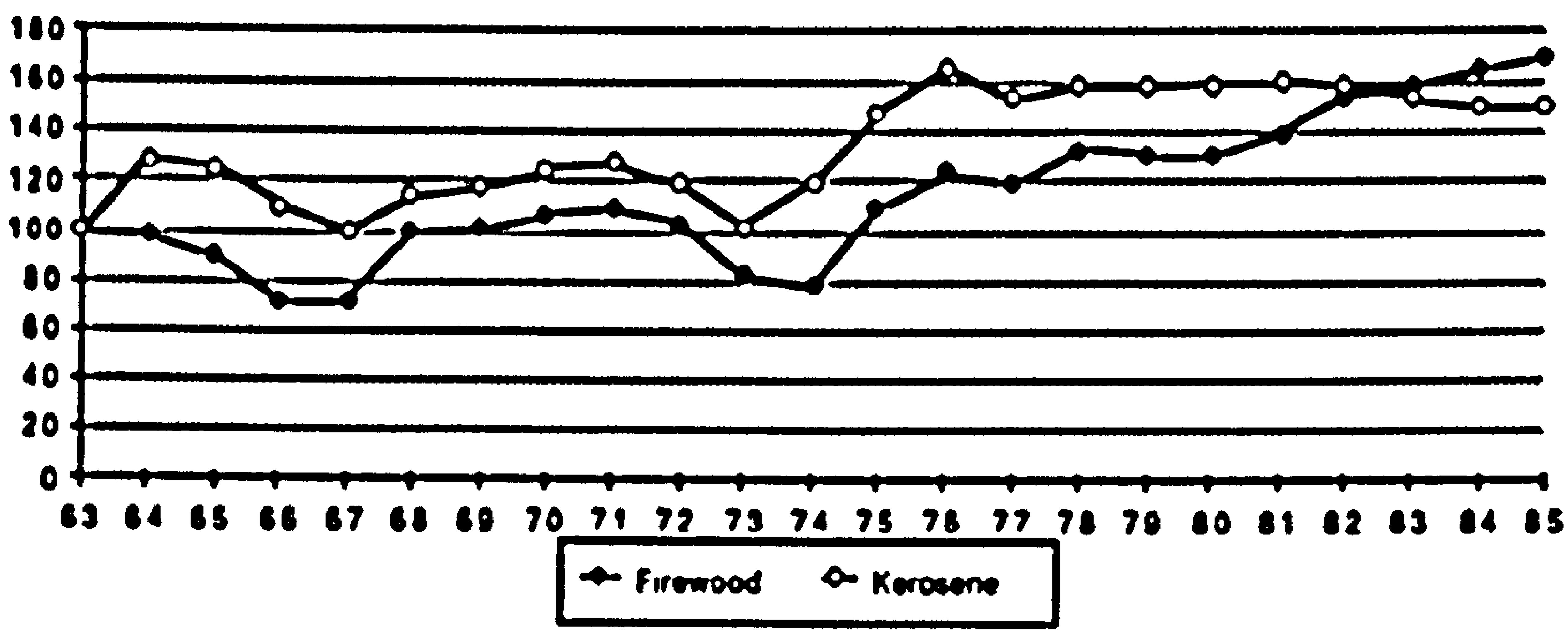
[13] In essence, an individual gathering his own wood must assign a value V to it such that it is equal to the market price P. If V<P, then it would be in his interests to sell it in the market and if V>P, then he should not be gathering wood but rather be buying it from the market. Hence equilibrium can only occur where V=P.

Figure 7.1
Real Fuel Prices - Rural India




In terms of the price functions and corollaries to Equation (7.1), this separation effectively lets us define two sets of problems in which we have two price functions:

$$P_E = F_1(P_R, P_T) \quad ...(7.12a);$$
$$P_T = F_2(P_K, P_W) \quad ...(7.12b);$$

where $P_R$ is the price of the agricultural residue and $P_T$ is the price function for traded fuels. This separation allows us to model, in trans-log form, the system in Equation (7.6).[14] In principle, Equation (7.12a) can also be transformed into a cost share model in cost shares $S_R$ and $S_T$, but it would not be estimable due to data constraints.

## § 7.4 Empirical Results

### 7.4.1 An Historical Perspective

The historical trend of real fuel prices in India is shown in Figure 7.1, with 1963 arbitrarily chosen as a reference year. Both wood and kerosene prices varied only about ± 25% from 1963 to 1973. After the oil embargoes of the early 1970s, kerosene prices jumped by about 60%, but remained remarkably stable in real terms from 1975 to 1985. It is clear, however, that fuelwood prices have doubled in real terms over the same ten year period.

In terms of consumption, most of the residential energy requirements are met by fuelwood.

[14] The trans-log model is sometimes mistakenly believed to assume, in this case, that people have a fixed energy budget which they spend in a manner to minimise energy prices. While the trans-log model can be used for such circumstances, it does not assume that the total energy share in the consumption basket remains constant.

In 1977, for example, some 89% of the measured residential energy consumption (i.e., excluding agricultural residues) can be attributed to fuelwood, with 10% to kerosene and 1% to other products (IEA [1979]).

### 7.4.2 Trans-Log Model Results

The cost share model was estimated for the period 1967 to 1982. As described in Section 7.3, it is necessary to estimate only one of the share equations in a two equation system, hence the kerosene cost share was dropped. The resultant estimate is as follows (with standard errors in parentheses):

Model I

$$S_W = \underset{(0.04438)}{-0.06254} + \underset{(0.01745)}{0.06252} \log P_W - \underset{(0.01800)}{0.06979} \log P_K \quad ...(7.13).$$

$F = 1139.4$ $\quad R^2 = 0.5533$ $\quad$ D-W = 1.6763

Own- and cross-price elasticities were calculated using Equation (7.7). First, however, tests were performed to determine whether the elasticities were significantly different from zero.[15] The null hypothesis that the own-price elasticity for fuelwood was zero was rejected at a 95% confidence level. With respect to the cross-price elasticity, however, the null hypothesis could not be rejected. Hence, recalling that the elasticities can vary from year to year, the model suggests the following:

| | | |
|---|---|---|
| $\eta_{WW,mean}$ = -0.24 | $\eta_{WW,1982}$ = -0.32 | $\eta_{KW}$ = 0 |

This suggests that fuelwood demand was inelastic to its own price, and that no interfuel substitution occurred due to relative price changes. These results are now further checked with the residuals model.

[15] The tests and the estimations of elasticities were conducted by the SHAZAM software used for the regressions. Referring to Equation (7.7), the relevant tests basically try to determine if $\eta_{ii}=0$ or $\eta_{ij}=0$ at the mean cost shares $S_i$ and $S_j$. This is equivalent, for example, to testing whether $\gamma_{ii}=S_i-S_i^2$. Results of the tests indicated the following t-statistics for the indicated tests: $\eta_{ww}=0$ ($t=2.1$); $\eta_{kw}=0$ ($t=1.5$). Simulations for kerosene suggested that its own price elasticity ($\eta_{kk}$) was only about -0.02, but tests indicated that this was no different than zero ($t=1.5$).

### 7.4.3 Residuals Model Results

The first part of the residuals model is meant to verify the cost share model and, as the cost share model indicated that $P_K$ should be insignificant, two regressions were undertaken which resulted in the following (with standard errors in parentheses):

Model IIa (Trial 1)

$$X_W = \underset{(2750.6)}{5408.5} + \underset{(54.82)}{217.43}\,POP - \underset{(46207)}{99190}\,P'_W \qquad ...(7.14a).$$

F = 893.4 $\quad R^2 = 0.5704 \quad$ D-W = 1.49

Model IIa (Trial 2)

$$X_W = \underset{(2898.6)}{5592.2} + \underset{(66.44)}{204.80}\,POP - \underset{(66197)}{115990}\,P'_W + \underset{(983890)}{362400}\,P'_K \qquad ...(7.14b).$$

F = 621.8 $\quad R^2 = 0.5757 \quad$ D-W = 1.50

It is clear that the regression without the kerosene price generates significant coefficients with the expected signs and that, when kerosene prices are added, these are not significant and contribute little to the overall explanatory power of the regression. This confirms that no interfuel substitution is evident. Further, a calculation of the own-price elasticity of fuelwood at the means in Equation (7.14a) yields $\eta_{WW} = -0.2974$. This concurs with the estimate generated by Model I.

The next step is to explore the residuals from Model IIa. Before applying the procedure described in Section 7.3, however, it is noted that some simple tests can be conducted on the residuals to determine their nature. A D-W=1.49 was computed, which, for n=20 and k=2, suggests that the Durbin-Watson test is inconclusive at a 95% level of confidence ($d_U$=1.54), although it concludes that no autocorrelation would exist at a 90% level of confidence. To a degree, therefore, we might expect our residuals to look like 'white noise', but it is nonetheless useful to conduct the estimation exercise.

The model specified in Equation (7.11) was estimated to yield (with standard errors in parentheses):

Model IIb

$$e_t = \underset{(1726.5)}{-1598.9} + \underset{(0.2824)}{0.2645}\,e_{t-1} + \underset{(43444)}{41065}\,P'_{W,t-1} \qquad ...(7.15).$$

F = 0.6 $\quad R^2 = 0.1337 \quad$ D-W = 2.09

By these tests it is clear that no apparent lagged response exists and that the residuals are, indeed, 'white noise'. We hence reject the hypothesis that exogenous changes to cooker efficiency arose as a result of changes to the capital stock.

### 7.4.4 Interpretation of Results

The results of the empirical exercise are best expressed as a response to the questions which were originally framed in Section 7.2. To reiterate, these are as follows:

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Q1. What happens to fuelwood demand when wood prices rise?

Q2. If the quantity of fuelwood demanded falls, do households:

- a) replace the fuelwood with fossil fuels?
- b) replace the fuelwood with agricultural residues?
- c) increase cooker efficiency?
- d) do none of [a] – [c]?

Q3. If agricultural residues are adopted, what is the effect on productivity?

Q4. If no substitution occurs, does malnutrition or disease ensue?

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In response to the first question, fuelwood demand falls when fuelwood prices rise, all other things equal. Both the cost share and the residuals model suggest that for every 10% increase in real fuel prices, fuelwood consumption falls by approximately 3%. When one considers that, in India, real fuelwood prices doubled over the period 1975 to 1985, the fuelwood consumption change which ensued from this would be of the order of a 30% decrease.

The second question relates to how households adapt when less fuelwood is being consumed. The empirical evidence for India suggests that substitution towards kerosene has not occurred, nor has there been a significant adoption of cookers with higher efficiencies. One is forced to conclude, within the above framework, that either households are making increased use of agricultural residues or they are simply not replacing the fuelwood with any other fuel.

If, indeed, they are using agricultural residues, then one might ask whether there are any adverse impacts on agricultural productivity. Conversely, if households are simply cutting back on fuelwood consumption, then we might be concerned that they are cooking less and might decrease their consumption of cooked foods. Some argue that this would lead to increased malnutrition or incidence of disease. While these questions were not explicitly addressed here, verifying whether such linkages exist is clearly of concern to planners.

The results suggest that, in India, continued increases in fuelwood prices will decrease fuelwood consumption, but that any real decreases in kerosene prices arising from low international oil prices or from deliberate kerosene subsidies will not have similar effects. The declining kerosene prices might initiate small increases in kerosene demand but will elicit no decrease in fuelwood demand.

While on the surface these results may seem surprising, they would be consistent with circumstances where either kerosene rationing occurred, or where kerosene and fuelwood were used in completely separate markets. As noted by Ahmad and Stern (1987; p. 311), both of these factors might exist in India: there was some explicit subsidised rationing of kerosene in India, and "the different ['fuel and light' goods – cow dung, firewood, coal, kerosene, and electricity – ] are consumed by very different household groups". Although investigating the specific local marketing arrangements was beyond the scope of this study, it would be useful to determine whether, for example, kerosene was readily available in traditional fuelwood markets or if some logistical (supply) constraints limited its availability. If such constraints do indeed exist, then pricing incentives in association with programmes which promote improvements to the kerosene supply system may well elicit some effective substitution.

## § 7.5 Conclusions

### 7.5.1 Summary

Deforestation of tropical moist forests in developing countries is becoming a vital concern as, in many circumstances, these forests have traditionally provided critical supplies of fuelwood to indigenous populations. The deforestation has often resulted in increased prices for fuelwood or has required greater individual effort for fuelwood collection. This has manifested itself further through decreased fuelwood consumption which, in turn, leads to potential decreases in total fuel use, decreases in cooked food consumption, increased incidence of related health problems, or substitution towards alternate fuels.

This chapter outlined the general fuelwood problem and discussed the potential impacts of price increases to final demand for various energy commodities. The issue is important because, in planning optimal allocation and intervention strategies in these economies, planners must have empirical evidence of what linkages, if any, exist between demand for traditional items (such as fuelwood) and manufactured or imported fossil fuel products. In particular, the substitution possibilities in final demand between kerosene and fuelwood in India are investigated.

The approach used involves first the estimation of a transcendental logarithmic specification of residential energy demand for two commodities: fuelwood and kerosene, to test the substitution effects between these commodities. The advantage of this approach is that it poses no *a priori* restrictions on the demand elasticities, and that it is founded in a simple theory of individual utility maximisation. The system of cost share equations is estimated using OLS techniques. A second step is then made using a simple single equation model of fuelwood demand to investigate whether changes in the capital stock efficiency (of cookers) have occurred.

The empirical results of the cost-share model indicated that the own price elasticity of fuelwood was approximately -0.3. Substitution effects through changes in relative fuel prices are non-existent. The single equation formulation confirmed these results, and additionally illustrated that there was no evidence for exogenous increases in cooker efficiency.

The results suggest that the increases in fuelwood prices from increased scarcity do indeed manifest themselves in lower fuelwood use, without substitution towards fossil fuel products. As there is no evidence suggesting increases in cooker efficiency, one must conclude that either no substitute is being adopted for the fuelwood, or that it is being substituted with other products such as livestock dung or crop residues. If no substitution occurs, there is some possibility that the situation may lead to health related problems. If, on the other hand, fuelwood is substituted by agricultural wastes, increased use of these products may decrease overall agricultural productivity. Either of these possibilities would be of concern to planners in these countries.

7.5.2 Policy Implications

Intervention in any sector to achieve any given set of goals will depend upon the policy objectives and the effects which a policy would have. Although this study does not prescribe any particular set of objectives, the results do indicate what the effects would be of certain policies and, thereby, suggest whether policies might achieve their stated or implicit goals.

First, for example, the results suggest that a policy of subsidising kerosene prices will not alleviate any pressures on fuelwood demand as individuals simply do not switch. The kerosene pricing mechanism in this case is not an effective policy lever. Conversely, however, if the policy goal is to restore individual fuelwood consumption to higher levels, then this can be achieved through decreasing fuelwood prices (which, it is noted, would likely only be sustainable through resource management programmes promoting more intensive forestry projects). These are, in fact, being pursued in India with vigour and the analysis suggests that this is an appropriate action if the goal is to restore a higher level of fuelwood consumption.

Second, the analysis indicates that residents are not by and large adopting more efficient cookers in their capital stocks as fuelwood prices have increased. If it is indeed a desire of the government that cooker efficiency increases, it is likely that some form of direct intervention will be required rather than relying on the fuelwood price mechanism.

### 7.5.3 Suggestions for Further Research

The analysis in this chapter had two primary goals. The first goal was to outline the fuelwood problem in a consistent framework which was amenable to empirical analysis. The second was to develop and demonstrate the viability of using interfuel substitution demand models for analysing fuelwood demand. While data problems arose in this study and will persist through others, it is believed that the approach adopted here is valid and can contribute to more coherent policy decisions in developing countries.

In particular, however, further research is warranted in three major areas:

a) data collection;
b) application of the methodology; and,
c) exploration of related issues.

The task of data collection is perhaps the most critical; the problems are essentially empirical, so the solutions must rely on empirical evidence. Although historical data are often poor in developing countries, the approach is amenable as well to cross-sectional analysis, which suggests that locational surveys can contribute significantly to the available data. As panel surveys are being conducted on a more formal basis in many regions, these would provide further benefits by collecting information relating to fuelwood and energy use in the home.

Once the data become available, this type of analysis can be extended to other regions and countries. Indeed, if sufficient data were available, it would be of immense interest to discover what similarities and differences exist between nations. While the current literature includes spot surveys and accounts, few have attempted to provide a more global analysis of fuelwood demand relationships.

Finally, there are a number of areas which were introduced but not investigated in this study. First, issues related to the use of agricultural residues are of theoretical concern and – in India – of empirical relevance. While it is not likely that useful aggregate data of the type used here will become available for agricultural residues, it seems feasible to undertake more region or village specific studies of the use of residues. One might expect that, if sufficiently rich data were available, some substitution effects from fuelwood to agricultural residues might be picked up in potentially related indicators such as agricultural productivity, agrochemical use, fodder purchases, or milk production. A second, perhaps more critical, issue relates to the overall question of whether malnutrition or disease incidence can be linked to lower fuelwood use. Research in the general area of LDC food requirements and food policy is receiving increasing attention, but seldom does this work address in any rigourous fashion whether food intake may be constrained by fuel availability.

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# CHAPTER 8
# SUMMARY AND CONCLUSIONS

The individual chapter summaries have for the most part provided specific conclusions arising from the analyses which were conducted. Appropriately, I shall be brief here: highlighting some of the salient features of the work and suggesting some potential avenues for further research.

The broad issues of rainforest conservation were characterised by noting first that a number of major land-use pressures are currently being blamed for tropical deforestation. The deforestation is resulting in a reduction of a number of environmental services which the rainforest provides both locally as well as globally. As the rest of the world becomes aware of some of the effects of deforestation, pressure has mounted to institute policy reforms which will promote rainforest conservation in developing countries.

One of the major empirical problems of deciding how to develop rainforests optimally is that the linkages between various components of the rainforest, between the rainforest and the global environment, and between the rainforest and the 'economy' are not well known. But economists are currently being called upon to contribute to the design of policies which will promote conservation. This thesis has attempted to demonstrate that, in spite of the information constraints, economic theory can provide some important contributions and that, where economic theories provide ambiguous conclusions, careful empirical analyses can assist in designing appropriate policies.

An important generalisation arising from the economic theory is that tropical deforestation is occurring too quickly with respect to the optimal rate. A corollary to this is that a sub-optimal amount of conservation is occurring. A review of the literature suggested that some of the factors which contribute to this result are:

a) much of rainforest exploitation is through conditions of open access;

b) the services rainforests provide to the rest of the world are public goods from which exclusion is essentially impossible;

c) those harvesting the resource do not take into account the effects their actions have on the rest of the world;

d) development is irreversible and benefits are uncertain; and,

e) typical valuation procedures of conservation benefits may understate social benefits because of free-rider effects, the lack of appropriability of research benefits, and potentially significant divergences between willingness-to-pay (WTP) and willingness-to-accept (WTA).

The last issue relating to WTP and WTA is still contentious and requires additional research in the context of rainforest conservation. Drawing on theoretical and empirical evidence form other environmental issues, the environmental economics literature suggests that WTA – the amount the world would accept as compensation for further rainforest *loss* – might exceed by up to an order of magnitude the amount the world would be willing to pay for more rainforests.

Although we might generalise that we should conserve more rainforest, we can not with the information available at hand estimate the optimal amount of conservation. A practical problem then becomes finding policies which promote conservation. In the process of evaluating such policies, one expects that information useful to the actual optimisation programme might also be generated.

The global situation was characterised as one where we in the developed world are – presumably – willing to compensate developing countries for their conservation efforts, whatever those efforts might be. Under these circumstances, this thesis addressed the following two questions:

Q1. Are the international inducements we pay worth the conservation received?
Q2. Will the internal policy reforms available to the LDC achieve conservation?

To address Q1, a concept labelled the "rainforest supply price" (RSP) was defined as the minimum amount of compensation which an LDC would have to receive to conserve a particular rainforest area. To allow comparisons between different conservation programmes, the RSP was calculated on the basis of a protection scenario which reflected the amount of rainforest area protected by conservation efforts. Calculation of the RSP involves a relatively simple extension of cost-benefit analysis and, to illustrate the point, a study was done of a conservation project intended to protect Korup National Park in Cameroon. The analysis suggested that the project was not in Cameroon's interest unless a 5.4 million ECU inducement is transferred to Cameroon. Given the protection afforded, the transfer is equivalent to a RSP of 1060 ECU per $km^2$ per year. Evaluations of six other tropical rainforest projects suggests that international donors made transfers having values ranging from 15 to 1575 ECU per $km^2$ per year. It was thus concluded that the inducements required are within a range which conservation interests are apparently willing to mobilise.

The second question – regarding the effectiveness of available reforms – was addressed through a number of empirical studies. In support of this work, a survey of 341 households around Korup National Park was analysed in detail to test a number of specific hypotheses. In particular, we were interested in knowing whether increasing incomes in a "buffer zone" around a park would promote conservation; it is often hypothesised that increased incomes would draw individuals out of the park and would give them something better to do than exploit the park. Empirical evidence did not, however, support this hypothesis. The evidence suggests that economic development in the buffer zone would increase pressures on the park because: a) higher incomes would reduce emigration from the region and would thus cause greater population pressure on the Park; and, b) hunting effort increases as non-hunting income increases.

While the research on Korup involved specific household data, a study using aggregated national data relating to fuelwood demand in India was also undertaken. The impetus behind this work was to determine whether kerosene subsidies would decrease fuelwood demand and, in the process, take some pressure away from the forest resource. While the results showed that fuelwood demand responded to its own price (having an elasticity of -0.3), there was no evidence for interfuel substitution between kerosene and fuelwood. While there are a number of potential reasons for this result, it suggests that indirect subsidies of kerosene would not promote rainforest conservation through this mechanism.

The conclusions of the analyses in Cameroon and in India provide a sobering backdrop to presumptions and rules-of-thumb which are often used in policy design. Intuitively one might have expected higher incomes in a buffer zone to promote conservation, or kerosene subsidies to reduce fuelwood use. But the empirical evidence shows this intuition to be incorrect in these cases. Moreover, the evidence is perfectly consistent with economic theory and, upon reflection, it does not take any great leap of faith to accept the conclusions: one can readily imagine, for example, that hunting increases as non-hunting incomes increase if people simply like to hunt and hunting is a 'normal' good having a positive income elasticity of demand.

While these specific results may come as no surprise to economists, the exercise provides an important lesson to conservation groups. In the past, it has often been generalised that economic development and environmental protection were conflicting goals. More recently, conservation groups have generalised that economic development and environmental protection are, in fact, complementary: that economic development initiatives can be used to promote conservation, and that such conservation will in the longer term improve economic development prospects. While the current sentiment is laudable, I would submit that neither generalisation is correct. *Under certain circumstances*, economic development and conservation are complementary. To contribute meaningfully to the design of policies, one of the challenges to the economics profession is to discover what those circumstances might be.

This challenge provides ample scope for additional research opportunities. In particular, I would note that important insights – relating to conservation – can be gleaned from household surveys. This study has shown that such surveys can play a useful role in providing economically meaningful results in the design of policies which are intended to promote conservation. As their use and analysis is becoming more common in the discipline of development economics, it would likely require little incremental effort to ask how observed behaviour might affect conservation of some of the critical environmental resources.

In addition, the use of the RSP as an analytical tool suggests some interesting avenues of research. Two directions stand out as being particularly relevant: one relating to conservation benefits and one relating to conservation costs.

First, the calculation of the RSP abstracted from the issue of the quality of particular rainforests; it essentially uses a square kilometre of rainforest as the numéraire for comparative purposes. While it was illustrated that, in theory, there would be little difficulty in using a 'quality-adjusted RSP' for making comparisons and selecting which rainforest to protect, in practice this requires some valuation of the 'quality' of any given rainforest area. For the most part this falls into the realm of evaluating the global benefits of saving rainforests. While some headway is being made in this area, it would also be useful to investigate which particular characteristics of rainforests attract support from the conservation community. If one looks at all of the 'conservation' projects in the world, for example, is there any systematic relationship between the amount of money given to any given project and, say, the number of threatened animal species, the total area, or the type of scenery?

A second avenue involves determining whether there is any relationship between RSP and rainforest location. On the assumption that conservation precludes other destructive land uses, we might conjecture that, other things equal, the RSP will be lower in poorer countries than in wealthier countries because of the lower opportunity costs in poorer countries. If this conjecture is correct, it implies that, if we are indifferent to which rainforest we save but have only limited funds to do so, and if we are concerned only with conservation, then we should be concentrating our efforts in conserving rainforests in the poorest areas since they will be the cheapest to save. Interestingly, this criterion might place Amazonia into the 'expensive' bracket.

Regardless of which avenues of research are pursued, the tools economists have at their disposal are quite diverse and can, with proper application of both the theory and the empirical research, potentially make important contributions to the design of policies which promote conservation.

Finally, I would like to close on a less technical note. The empirical work in this thesis spent considerable effort trying to describe what influenced people's behaviour. A case in point is migration. But we should always remember that trying to predict migratory adjustment – either through observing aggregated flows or individual events – is a tricky process and we should never presume to know ultimately, for example, what makes people leave home. In designing models we may at times overlook, or bury, factors which are obvious to the people we are studying but are totally foreign to us. A striking example of this involves a local farmer near Korup National Park with whom I passed an enjoyable few hours one morning. He was about thirty years old, had lived on the fringe of the primary forest his entire life, and was by all appearances fairly typical of everyone else I had encountered. When we came around to discussing the possibility of moving away to a more lucrative lifestyle, he admitted that he had heard a lot of how much better life was elsewhere, but that he himself would never leave. When I asked him why he would not leave, he was incredulous that I did not know that the *juju* would not protect him if he left the area. *Juju* is the animistic spirit – the *magic* – resident in the trees and animals of the rainforest; many in the region believe that it guards and guides them in their daily lives. Of the twelve villages in the primary and high secondary forest zone of Korup, all but one had *juju* houses in which to celebrate and pay homage to the *juju* spirits.

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# APPENDIX
# KORUP NATIONAL PARK HOUSEHOLD SURVEY, 1988

## § A.1 Background

The analyses presented in Chapters 5 and 6 of this thesis rely to a large extent on household survey data collected at the Korup Project in Cameroon. The purpose of this appendix is to provide additional detail on the survey which, although highly relevant to the analyses conducted in the central text of the thesis, would unnecessarily distract from the key arguments being made. This appendix first describes the population at which the survey was targeted. Next, it describes the questionnaire guide used in the survey, highlighting the aggregate summaries in each key area. Thereafter, the data reduction process – i.e., the manner in which information is reduced from its initial raw form on the questionnaires to a final form which is amenable to analysis using computer-based economic evaluation packages – is discussed. Finally, some summary comments are presented which review some of the qualitative aspects of the survey procedure.

## § A.2 Target Population

There are a total of 30 settlements which are found within 3 kilometres of the Korup National Park boundary, and approximately another 40 which are within the usual trading areas of these villages. Based on surveys of the 1976 Census, the regional population is approximately 12,000 people.

Of these villages, 24 were surveyed in the demographic and income survey. As indicated in the following table, this represented all of the villages in the Park and the Western Buffer Zone (WBZ), and 12 of the 18 villages in the Eastern Buffer Zone (EBZ).

| Region | Villages in Region | Villages Surveyed |
|---|---|---|
| Western Buffer Zone | 6 | 6 |
| Korup National Park | 6 | 6 |
| Eastern Buffer Zone | 18 | 12 |
| External Trading Area | ~40 | 0 |

Although there is a road which extends to the edge of the buffer zone, there are no roads within the area and travel is normally by foot or, during the dry season, by boat along the Ndian River. A distinction was made between the two different buffer zones on the basis of accessability to the main road systems in the region: those in the EBZ could walk to the roads within a few days without crossing through the park, whereas those in the WBZ would need to pass through the park first on any such walk.

The target population within these 24 villages consisted of 379 households, although demographic data was obtainable for only 357 (94%) of the households. Those missing represented households which were obviously lived in but for which no one in the village was able to give reliable information. Income data were obtained on only 343 (91%) of the households. Missing data in this event arose when the interviewee was not a household member and knew enough about the household's composition but little about its activities. Finally, the number of households which were ultimately analysed was further reduced by two to 341 (90%). These two were rejected because other obvious evidence suggested that the responses were not reliable.[1]

A summary of each village is presented in Table A.1. Tables A.2 to A.5 provide aggregates for the Eastern Buffer Zone, the Western Buffer Zone, Korup National Park, and the entire survey sample. Although the migration data are analysed rigourously in Chapter 5, it is obvious even from the descriptive statistics that there has been an exodus of individuals of working age, both male and female, from these rural areas. For example, in the survey as a whole, 24% of the 15-34 year age group was "away at work" whereas only 15% of the 35-54 year age group and 4% of the 55+ year age group was absent for work reasons.

[1] One should normally have fairly good reasons for discarding data on the basis of *a priori* evidence. In this case, Household 041 was excluded because the household head claimed to be a highly trained crocodile and hippo hunter who regularly sold his catches to the Calabar Zoo in Nigeria. Apart from the fact that there are no hippos in the area, his stated annual income amounted to 188 million CFAF, or about £400,000. The second case involved Household 331 in the village of Lobe. There lived a single lady who claimed that her son was a rich cocoa farmer in Tombel who sent her about 4 million CFAF annually. Others in her village claimed that she received nothing from her son and that she was fed by those in Lobe. As Tombel was one of the villages surveyed, it was possible to find her son in the sample (Household 360) and the data indicated that his income, with which he had to support 10 household members, was only 450,000 CFAF.

Table A.1
Summary of Village Data

| Region/Village | Households: Surveyed | Households: On Map | Status: Present | Status: Abs School | Status: Abs Work | Status: Abs N/S | Status: Total |
|---|---|---|---|---|---|---|---|
| **Western Buffer Zone** | | | | | | | |
| Akpasan | 56 | 57 | 309 | 0 | 5 | 0 | 314 |
| Akwa | 12 | 12 | 79 | 10 | 6 | 2 | 97 |
| Ekoneman | 4 | 7 | 42 | 2 | 5 | 1 | 50 |
| Ekong I | 36 | 39 | 275 | 7 | 16 | 1 | 299 |
| Mbofong | 6 | 8 | 32 | 6 | 2 | 0 | 40 |
| Nguru-Korup | 1 | 1 | 3 | 0 | 3 | 0 | 6 |
| Subtotal WBZ | 115 | 124 | 740 | 25 | 37 | 4 | 806 |
| **Korup National Park** | | | | | | | |
| Bareka Batanga | 5 | 5 | 13 | 3 | 7 | 3 | 26 |
| Bera | 12 | 12 | 56 | 1 | 8 | 1 | 66 |
| Ekong II (Erat) | 35 | 38 | 266 | 6 | 24 | 7 | 303 |
| Ekundo-Kundo I | 18 | 18 | 92 | 16 | 7 | 6 | 121 |
| Esukutan | 23 | 25 | 197 | 2 | 4 | 2 | 205 |
| Ikenge | 20 | 20 | 137 | 14 | 33 | 10 | 194 |
| Subtotal KNP | 113 | 118 | 761 | 42 | 83 | 29 | 915 |
| **Eastern Buffer Zone** | | | | | | | |
| Babiabanga | 6 | 6 | 40 | 0 | 8 | 5 | 53 |
| Bajo | 17 | 18 | 58 | 21 | 28 | 1 | 108 |
| Bakut | 22 | 25 | 146 | 6 | 32 | 5 | 189 |
| Baleka Batanga | 7 | 7 | 24 | 7 | 14 | 1 | 46 |
| Banyu | 5 | 5 | 22 | 6 | 0 | 9 | 37 |
| Baro | 29 | 30 | 132 | 12 | 52 | 0 | 196 |
| Basu | 6 | 6 | 31 | 12 | 14 | 3 | 60 |
| Ekogate | 4 | 4 | 26 | 1 | 3 | 6 | 36 |
| Lobe | 6 | 6 | 28 | 0 | 5 | 1 | 34 |
| Mopako | 11 | 11 | 64 | 12 | 15 | 12 | 103 |
| Ngenye | 14 | 15 | 71 | 4 | 38 | 2 | 115 |
| Tombel | 2 | 4 | 20 | 0 | 0 | 0 | 20 |
| Subtotal EBZ | 129 | 137 | 662 | 81 | 209 | 45 | 997 |
| TOTAL | 357 | 379 | 2,163 | 148 | 329 | 78 | 2,718 |

Table A.2
Summary of Village and Population Demographics - Eastern Buffer Zone

Total number of households surveyed: 129

Summary of Village: 30 All EBZ:Cameroon Side --EBZ:Cameroon Side--

Includes households 1 to 361 inclusive

| | |
|---|---|
| Households surveyed | 129 |
| Households on map | 137 |
| Schools | 3 |
| Churches | 5 |
| Meeting Places | 1 |
| Commercial Buildings | 0 |
| Unoccupied Abandoned Sites | 31 |
| Sites Under Construction | 2 |
| Households with Zinc | 29 |
| Households with Concrete Blocks | 2 |

Population Distribution for All EBZ:Cameroon Side

| | | 0-14 | 15-34 | 35-54 | 55+ | TOTAL |
|---|---|---|---|---|---|---|
| Present | F | 116 | 110 | 63 | 36 | 325 |
| | M | 135 | 89 | 73 | 40 | 337 |
| | F+M | 251 | 199 | 136 | 76 | 662 |
| At School | F | 28 | 9 | 0 | 0 | 37 |
| | M | 24 | 19 | 1 | 0 | 44 |
| | F+M | 52 | 28 | 1 | 0 | 81 |
| At Work | F | 6 | 79 | 17 | 1 | 103 |
| | M | 6 | 64 | 30 | 6 | 106 |
| | F+M | 12 | 143 | 47 | 7 | 209 |
| Abs N/S | F | 16 | 4 | 2 | 0 | 22 |
| | M | 18 | 5 | 0 | 0 | 23 |
| | F+M | 34 | 9 | 2 | 0 | 45 |
| Absent | F | 22 | 83 | 19 | 1 | 125 |
| | M | 24 | 69 | 30 | 6 | 129 |
| | F+M | 46 | 152 | 49 | 7 | 254 |
| Total | F | 166 | 202 | 82 | 37 | 487 |
| | M | 183 | 177 | 104 | 46 | 510 |
| | F+M | 349 | 379 | 186 | 83 | 997 |

Table A.3
Summary of Village and Population Demographics - Western Buffer Zone

Total number of households surveyed: 115

Summary of Village: 29 All WBZ:Nigeria Side --WBZ:Nigeria Side--

| | |
|---|---|
| Includes households 1 to 361 inclusive | |
| Households surveyed | 115 |
| Households on map | 124 |
| Schools | 2 |
| Churches | 0 |
| Meeting Places | 5 |
| Commercial Buildings | 0 |
| Unoccupied Abandoned Sites | 14 |
| Sites Under Construction | 1 |
| Households with Zinc | 38 |
| Households with Concrete Blocks | 0 |

Population Distribution for All WBZ:Nigeria Side

| | | 0-14 | 15-34 | 35-54 | 55+ | TOTAL |
|---|---|---|---|---|---|---|
| Present | F | 171 | 122 | 68 | 25 | 386 |
| | M | 162 | 110 | 58 | 24 | 354 |
| | F+M | 333 | 232 | 126 | 49 | 740 |
| At School | F | 7 | 0 | 0 | 0 | 7 |
| | M | 16 | 2 | 0 | 0 | 18 |
| | F+M | 23 | 2 | 0 | 0 | 25 |
| At Work | F | 1 | 12 | 2 | 0 | 15 |
| | M | 1 | 19 | 2 | 0 | 22 |
| | F+M | 2 | 31 | 4 | 0 | 37 |
| Abs N/S | F | 0 | 1 | 0 | 2 | 3 |
| | M | 0 | 1 | 0 | 0 | 1 |
| | F+M | 0 | 2 | 0 | 2 | 4 |
| Absent | F | 1 | 13 | 2 | 2 | 18 |
| | M | 1 | 20 | 2 | 0 | 23 |
| | F+M | 2 | 33 | 4 | 2 | 41 |
| Total | F | 179 | 135 | 70 | 27 | 411 |
| | M | 179 | 132 | 60 | 24 | 395 |
| | F+M | 358 | 267 | 130 | 51 | 806 |

Table A.4
Summary of Village and Population Demographics - Korup National Park

Total number of households surveyed: 113

Summary of Village: 28 All KNP --KNP--

| | |
|---|---|
| Includes households 1 to 361 inclusive | |
| Households surveyed | 113 |
| Households on map | 118 |
| Schools | 1 |
| Churches | 4 |
| Meeting Places | 6 |
| Commercial Buildings | 1 |
| Unoccupied Abandoned Sites | 31 |
| Sites Under Construction | 1 |
| Households with Zinc | 32 |
| Households with Concrete Blocks | 0 |

Population Distribution for All KNP

| | | 0-14 | 15-34 | 35-54 | 55+ | TOTAL |
|---|---|---|---|---|---|---|
| Present | F | 155 | 146 | 67 | 21 | 389 |
| | M | 164 | 121 | 64 | 23 | 372 |
| | F+M | 319 | 267 | 131 | 44 | 761 |
| At School | F | 11 | 5 | 0 | 0 | 16 |
| | M | 15 | 11 | 0 | 0 | 26 |
| | F+M | 26 | 16 | 0 | 0 | 42 |
| At Work | F | 2 | 31 | 5 | 0 | 38 |
| | M | 0 | 32 | 13 | 0 | 45 |
| | F+M | 2 | 63 | 18 | 0 | 83 |
| Abs N/S | F | 14 | 4 | 0 | 0 | 18 |
| | M | 9 | 2 | 0 | 0 | 11 |
| | F+M | 23 | 6 | 0 | 0 | 29 |
| Absent | F | 16 | 35 | 5 | 0 | 56 |
| | M | 9 | 34 | 13 | 0 | 56 |
| | F+M | 25 | 69 | 18 | 0 | 112 |
| Total | F | 182 | 186 | 72 | 21 | 461 |
| | M | 188 | 166 | 77 | 23 | 454 |
| | F+M | 370 | 352 | 149 | 44 | 915 |

Table A.3
Summary of Village and Population Demographics - Entire Survey

Total number of households surveyed: 357

Summary of Village: 27 TOTAL 1 - 24
Includes households 1 to 361 inclusive

| | |
|---|---|
| Households surveyed | 357 |
| Households on map | 379 |
| Schools | 6 |
| Churches | 9 |
| Meeting Places | 12 |
| Commercial Buildings | 1 |
| Unoccupied Abandoned Sites | 76 |
| Sites Under Construction | 4 |
| Households with Zinc | 99 |
| Households with Concrete Blocks | 2 |

Population Distribution for TOTAL 1 - 24

| | | 0-14 | 15-34 | 35-54 | 55+ | TOTAL |
|---|---|---|---|---|---|---|
| Present | F | 442 | 378 | 198 | 82 | 1100 |
| | M | 461 | 320 | 195 | 87 | 1063 |
| | F+M | 903 | 698 | 393 | 169 | 2163 |
| At School | F | 46 | 14 | 0 | 0 | 60 |
| | M | 55 | 32 | 1 | 0 | 88 |
| | F+M | 101 | 46 | 1 | 0 | 148 |
| At Work | F | 9 | 122 | 24 | 1 | 156 |
| | M | 7 | 115 | 45 | 6 | 173 |
| | F+M | 16 | 237 | 69 | 7 | 329 |
| Abs N/S | F | 30 | 9 | 2 | 2 | 43 |
| | M | 27 | 8 | 0 | 0 | 35 |
| | F+M | 57 | 17 | 2 | 2 | 78 |
| Absent | F | 39 | 131 | 26 | 3 | 199 |
| | M | 34 | 123 | 45 | 6 | 208 |
| | F+M | 73 | 254 | 71 | 9 | 407 |
| Total | F | 527 | 523 | 224 | 85 | 1359 |
| | M | 550 | 475 | 241 | 93 | 1359 |
| | F+M | 1077 | 998 | 465 | 178 | 2718 |

Figure A.1
Example of Survey Form

HH 70 HOUSEHOLD COMPOSITION AND INCOME: KORUP NATIONAL PARK, CAMEROON

| | | |
|---|---|---|
| Village: | Babiabanga | Location: 2 |
| HH Head: | SUNGO ACHUMACHU | Born in village |
| Interviewed: | HH head | on 3/24/88 |

HOUSEHOLD COMPOSITION HH 70

| Relation | Sex | Age | Schl | Status | Location | X-Ref |
|---|---|---|---|---|---|---|
| HH head | M | 50 | 0 | Present | | |
| Spouse | F | 45 | 0 | Present | | |
| Spouse | F | 43 | 0 | Present | | |
| Child | M | 23 | 7 | Present | | |
| Child | M | 25 | 7 | Present | | |
| Child | M | 18 | 5 | Present | | |
| Child | M | 15 | 6 | Present | | |
| Child | M | 12 | 1 | Present | | |
| Other HH | M | 55 | 0 | Present | | |
| Child | F | 35 | 7 | Abs N/S | Tiko | |
| Child | F | 20 | 7 | Abs N/S | Bakundo | |
| Other HH | F | 14 | 5 | Abs N/S | Bakundo | |
| Other HH | F | 12 | 4 | Abs N/S | Bakundo | |
| Other HH | M | 6 | 3 | Abs N/S | Manyemen | |

HOUSEHOLD INCOME IN 1987 (CFAF) HH 70

| | | | |
|---|---|---|---|
| Household Income Estimate: | -1 | Zinc Construction: | No |
| Number of Farms: | 3 | HH Self-sufficient: | Yes |
| Average Walk: | 25 min | | |

| | |
|---|---|
| **Cash Crops:** | |
| Coffee (6 bags) | 102000 |
| Cocoa (15 bags) | 405000 |
| Other | Yes |
| **Food Crops:** | |
| Cassava | |
| Plantain | |
| Cocoyam | |
| Banana | |
| Oil Palm | |
| **Farming Problems:** | |
| 1 - Animals | |
| 2 - Insects | |
| **Sales:** | |
| Livestock | 20000 |
| Hunting | 25000 |
| Trapping | 15000 |
| Fishing | 0 |
| **Trading:** | |
| Snuff | 0 |
| Afofo | 0 |
| Cigarettes/Tobacco | 0 |
| Beer | 12000 |
| Wine | 0 |
| General Goods | 0 |
| Kerosene | 0 |

| | |
|---|---|
| **Times eaten per week:** | |
| Meat in Rainy Season | 3 |
| Meat in Dry Season | 3 |
| Fish in Dry Season | 1 |
| Fish in Rainy Season | 0 |
| **Forest Product Gathering:** | |
| Timber | 0 |
| Mango | 30000 |
| Njangsang | 20000 |
| Njabe | 0 |
| Shell Nut | 10000 |
| Miscellaneous (see Memo) | 0 |
| Country Onion | 0 |
| Pepe | 0 |
| Kola | 0 |
| **Forest Product Manufacturing:** | |
| Cane Rope | 0 |
| Woven Bags | 15000 |
| Fishing Nets/Baskets | 0 |
| Mats | 0 |
| Furniture | 0 |
| Building | 0 |
| Palm Wine | 0 |
| Afufu | 0 |
| Canoes | 0 |
| Palm Oil | 0 |
| **Remittances (see Memo):** | 0 |

## § A.3 Survey Instrument

The household surveys were undertaken through a relatively informal interview process, usually in the respondent's home. The interviewer was guided by a survey instrument intended to provide the required demographic and income information about the household. An example of the survey is provided in Figure A.1. The original survey used in the field consisted of three pages; this example was replicated by one of the report generation routines developed for analysing the data. The data reduction process is discussed in Section A.4.

The first part of the survey form deals with the basic background of the household head and of the household. Individuals were asked whether they were born in the village and, if they were not, when they arrived in the village and from where. In addition, this part of the survey specifies the location of the household in the village through a map reference number.

The next part of the survey obtained information about the household composition. The actual survey form also reported names of all of the individuals in the household, although these are suppressed from the output to maintain the confidentiality of the individuals. In specifying the "status" of each individual, they were eventually categorised as either: present, absent at school, absent at work, or absent not-specified. If they were absent, information was obtained regarding their whereabouts. Those individuals that were "temporarily absent" (which was not uncommon for those away on hunting trips) were treated as present.

The collection of income data took most of the effort in the survey process, in that respondents were often uncertain about their exact income levels and at times found it difficult to estimate. This was most obvious in the response to the first question, which was "What was your family's total cash income from all sources in 1987?" In many cases the respondent had no idea how much it was and, where responses were given, they were not always consistent with answers provided later in the interview.[2] Respondents

[2] For those households where both disaggregated incomes and total income estimates were available, there was a distinct tendency to underestimate the total income (or overestimate the individual sector incomes). Cursory analysis of the data indicates that, on average, the aggregate of the individual sectors was 50% higher than the total income estimate. A simple OLS regression of the individual's household income estimate (HHY) on gross income (INCOMEG) as a sum of the aggregates yields the following results (with standard errors in parentheses):

| | | | |
|---|---|---|---|
| HHY = | 0.670 INCOMEG | - 39.6 | Observations = 63 |
| | (0.062) | (65.2) | R-squared = 0.65 |

If there were perfect agreement, the constant would be zero and the slope term would be one. As it stands, the constant is not significantly different from zero (F=0.37; t=0.61) but the slope is significantly less than one (F=28.1; t=5.3). As the slope is 0.67 we can conclude that the total income given in general is an generally had much less trouble answering questions about income from various single sources and, to that extent, the survey performed a useful function by focussing on the disaggregated income sources.

Before getting into the details of cash incomes, household heads were asked to describe their farm ownership and farm locations. They were asked how many farms they had, and what they grew on each of them. Ideally, it would have been desirable to have each farmer estimate their own farm area, but many would not have had the required information. Fortunately, it is common in that part of the country to refer to a single "farm" as a standard unit measured as a "lope". One "lope" is approximately 50 metres by 150 metres in size, or about 0.75 hectares. Household heads were also asked to estimate the distance which they had to walk to get to their farms, and were asked whether they grew enough food on the farm to feed their entire household.

The survey did not explicitly intend to collect information about family wealth. As wealth is, however, often an important economic variable in describing and analysing the well-being of a household's members, some data were gathered regarding the ownership of various assets. In addition to farm land, household construction was thought to be a potential indicator of family wealth. While most houses were of 100% thatch construction, some had a zinc roof and fewer still had concrete blocks included in their construction. This information was thus recorded for every household. Although it would have been helpful to have had information on the ownership of consumer durables (such as watches or radios) no such data were collected.

Details about a household's farming were split into three areas: cash crop production, food crop production, and farming problems. With respect to cash crops, individuals were asked whether or not they grew coffee and cocoa, how much was sold, and how much income was earned from the sale. Some individuals knew the quantity sold but not the income, or vice versa, but in principle whatever information was offered was recorded. It should be noted that the standard unit of measure was a "bag", which was the usual unit purchased by the government cooperative and which theoretically consists of 50 kg of

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underestimate.

One possible explanation for this is that the "total household income" question was posed first. As the respondent was normally the household head and normally male, he may have excluded at that juncture those sources which were normally accruing to the women. These sources would include food crop sales, livestock sales, fishing, forest gathering, and some of the forest manufacturing. The results for this regression, where the explanatory variable is income normally earned by males (INCGMALE), yields:

| | | | |
|---|---|---|---|
| HHY = | 0.837 INCGMALE | - 21.9 | Observations = 63 |
| | (0.063) | (53.3) | R-squared = 0.74 |

This formulation is somewhat more acceptable, although it suggests that there is still a slight yet significant ($t=2.6$) underestimation of total income by the respondent.

product. The product was normally brought to the coop by headloading. Table A.6 provides a summary, by village, of the activity in cash crops. Note that average prices vary considerably among villages. Although to some extent this can be attributed to different costs for bringing the product to market, most of the differences are attributable to variations in product quality. Discussions with the coop indicated that they normally go through the bags, selecting only those beans which are acceptable, and then apply one of three prices to those which are still acceptable depending upon whether they are high grade, low grade, or sub-standard.

Some households also sold a portion of their food crops for cash, usually to travellers, and these were included as "Other Cash Crops" in the survey. Table A.7 indicates that about 35% of the households surveyed obtained some income from the sale of food crops.

Table A.6
Summary of Cocoa and Coffee Production Activity

| Region/Village | HHs | Coffee Grow | Coffee Sell | Coffee Price MCFAF | Coffee Sales MCFAF | Cocoa Grow | Cocoa Sell | Cocoa Price MCFAF | Cocoa Sales MCFAF |
|---|---|---|---|---|---|---|---|---|---|
| **Western Buffer Zone** | | | | | | | | | |
| Akpasan | 56 | 2 | 1 | n/a | 15.0 | 0 | 0 | . | 0.0 |
| Akwa | 12 | 0 | 0 | . | 0.0 | 8 | 8 | 17.0 | 664.5 |
| Ekoneman | 4 | 0 | 0 | . | 0.0 | 2 | 2 | 32.0 | 1,792.0 |
| Ekong I | 36 | 7 | 0 | . | 0.0 | 20 | 1 | 11.0 | 11.0 |
| Mbofong | 6 | 0 | 0 | . | 0.0 | 6 | 4 | 17.0 | 323.7 |
| Nguru-Korup | 1 | 1 | 1 | 5.7 | 8.5 | 0 | 0 | . | 0.0 |
| Subtotal WBZ | 115 | 10 | 2 | | 23.5 | 36 | 15 | | 2,791.2 |
| **Korup National Park** | | | | | | | | | |
| Bareka Batanga | 5 | 2 | 2 | 17.0 | 238.0 | 1 | 1 | 27.0 | 270.0 |
| Bera | 12 | 1 | 1 | 15.0 | 15.0 | 2 | 2 | 19.0 | 196.0 |
| Ekong II (Erat) | 35 | 5 | 0 | . | 0.0 | 19 | 1 | 40.0 | 80.0 |
| Ekundo-Kundo I | 18 | 5 | 4 | 10.0 | 200.0 | 8 | 2 | 40.0 | 120.0 |
| Esukutan | 23 | 4 | 4 | 5.7 | 102.0 | 20 | 19 | 17.0 | 4,359.6 |
| Ikenge | 20 | 8 | 6 | 20.2 | 616.0 | 16 | 12 | 26.1 | 1,812.6 |
| Subtotal KNP | 113 | 25 | 17 | | 1,171.0 | 66 | 37 | | 6,838.2 |
| **Eastern Buffer Zone** | | | | | | | | | |
| Babiabanga | 6 | 6 | 6 | 17.0 | 986.0 | 6 | 6 | 27.0 | 3,402.0 |
| Bajo | 17 | 14 | 14 | 10.0 | 391.8 | 14 | 14 | 10.4 | 240.9 |
| Bakut | 22 | 11 | 11 | 15.0 | 1,095.0 | 21 | 21 | 32.0 | 6,528.0 |
| Baleka Batanga | 7 | 6 | 6 | 18.0 | 612.0 | 7 | 7 | 27.0 | 1,566.0 |
| Banyu | 5 | 3 | 3 | 17.0 | 102.0 | 3 | 3 | 27.0 | 189.0 |
| Baro | 29 | 22 | 22 | 15.1 | 2,128.2 | 27 | 27 | 40.0 | 7,812.7 |
| Basu | 6 | 5 | 5 | 6.0 | 108.0 | 1 | 1 | n/a | 1.0 |
| Ekogate | 4 | 3 | 3 | 5.7 | 561.0 | 2 | 2 | 17.0 | 630.4 |
| Lobe | 6 | 6 | 5 | 17.0 | 510.0 | 6 | 5 | 27.0 | 999.0 |
| Mopako | 11 | 4 | 0 | . | 0.0 | 5 | 0 | . | 0.0 |
| Ngenye | 14 | 4 | 2 | 6.0 | 120.0 | 6 | 3 | 17.6 | 158.5 |
| Tombel | 2 | 0 | 0 | . | 0.0 | 2 | 2 | 27.0 | 540.0 |
| Subtotal EBZ | 129 | 84 | 77 | | 6,614.1 | 100 | 91 | 252.1 | 22,067 |
| TOTAL | 357 | 119 | 96 | | 7,808.6 | 202 | 143 | 252.1 | 31,697 |

Table A.7
Summary of Food Crops Grown (households growing)

| | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Total Households | 125 | 113 | 103 | 341 |
| Food Crop Income | 34 | 35 | 51 | 120 |
| No Food Crops[3] | 4 | 1 | 0 | 5 |
| Cocoyam | 109 | 104 | 96 | 309 |
| Plantain | 111 | 93 | 89 | 293 |
| Cassava | 73 | 107 | 88 | 268 |
| Banana | 92 | 76 | 99 | 267 |
| Yam | 29 | 22 | 38 | 89 |
| Oil Palm | 32 | 17 | 32 | 81 |
| Vegetables | 12 | 19 | 3 | 34 |
| Maize | 4 | 14 | 13 | 31 |
| Egusi | 6 | 14 | 10 | 30 |
| Pineapple | 11 | 5 | 6 | 22 |
| Pepe | 5 | 2 | 13 | 20 |
| Okra | 0 | 7 | 3 | 10 |
| Sugar Cane | 1 | 4 | 3 | 8 |
| Citrus | 2 | 1 | 4 | 7 |
| Ground Nut | 0 | 2 | 3 | 5 |
| Papaya | 1 | 0 | 4 | 5 |

It should be noted that, in general, when asked if something contributed to their income, one of several responses were given. Depending on the response, the value noted in the data base was set as follows:

| | | |
|---|---|---|
| a) | do not know: | Value = -1 (missing data) |
| b) | none: | Value = 0 |
| c) | yes but a negligible amount was sold: | Value = 1 |
| d) | yes: | Value = Income in CFAF |

With respect to food crops, respondents were asked simply which crops they grew. Respondents typically listed at least half a dozen varieties from the list shown in Table A.7. Cassava, plantain and cocoyams (taro) were grown almost universally. Only 5 households were in a position that they grew no food crops of any variety.[4] Of all of the varieties documented, it is interesting to note that one native forest plant – pepe – was being *cultivated* by 20 households.

To conclude the farming section of the survey, respondents were asked to indicate, in order of priority, the problems which they encountered on their farms. These problems ranged

[3]The particular situations of the households which grow no food crops are documented in Table A.10.
[4] The situations of these households are described later in Table A.10, but it was normally the case in these circumstances that the household members were physically incapable of farming and required support from other village households.

Table A.8
Summary of Farming Problems

| Problem | Times Cited | Times Cited #1 |
|---|---|---|
| Cocoa Disease | 84 | 23 |
| Porcupines | 83 | 34 |
| Coffee Disease | 81 | 77 |
| Cutting Grass | 79 | 31 |
| Monkeys | 70 | 27 |
| Rat Moles | 51 | 4 |
| Snakes | 24 | 1 |
| No Road | 22 | 7 |
| Animals | 15 | 3 |
| Poor Soil | 5 | 1 |
| Birds | 4 | 1 |
| No Chemicals | 4 | 0 |
| No Labour | 3 | 0 |
| No Advice | 2 | 1 |
| Deer/Duiker | 1 | 1 |
| Insects | 1 | 1 |
| Korup Park | 1 | 0 |
| Non-payment | 1 | 0 |
| Theft | 1 | 0 |
| SUM | 532 | 212 |

from identifying specific animal pests, to more general infrastructure problems. An exhaustive list of the responses along with the frequency at which the problem arose is provided in Table A.8. It should be noted that respondents were not guided in their answers to the question by presenting them with a list of potential hindrances; the list appearing in Table A.8 was compiled from their free responses. It is quite likely that some overlap occurs between categories of "pests". For example, depending upon the familiarity of an individual with the various blights and afflictions experienced by cocoa, some "insect" problems may have been misidentified as "diseases". Similarly, the generic category of "animals" was meant to include unidentified larger mammals which could include monkeys, deer, duiker, forest elephants, and forest buffalo.

It is clear from the enumeration of the farming problems that the most pervasive problems are associated with cash crop diseases. Small mammals (porcupines, cutting grass, and rat moles) were often cited, as were monkeys. Input constraints (for extension services, fertilisers, labour, or road access) were not a particular concern to most farmers, although the most common of these cited was the poor access to markets because of the lack of roads. Finally, it is notable that the existence of the park was itself not regarded as a hindrance to farming activities, even though farming is technically a disallowed pursuit within its boundaries.

The next section of the survey deals with specific income sources, which are, for the purposes of the thesis, disaggregated into the following subcategories:

a) Cash Crop Sales
b) Livestock Sales
c) Hunting Income
d) Trapping Income
e) Fishing Income
f) Trading Income
g) Income from Gathered Forest Products
h) Income from Manufactured Forest Products
i) Remittance and Labour Income

Table A.9 provides a summary of the number of households involved in each activity. First, it is noted that, of the households surveyed, 15 households, or 4% of the total, had no household cash income. The circumstances of these households are summarised in Table A.10.

Livestock sales refer almost exclusively to chickens. Cattle is not raised in this part of the country, and only a few households keep goats and pigs. To a great extent, goats and pigs are regarded as pests as they are usually given free reign and thus cause damage to crops. Most of the villages in the survey have thus taken steps to eliminate them simply by banning their presence in the village. Chickens, on the other hand, are raised by many households and are on occasion sold. As noted in Table A.9, some 44% of the households in the sample derived income from this source.

Hunting, trapping and fishing provide an important source of income in the region. Table A.9 indicates that households both within the park and in the buffer zone rely on it, even though both hunting and trapping are illegal.[5]

Also, about 50% of the households are engaged in some form of trading activity. This is not unusual because of the isolation of the villages from the major regional trading centres. Individuals travelling to market areas would often return with additional goods for resale in their villages.

Perhaps most striking from Table A.9 is the activity involved in forest product gathering and sale. Fully 84% of the households surveyed were involved to some degree in gathering natural forest products. Further, this activity was not isolated to those within the park, extending as well into villages in the buffer zone. In addition, about 59% of the households were involved in the sale of goods manufactured from forest products, although the majority of this was attributable to the manufacture of wines and distillates.

[5] Technically, hunting and trapping are also illegal in the buffer zone, but most people believe that it is only illegal within the park.

Table A.9
Summary of Income Sources (households)

| Source | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Total Households | 125 | 113 | 103 | 341 |
| No Income[6] | 4 | 10 | 1 | 15 |
| Cash Crops | 113 | 47 | 72 | 232 |
| - Cocoa | 91 | 15 | 35 | 141 |
| - Coffee | 77 | 2 | 17 | 96 |
| - Other | 34 | 35 | 51 | 120 |
| Livestock | 45 | 48 | 57 | 150 |
| Hunting | 37 | 19 | 51 | 107 |
| Trapping | 47 | 61 | 75 | 183 |
| Fishing | 50 | 66 | 70 | 186 |
| Trading | 32 | 76 | 63 | 171 |
| - Snuff | 1 | 14 | 13 | 28 |
| - Afofo | 13 | 8 | 23 | 34 |
| - Cigarettes/Tobacco | 9 | 27 | 27 | 63 |
| - Beer | 12 | 6 | 7 | 25 |
| - Wine | 1 | 17 | 13 | 31 |
| - Kerosene | 3 | 10 | 5 | 18 |
| - General Goods | 9 | 21 | 16 | 46 |
| Gathered Forest Products | 96 | 94 | 96 | 286 |
| - Timber | 2 | 3 | 2 | 7 |
| - Bush mango | 63 | 93 | 92 | 248 |
| - Njangsang | 75 | 37 | 58 | 170 |
| - Njabe | 8 | 23 | 45 | 76 |
| - Shell Nut | 14 | 31 | 55 | 100 |
| - Wild Onion | 0 | 0 | 10 | 10 |
| - Pepe | 2 | 1 | 21 | 24 |
| - Kola Nut | 7 | 0 | 4 | 11 |
| - Miscellaneous | 1 | 2 | 5 | 8 |
| Manufactured Forest Products | 58 | 64 | 78 | 200 |
| - Cane Rope | 0 | 16 | 0 | 16 |
| - Woven Bags | 15 | 5 | 21 | 41 |
| - Fish Nets/Baskets | 2 | 7 | 6 | 15 |
| - Mats | 21 | 12 | 30 | 63 |
| - Furniture | 0 | 1 | 3 | 4 |
| - Building | 2 | 3 | 0 | 5 |
| - Afofo or Wine | 29 | 40 | 60 | 129 |
| - Canoes | 0 | 3 | 0 | 3 |
| - Palm Oil | 2 | 1 | 20 | 23 |
| Remittances | 8 | 2 | 18 | 28 |

[6] The particular situations of the households with no cash income are documented in Table A.10.

Table A.10
Summary of Circumstances of Households with No Cash Income or No Food Crops

| HH | Area | Income | Crop | Household Details |
|---|---|---|---|---|
| 2 | WBZ | No | Yes | The head, aged 50, was born in the village and now lives with his 2 wives and 3 of his young children. He has 5 farms on which he grows cassava, plantain and cocoyam, and he does some trapping for their own consumption. The women gather bush mango but it generates negligible income. |
| 10 | WBZ | No | Yes | The head, aged 45, arrived from Nigeria and now supports just himself and his young son. He has 2 farms on which he grows cassava, plantain, cocoyam, banana and maize. |
| 32 | WBZ | No | No | Offiong Arong, aged 60, and his wife are both blind. They depend entirely on the goodwill of their neighbours for food. |
| 33 | WBZ | No | Yes | The head, aged 70, lives here with his son and two grandchildren and together they are self-sufficient from their farms and from what they trap near their farm. |
| 50 | WBZ | No | Yes | Alice Morimo, aged 30, has lived in the village for 15 years and now supports herself and seven children. All of her school-aged children are in school, with the exception of her oldest daughter, who has no schooling and who helps her mother do the farming on which they survive. |
| 54 | WBZ | No | Yes | Usim Alfred, aged 27, was born in the village and supports his wife and two infant children by farming. |
| 56 | WBZ | No | Yes | Christina Inyang, age 65, was born in the village and now lives here with a 16 year old son who is still in school in the village. They farm food crops and fish, and did some trading of kerosene and cigarettes last year although it generated negligible income. |
| 77 | EBZ | No | No | Tekla Eta, age 60, arrived in the village around 1930 from a neighbouring village. She lives alone, receiving fish, meat, and food crops from fellow villagers. |

(...continued)

Table A.10 (continued)

| HH | Area | Income | Crop | Household Details |
|---|---|---|---|---|
| 123 | EBZ | No | No | The head, age 50, had moved away to Tombel with his family after his house here had collapsed. His sons are now working in Tombel and he is back here alone rebuilding his house. He has one farm but, having been neglected, it does not produce anything and he is dependent on his neighbour's good will in the meantime. As he was born in this village (Banyu) he intends to return his family here permanently when his house is rebuilt. |
| 125 | EBZ | Yes | No | This man, aged 27, lives alone, having arrived in the village in 1979. He has a farm plot but it is not producing anything as he spends his time trading, earning cash from the resale of general goods. He buys his food and does some trapping for his own meat. |
| 127 | KNP | No | Yes | He is the village chief and lives with one of his younger sons. His older sons, who have moved away, send him some (apparently negligible) amount of money, and he lives primarily from the goodwill of his neighbours and from his one cassava farm. |
| 160 | EBZ | No | No | John Oyaong, age 56, lives alone. He was born in the village and, as he is lame, cannot farm or work. He receives help from everyone in the village. |
| 207 | WBZ | No | Yes | The head, age 25, and his brother, farm cassava and vegetables to support themselves. |
| 209 | WBZ | No | Yes | Mary Afion, age 65, and her son have lived in the village all of their lives. They are self sufficient from their food crops and fishing. |
| 218 | WBZ | No | Yes | The head, age 30, supports himself and four other household members through farming. He was born in the village and has lived here all of his life. |
| 340 | EBZ | No | Yes | The head, age 31, lives here with his three eldest sons and two young daughters. They are self sufficient through farming, fishing, trapping, hunting and some poultry raising. |

## § A.4 Data Reduction Process

### A.4.1 Introduction

Information presented in the previous section was extracted directly from a data base which was constructed from the survey data. As extensive statistical analyses of these data were to be conducted, it was imperative that they be organised in a fashion amenable to the different types of analyses. The data reduction and management process which was undertaken to fulfill these demands was comparable in effort to the work done in actually collecting the survey information in the first case. The purpose of this section is to describe, in some detail, the procedures which were followed in reducing the data.

As a preamble, it should be noted that the original questionnaire was not designed by WWF with any rigourous statistical analysis in mind. It was meant to provide a count of individuals in the area while also allowing some qualitative characterisation of the types of activities in which they were engaged. The format of the questionnaire does, however, lend itself to some considerable analysis if the data can be put into a suitable format. Given that the survey was not designed with any particular data management system in mind, however, it was necessary to custom build a data management system.

In looking at the design of the data management system, it is useful to summarise the demands which would be made of it. These are:

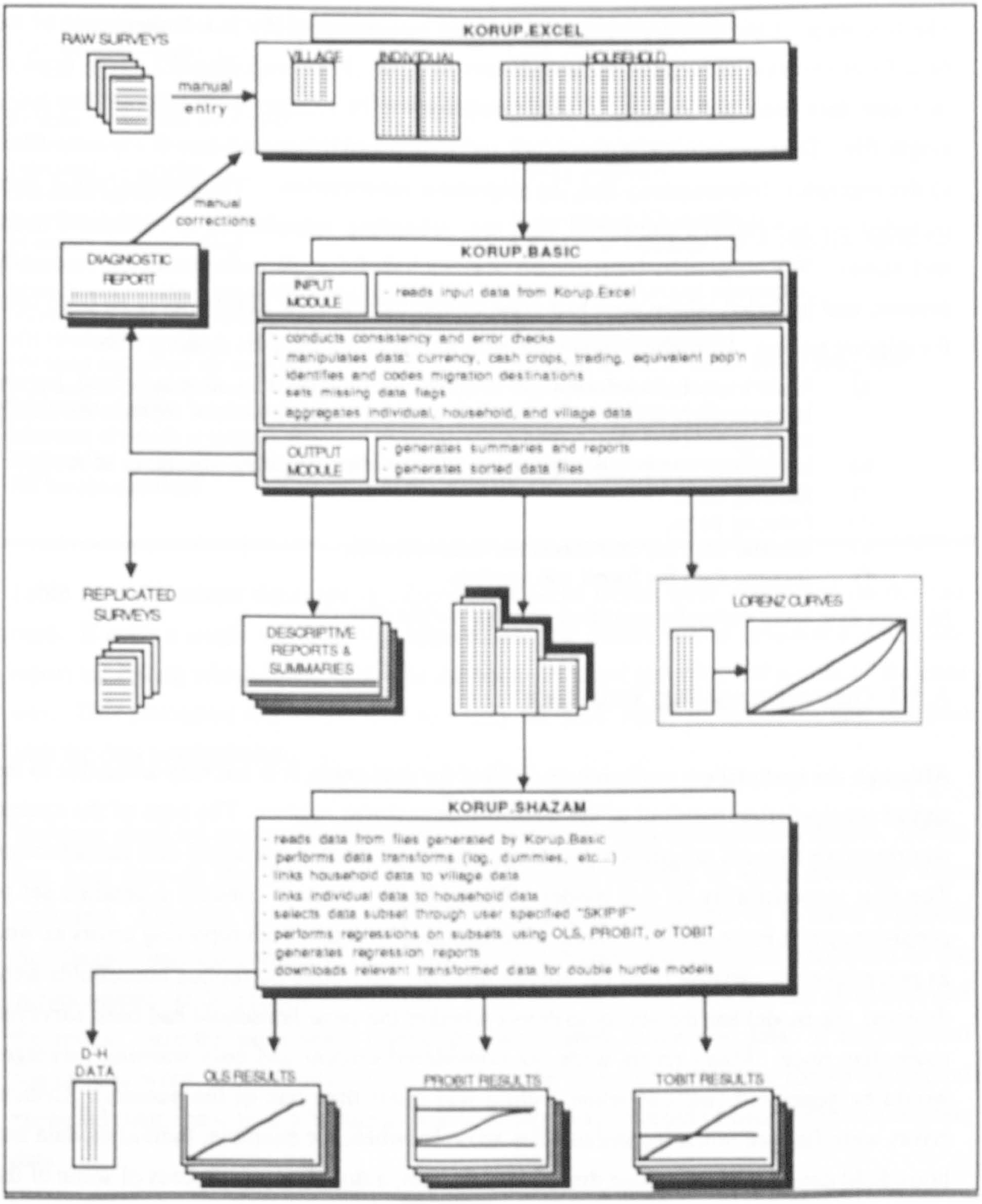
a) replication of the original survey data;
b) ability to recognise inconsistencies in the data;
c) aggregation of individual data to a household level;
d) aggregation of household data to a village level;
e) aggregation of village data to a regional level;
f) correlation studies of individual or household behaviour to characteristics of the individual, household, village, or region; and,
g) amenability to repeating the process at some future date to allow the analysis of panel data.

Further, these requirements had to be met under the following constraints:

a) the existence of substantial amounts of qualitative information;
b) missing data; and,
c) data requiring manipulation before statistical analyses can be undertaken.

The framework for the data management system which was designed to accommodate these requirements is shown in Figure A.2. The entire system was maintained on an Apple Macintosh SE.

Figure A.2
Schematic Diagram of Data Management System



A.4.2 Data Entry

The first stage of the data management involved manual entry (by H.J. Ruitenbeek) of the data from the raw surveys. A spreadsheet system (Microsoft Excel™) was used to facilitate data entry and editing. Village data for the 24 villages were entered into just a single file. Data pertaining to the 2,718 individuals were entered into 2 separate files: a) demographic information; and, b) migration information. The demographic data included the individual's household, age, sex, schooling, relationship to household head, and status. The migration information was included for all individuals not normally present, and included where they had gone to and their names. This was to be used later for migrant tracing. Household data were split into six separate files dealing with:

a) basic household information (village, location on map, date surveyed, person interviewed, and any qualitative notes or "memo items" which should be stored);
b) household composition (number of individuals present, absent, in school);
c) farming data;
d) farming pests;
e) income data for non-forest use sources; and,
f) income data for forest use sources.

Missing data were normally specified as a "-1" in the data set.

A.4.3 Diagnostics and Data Verification

Although the spreadsheet environment is ideal for data entry, it is not very amenable to the sort of manipulation required of the overall management system. The core of the system was therefore a model programmed in Basic which did most of the actual data management. The first responsibility of this model – Korup.basic – was to conduct a detailed set of consistency and error checks. These were intended to detect both reporting errors as well as potential errors arising from the survey process. Although no replica households were detected, the model has the ability to detect whether the same household had been surveyed more than once. Many errors were not considered critical and only warning messages would be generated (such as when a child was older than one of the parents). Critical errors were flagged when inconsistencies arose between, for example, individual data and household data. This is because there was, in effect, a double entry process of some of the key characteristics dealing with household demographics: once for individuals and once for the household as a whole. If, upon aggregating the individuals in a household it was found to disagree with the household data, then the errors would be flagged.

Table A.11
Diagnostic Checks Undertaken by Data Management System

| | |
|---|---|
| HH Count Inconsistent with Village Data | Number of farms undefined |
| Data less than zero and ≠ -1 | Cash crop undefined |
| Village location not specified | Food crop undefined |
| Date of survey not 1988 | Livestock undefined |
| Relation to HH Head undefined | Hunting undefined |
| Incomplete data on birthplace of HH Head | Trapping undefined |
| Individual sex undefined | Fishing undefined |
| Individual age undefined | Traded good XX undefined |
| Individual schooling undefined | Forest product XX undefined |
| Migratory status undefined | Naira/CFAF exchange rate inconsistent across files |
| Mismatch of HH Head sex to individual data | Miscellaneous product unspecified |
| Mismatch of HH Head age to individual data | Coffee Value/Amount mismatched |
| Mismatch of HH Head schooling to individual data | Cocoa Value/Amount mismatched |
| HH Head never present | Pest ranking inconsistent |
| HH Head and spouse are same sex | HH Head moved to village before being born |
| Miscount of people present | Years of schooling > (Age-5) |
| Miscount of people at school | Individual older than 90 |
| Miscount of people at work | Children older than parents |
| Miscount of people absent (N/S) | Remittance source unspecified |
| HH Income undefined | |

Table A.11 illustrates the types of diagnostic checks which were conducted on the data base. If even a single warning was appropriate, the model would generate a diagnostic report indicating where in the data base the error occurred and what the nature of the error was. This procedure allows the user to verify the data, make adjustments, and continue with the data manipulation.

The error checking routines were a useful attribute of the data management system. On the first pass through the data base, about one hundred warning or error messages were generated. Although in most cases these were due to data entry errors, in some instances they flagged unusual household circumstances which had been improperly recorded on the questionnaire. If the required corrections were obvious – such as when the HH Head and the spouse were the same sex – corrections were made to the raw data. If the required corrections were not obvious – such as when the years of schooling for an individual exceeded their age – then a 'missing data' indicator was inserted in lieu of the suspect raw data.

A.4.4 Data Manipulation

Once a "clean" data set is available, the model conducts a number of data manipulation steps. These are:

a) currency conversion;
b) cash crop valuation;
c) calculation of net incomes from hunting and trading;
d) calculations of equivalent populations.

Table A.13
Price Estimates Required for Cash Crop Producers (from sample of 357 households)

| | EBZ | WBZ | KNP | Total |
|---|---|---|---|---|
| Total Cocoa Sellers | 91 | 15 | 37 | 143 |
| - No Estimate Needed | 28 | 3 | 36 | 67 |
| - Own-Village Estimate | 49 | 0 | 1 | 50 |
| - Neighbour-Village Estimate | 14 | 12 | 0 | 26 |
| Total Coffee Sellers | 77 | 2 | 17 | 96 |
| - No Estimate Needed | 23 | 1 | 17 | 41 |
| - Own-Village Estimate | 40 | 0 | 0 | 40 |
| - Neighbour-Village Estimate | 14 | 1 | 0 | 15 |

The second adjustment which was required was in the valuation of cocoa and coffee income. Respondents gave a variety of responses, and many were incomplete. Although the survey was meant to obtain data on both income and quantities, not all respondents could give this information: some provided only income and others provided only quantities (in terms of the number of bags). A remedial measure was applied to value the output of those individuals which gave only quantity information. In essence, a price was applied to their output which was calculated as follows:

a) the average price received in their village by those individuals reporting both income and output; or,
b) if no average price could be established in this manner, the average price of the nearest village for which a price could be calculated in this manner.

As noted in Table A.13, a considerable number of households were found in this position. To keep them in the sample, the application of a pricing estimate was required and the one selected was believed to be the most appropriate.

The third adjustment which was required was to the income from goods for which intermediate inputs were purchased. All of the income in the data base was gross income. While this is certainly appropriate for most sources of income as there were no purchased variable inputs,[8] it is not the case for either hunting or trading. Hunting requires the purchase of cartridges and carbide for lamps and, based on Infield (1988), a downward adjustment of 25% was made to the gross earnings from hunting to reflect the costs of these inputs. Trading involves resale of manufactured commodities but, unfortunately, no detailed information was available on the margins generated through trading. The only sources of information available were the respondents themselves and many did not say

[8] The primary input to all activities in the region was labour and, as noted in Chapter 5, there was a strong preference to using family labour rather than hiring labour. While some activities would have had some initial capital cost requirements, non-labour variable inputs would be limited to: chemicals for cash crops, cartridges and carbide for hunting, costs of goods for trading. As no evidence was found of the application of chemicals, no adjustment for this was made to cash crop income.

what the cost of their goods had been. Based on the sporadic information which was available, however, the following margins were assumed in calculating the net incomes from trading:

| | |
|---|---|
| Snuff, Cigarettes and Tobacco | 20% |
| Kerosene | 20% |
| Wine, Beer and Spirits | 30% |
| General Manufactured Goods | 40% |

Finally, in calculating various inequality indices, the index depends upon sorting populations according to income or asset distribution. As discussed in the main text, adjustments are sometimes made to recognise the fact that some individuals have different requirements than others. In particular, adjustments are made for individual characteristics of sex and age. The assumed equivalent consumption unit scales used for this adjustment are shown in Table A.14.

Table A.14
Equivalent Consumption Unit Scales
(Base: Males 20-39)

| Age Cohort | Male | Female |
|---|---|---|
| 0-3 | 0.50 | 0.50 |
| 4-9 | 0.80 | 0.80 |
| 10-19 | 1.00 | 0.80 |
| 20-39 | 1.00 | 0.70 |
| 40-49 | 0.95 | 0.70 |
| 50-59 | 0.90 | 0.65 |
| 60+ | 0.75 | 0.50 |

Source: Estimates provided by Professor Q.B.O. Anthonio, University of Ibadan, Ibadan, Nigeria, as typical consumption requirements for rural West African populations.

A.4.5 Migrant Identification

The survey gathered information both on those normally present in the household as well as those which were absent for one reason or another. The purpose of the migrant identification procedure conducted by the data management system is two-fold: a) to prepare summaries of the characteristics of the migrants; and, b) to assist in tracing those migrants which migrated to a village which is included in the survey sample. The first of these tasks is relatively straight forward, involving simply coding the destinations of the individual migrants according to whether they were migrating to a rural destination or to an urban destination. To prevent errors in the data analysis, this step was automated through specifying valid urban destinations. The only five which were specified were Yaoundé, Douala, Kumba, Limbe, and Calabar. Yaoundé is the capital city of Cameroon, and Douala is the capital of Littoral Province and the largest city in the country. Strictly speaking, Kumba and Limbe can perhaps be better described as large towns, although they are both major regional trading centres. Calabar is the regional capital of Cross River State in Nigeria.[9]

9 The populations of the major centres are approximately as follows: Yaoundé - 800,000; Douala - 1,200,000; Calabar - 200,000.

The second step, that of migrant tracing within the survey, is more complex. The procedure involved first flagging all of those individuals which migrated to a destination village which fell within the survey. This consisted of some 53 individuals. The model then listed potential candidates by identifying everyone in the "target" village who was within 10 years of age and the correct sex as the particular individual. With this list, a *manual* search was then conducted through the *raw surveys* to attempt to find a match based on the individuals' name, age, sex, and years of schooling. Because of the usual variances in reporting, there is no reason to believe that individuals would match exactly. Indeed, no "perfect" matches were identified, but positive identification on the basis of name and approximate demographic characteristics was possible in 16 of the 53 cases. The others may have been present in the village but were not identifiable because of name changes. To complete the procedure, the data base in Korup.Excel was then corrected manually to make the individuals' characteristics correspond to those of the individual in the target household. The revised data assumed that the data corresponding to the household where the individual was present were the correct data, and those in the household where the individual was absent were adjusted. Finally, specifiers were placed in the data base to allow the migrant to be traced and linked automatically in subsequent invocations of the model.

### A.4.6 Aggregation and Output

Once all of the preceding steps have been carried out, the information contained in Korup.basic will be ready for analysis. At this stage the model flags all households and individuals for which one or more income sources are missing. Although demographic summaries will be conducted for the entire data set, the income summaries are prepared only for a slightly smaller subset. The model then prepares various aggregations, which are essentially a straightforward counting procedure, and generates standard reports. In addition, the model is capable of replicating any of the raw data surveys, excluding the names of those individuals which are present. This survey replication procedure is useful in that it generates a complete archive of the original surveys which can be more easily referenced than the data in the individual data files.

In addition to the reports, the model generates two types of data files for further analysis. The first is a sorted list of incomes or assets for generating Lorenz curves and calculating various measures of inequality. The data which are downloaded include the population (or equivalent population), the total household income (or assets), and the decomposition of the total by sub-categories. Sorting is done on the basis of per capita income (or asset) in the household where each household member is then assumed to earn that income. The actual calculation of GINI coefficients and Atkinson indices, as well as the drawing of Lorenz curves, is performed by a separate Excel utility.

The second set of data files generated are those required for the econometric analysis. There are separate files for the data pertaining to individuals, households, and villages.

A.4.7 Econometric Models

Because of the preponderance of qualitative information, it was clear at the outset that analyses involving qualitative dependent variables would be required. To conduct this task, Version 6.0 of SHAZAM based on White (1987) was selected. The particular features which made SHAZAM a suitable program for these tasks were:

a) its ability to do PROBIT and TOBIT analyses;
b) its ability, with a single user-specified command, to exclude households in a data set if particular data were missing; and,
c) its ability to cross-reference data internally of different vector lengths.

This last attribute was especially critical to the overall modelling ease as it allowed the specification of separate data blocks for the 2,718 individuals, the 357 households, and the 24 villages. Through simple lookup functions, analyses could be conducted without having to create massive data blocks.[10] The primary disadvantage of SHAZAM is that it is extremely cumbersome for entering, verifying and editing large amounts of data and, hence, the front-end tasks completed by Korup.basic were vital to making the use of SHAZAM a viable option. Finally, however, as SHAZAM was available for a micro-computer it could be readily integrated with the other modules of the data management system.

SHAZAM has its own versatile command language which allows a substantial degree of data manipulation if one is confident that the initial data are clean. The command language was used to read the input data files, and then perform different types of transformations (such as logarithms, dummy variable creation, and so on) which would eventually be required for the econometric analyses. Also, through the command language, the appropriate links between individual, household, and village can be established. SHAZAM was then used to perform all of the regressions on the survey sample data. As SHAZAM does not, however, have the facility to do double hurdle evaluations, it was used to download data to a text file which could be used to perform the double hurdle analyses.[11]

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[10] It should be noted that this feature was not available on Version 5.

[11] The double hurdle model is maintained on a Cray mainframe computer to which the data were downloaded. I am grateful to Dr. Joanna Gomulka for her assistance with this procedure and for providing access to that model.

This file was created by SHAZAM (rather than by Korup.basic) to ensure that the data being used for the double hurdle model would be consistent with those used within SHAZAM. As both the double hurdle routine and SHAZAM have the ability to do a TOBIT analysis (which is, after all, just a limiting case of the double hurdle specification), results could be compared to ensure that they were comparable.

## § A.5 Summary Comments

In summary, with a view to conducting improved surveys in the future, it is useful to highlight some of the good and bad characteristics of the survey and data reduction process which arose here.

First, a particular advantage of this survey was the detail in the demographic information collected on those members of the household that had left the household and the village. This detail allows one to infer – albeit to a limited degree – why people migrate. While migratory flows are normally analysed on a gross basis, the availability of data for individuals with similar characteristics allows a more refined analysis of the migration decision. Notwithstanding this, however, the survey could have been improved had additional information been obtained on those normally present. Of those normally present, migration data were available for only the head of the household, and it was not known if the other household members were originally from that village or if they had moved there recently. It would be a relatively straight-forward matter to ask, as was done with the head of the household, if each individual was born in the village and, if not, from where they had come.

Second, although the demographic data were in a format which was amenable to double entry and thus could be verified for internal consistency, the household income data was not in a format which would allow independent checks. The one question which would potentially have provided this check ("What was the household's total income?") was usually not pursued by interviewers because the individual being interviewed did not know and, in the few cases where they had an opinion (which, in this case, occurred only 66 out of 357 times), it was, as noted earlier, usually less than the totals based on sectoral incomes. It would have been useful to pursue this further during the interview process – requiring some reconciliation before the interview was brought to a close.

Third, any additional surveying which is done in the area should gather more detailed information on consumer durables and other assets. As noted in Chapter 5, casual observations suggested that there were few apparent differences in conspicuous consumption, yet there is a large degree of income inequality in the sample. While the analysis in Chapter 5 suggested that some of the income was being capitalised by inconspicuous investment in education, such a conclusion would be more robust if supporting data were available on physical assets.

Fourth, one valuable item which was collected during the survey were detailed maps of each of the villages allowing specific identification of the households. While this was not used in this study except to verify the survey coverage and to ensure that no household had been surveyed more than once, it is critical information should a resurvey ever be conducted for the purposes of collecting panel data.

Fifth, it is worth noting that there is some advantage in having transcribed the data from the raw surveys into a computer based data management system myself. It gives some insights into the overall quality of the data which might not jump out at the analyst when simply looking at the final summary results. For example, the distinction between the Eastern and Western Buffer Zone was actually selected *after* all of the results had been tabulated. The distinction was made primarily because of comments from the individuals being interviewed in the WBZ that they were so isolated that it was sometimes difficult for them to find out about work opportunities, or for them to sell their cash crop production. This latter assertion was obvious when going through the raw data for the WBZ – as many cash crop growers with mature trees did not actually market their crop. As noted in Table A.6, only about one-third of the households growing cocoa or coffee in the WBZ sold their output, whereas in the EBZ essentially everyone growing coffee or cocoa would sell it. Also, the 'hands on' transcription of the data suggested that – by and large – the data were of fairly good quality. From an original sample of 379 households, a working data base of 341 households was generated. The data generally appeared to be best when the household head himself or herself was being interviewed, and more missing data and inconsistencies arose when the household head was not available.

Finally, on a more general note, one should realise that similar surveys are often undertaken by development agencies to provide a "socio-economic" baseline for assessing – at some future date – the impacts of a particular project on local communities. While these surveys are not originally designed for rigourous economic analyses – as indeed was the case here – this exercise has demonstrated the feasibility of casting the data into a structure which is amenable to fairly standard econometric analyses. Furthermore, as demonstrated in Chapters 5 and 6, the results of these analyses provide estimates which are economically meaningful. This is an encouraging feature as a common rationalisation for *not* proceeding with rigourous analyses of such surveys is that the data are too noisy.

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