

**ECONOMETRIC MODELLING OF THE EFFECTS OF
INTERSECTORAL LABOUR MOBILITY ON
DEFORESTATION IN GHANA, 1970–99.**

BY

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF
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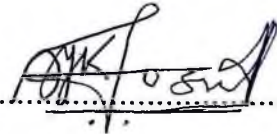
DECLARATION

I, **VICTOR OWUSU**, the author of this thesis, "**ECONOMETRIC MODELLING OF THE EFFECTS OF INTERSECTORAL LABOUR MOBILITY ON DEFORESTATION IN GHANA, 1970–99**" do hereby declare that, with the exception of references to past and present literature duly cited in this study, the entire research leading to this thesis was done by me at the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon. I further declare that the research has never been presented either in whole or in part for any degree in this University or elsewhere.

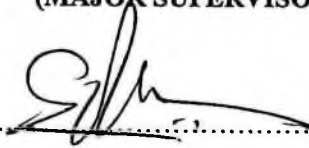


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This thesis has been submitted for examination with our approval as supervisors.



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DEDICATION

This thesis is dedicated to my daughters

Akua Durowaa Owusu and Adwoa Takyiwa Owusu.

First, I express my gratitude to the Almighty God whose divine guidance and wisdom have enabled me to complete this thesis research successfully. Second, I am grateful to my Major Supervisor, K. Yerfi Fosu for his immense contribution, direction and constructive criticism. I also appreciate my Major Supervisor's efforts of arranging for me to visit Vrije Universiteit, Amsterdam to undertake the econometric modelling and update the literature of this M Phil thesis. I sincerely owe a debt of gratitude to Dr Bruce Sarpong of Legon who was the Co-Supervisor of this thesis. I wish to thank Prof. Nico Heerink of Wageningen University, The Netherlands and Prof. Awudu Abdulai, Department of Agricultural Economics, Swiss Federal Institute of Technology, Zurich, Switzerland whose invaluable input assisted in refining the thesis.

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ABSTRACT

The study analyses the effects of intersectoral labour mobility between agricultural and non-agricultural sectors on deforestation in Ghana. It is based on annual time series data covering the period 1970–99. The study describes the basic determinants of intersectoral labour mobility and deforestation and estimates the magnitudes of the effects of their determinants in Ghana. The empirical results show that the effects of intersectoral labour mobility between agricultural and non-agricultural sectors on the environment is weak in the long run but statistically strong in the short-run. Furthermore, unemployment rate in the non-agricultural sector has contributed to the slow down of intersectoral labour mobility to the non-agricultural sector. In addition, the increased rural population pressure on land has tended to increase the forest area cleared for agriculture. The study also observed that the producer price of cocoa tended to exert a significant positive effect on deforestation through agricultural expansion. This result suggests, *inter alia*, that policies which tend to provide incentives to farmers and encourage the use of improved technologies which stimulates increased productivity in the cocoa sector will reduce pressure on land and slow down the rate of deforestation in Ghana. Other policy recommendations and suggestions for future research are also made in the study.

LIST OF ACRONYMS

ADB	African Development Bank
ADF	Augmented Dickey Fuller
AERC	African Economic Research Consortium
BG	Breusch Godfrey
COCOBOB	Ghana Cocoa Board
CSAE	Centre for the Study of African Economies
DGLS	Dynamic Generalised Least-squares
DF	Dickey Fuller
DOLS	Dynamic Ordinary Least-squares
DW	Durbin Watson
ECA	The European Commission for Africa
ECM	Error Correction Mechanism
ERP	Economic Recovery Programme
FAO	Food and Agriculture Organisation of the United Nations
GCA	Global Coalition for Africa
GDP	Gross Domestic Product
Ha	Hectares
IFS	<i>International Financial Statistics</i> Published by the International Monetary Fund
ILO	International Labour Organisation
IMF	International Monetary Fund

LM	Lagrange Multiplier
MCV	MacKinnon Critical Value
OAU	Organisation of African Unity
RSS	Residual Sum of Squares
SAP	Structural Adjustment Programme
UN	United Nations
UNEP	United Nations' Environmental Programme
WRI	World Resources Institute

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CHAPTER 1

INTRODUCTION

1.1. Background

The relationship between people and the environment has changed over time. Nations all over the world are recognising that the environment and development are inextricably interlinked. Excessive deforestation, significant declines in natural biomass and reduction in soil quality, in many cases induced by rapid population growth, have been identified as key factors explaining the apparent fall or stagnation of rural income in Africa (African Development Bank *et al.*, 1984; FAO, 1986). The process of economic development involves reallocation of resources, *inter alia*. One such economic phenomenon of resource transfer which has been accelerating over the years in developing countries is the mobility of labour between the agricultural and non-agricultural sectors. A typical dualistic economy postulated by Lewis (1954) and Ranis and Fei (1961) suggests the existence of unlimited supplies of labour with a zero marginal product in agriculture. The exodus of labour from agriculture to non-agriculture would continue if an autonomous expansion in the non-agricultural sector moves in tandem with job creation. The universal validity of labour surplus models may be applicable in developed countries, but their strict adherence in developing countries has not been upheld (Collier, 1979). This is particularly true of tropical Africa where there

exist limited markets of manufactured goods and a slight increase in agricultural employment.

In Ghana, the transfer of labour from the agricultural sector to non-agricultural sector has occurred in relative terms. The total labour force in Ghana still remains predominantly agricultural. The share of agriculture in total employment has declined; but in absolute terms, employment in the agricultural sector has actually increased (Ewusi *et al*, 1983). While there was decline in the proportionate share of agriculture in total employment from 63 percent to 53 percent between 1960 and 1970; in absolute terms, there was an increase in the number of persons employed in the agricultural sector. In all regions except Greater Accra, well over 80 percent of the male labour force aged 15 years and over were employed in the agricultural sector during 1960–1970.

Between 1980 and 1985, formal sector employment increased by 75 percent per annum, while the average annual growth of labour force was 2.3 percent. With the implementation of the Economic Recovery Programme and Structural Adjustment Programme (ERP/SAP), formal sector employment decreased by 9.2 percent per annum between 1986 and 1991. However, the growth rate of the labour force remained the same, at 2.3 percent per annum (Boateng, 1999). In the short run, more unemployment is created particularly among low-skilled workers through layoffs and retrenchment. A recent study conducted by the World Bank shows, among other things, that a significant

amount of labour was shed after privatisation of majority of firms in Ghana (London Economics, 1996).

Policy reforms under ERP/SAP initiated in April 1983 have encouraged reversed migration in Ghana as urban dwellers have returned to the farm (Jaegar, 1992; Abdulai, 1999). The primary goal of the adjustment programme was to liberalise the price system in order to stimulate production in sectors where Ghana possesses a comparative advantage. Evidence suggests major intersectoral flow of workers since 1983 from the non-agricultural sector to agricultural sector, this coinciding with growth in the agricultural sector especially the production of cocoa as targeted by the ERP (Fosu, 1989; Beaudry and Sowa, 1994).

Prior to 1970, 46.5 percent of net migration was directed towards Accra. However, the patterns of migration were completely reversed in the 1980s (Ewusi *et al.*, 1983). Between 1982 and 1987, net migration out of Accra accounted for almost 60 percent of net outmigration in Ghana and the Western Region being an expanding cocoa production zone, has attracted a lot of these migrants (Beaudry and Sowa, 1994). Agricultural policies pursued in an attempt to achieve economic development by following export-led growth models seem to have stimulated extensive deforestation through increases in the area of cultivated land (Fosu, 1992, 1996; Fosu and Heerink, 1996).

The current observation on the African continent is that most countries seem to be caught in a vicious circle of increasing population growth and lack of non-agricultural employment opportunities (Knerr, 1992). The role of human population pressures on economic development and tropical deforestation has received significant attention. The major dividing line in the debate on the causes of tropical deforestation is the explanation emphasising poverty and population growth as the driving force on the one hand, and the explanation emphasising market factors such as prices, access costs and property rights on the other (Angelsen, 1999). Population would influence deforestation through its effect on the minimum acceptable level of consumption. The minimum acceptable level of aggregate consumption will increase if population increases, leading to more deforestation.

Farmers make a number of farm decisions such as area cultivated, crop choice, labour and other inputs, cropping and fallow periods that are relevant to the management of natural resources. Agricultural household, in the view of Nakajima (1986), is both a producer and consumer. In the former role, households act like profit maximising producers whose activities could lead to deforestation when output prices or productivity increases. Increased productivity in frontier agriculture will cause a downward pressure on domestic food prices, which will dampen the effects on agricultural expansion. Technological progress on the other hand exerts an upward pressure on wages, which would dampen the effects of deforestation. The net effect therefore will depend on price elasticities in the output and labour markets (Angelsen,

1999). Higher population increases the prices of agricultural products and increased labour supply would reduce the wage rate. If there are sufficient employment opportunities in the non-frontier agricultural sector or off-farm income opportunities, the natural tendency is to reduce pressure on forest frontier.

The process of environmental degradation is intimately associated with frontier expansion. If there is shortage of land, the degradation is exacerbated as farm workers are forced to overexploit the land. Moreover, when other realistic alternatives do not exist, adjustment programmes characterised by the curtailment of subsidies on agricultural inputs, inter alia, stimulate the expansion of export crop production through increases in area of cultivated land (Khan and Knight, 1985; Zulu and Nsouli, 1985; Fosu, 1989; World Bank, 1989).

The tropical rainforest, which constitutes about 41 percent of the total tropical forest cover, is considered to be the richest and most valuable ecosystem on the earth. However, the FAO (1992) estimated that during the 1980s, about 15.4 million hectares of tropical forests were lost each year, while from 1990 to 1995 the annual loss was estimated at 12.7 million hectares (FAO, 1997). West Africa has experienced marked acceleration of forest loss during the last few decades of the Twentieth Century. Food and Agriculture Organisation (FAO) estimates that 30 million hectares have disappeared from the region during the Twentieth Century whereas the World Monitoring Centre

suggests that only 13 percent of "original" forest cover remains (Leach and Fairhead, 2000).

The physical destruction of Africa's tropical forest is largely effected through shifting cultivators who act within a socio-economic framework which leaves them fewer alternatives for survival than to regularly clear new forests (Knerr, 1992). For example, about 70 percent of original closed forest in Ghana have been destroyed due to the demand for agricultural lands, fuelwood and logging and bush fires (Ampadu-Agyei *et al*, 1994). The conversion of land from its natural climax vegetation to a more specific vegetative cover and land use system is driven by the human needs of today, short term and increasing demand for food, fuel, timber and raw material to improve living standards and food security (Knerr, 1992).

1.2. Problem Statement

Tropical deforestation is one of the environmental crises of our time. Historical evidence portrays that forests have consistently lost ground to agriculture, and while deforestation stabilised in Europe in the last century, the trends in tropical countries point towards their accelerating unequal competition (Buschbacher, 1986). According to the FAO (1993), the links between population pressure, poverty, non-availability of non-agricultural employment, intersectoral labour mobility and deforestation are thought to be very strong. The Ghanaian economy derives its present strength principally from

agriculture, mining and forestry. Moreover, food crop and livestock production must expand in order to feed the ever-increasing population of over 18 million people, currently growing at a rate of 2.5 percent per annum country (Ghana Statistical Service, *Ghana Housing and Population Census*, 2000).

Despite the growing evidence of commodity crises in the 1970s in Africa, and the serious decline in export earnings from cocoa during the structural adjustment era in Ghana, the major focus of agricultural policy has not been divulged from promoting rehabilitation of cocoa production in agriculture and maintenance of a monocultural export oriented economy. An attempt to diversify exports through policy initiatives of tax concessions to promote a new range of non-traditional export crops such as pineapple, coffee, medicinal plants, cane furniture (Jebuni *et al*, 1992) has also unfortunately been a disincentive to the goal of environmental sustainability.

Labour-use patterns differ significantly in Ghana, and different crops require different soil types for optimum performance. The local farmer tends to scatter or rather distribute his farm in order to take advantage of suitable soils. The foremost factor influencing the existing behavioural pattern of farm labour allocation is economic. Soils in Ghana, being deficient in major nutrients, are generally poor (Ewusi *et al*, 1983). Small-scale farmers in the Southern sector, unlike their counterparts in the North, do not use farm manure or much chemical fertilisers to enrich the soils (Ewusi *et al*, *ibid.*).

Diminishing returns sets in as labour-use is intensified. The farmer then chooses to distribute his labour over a number of lands.

Ghana has over 15,000 sq. km of rain forest but its rich forest resources are rapidly diminishing at an alarming rate of 25,000 hectares per year (Fosu, 1996). The issues which arise are the following: What are the determinants of intersectoral labour mobility in Ghana during the 1970 to 1999 period? To what extent has the transfer of labour between the agricultural and non-agricultural sectors contributed to deforestation in Ghana? The present study seeks to address these pertinent issues.

1.3. Objectives of the Study

The primary objective of the present study is to analyse the effect of migration of labour on deforestation in Ghana.

The specific objectives are as follows:

1. To estimate the rate of intersectoral labour mobility between agriculture and non-agriculture sectors in Ghana and the magnitudes of the effects of its determinants in Ghana during the period 1970–99.
2. To model the effects of migration of labour on deforestation in Ghana.

3. To provide policy recommendations concerning occupational labour mobility, and its effects on deforestation in Ghana.

1.4. Justification of the Study

The current study is very relevant for a number of reasons. First, the factors underlying labour force migration are very crucial in any development process. Ignorance of this has resulted in several problems such as chronic urban unemployment and under-employment in almost every contemporary developing country (Todaro, 1969). Second, conversion of forestland has conferred substantial economic benefits by allowing expansion of agriculture and sustenance for a rapidly growing population. However, diminishing returns limits this process. In addition, the livelihoods of forest-dependent people are undermined and forest-based foreign exchange revenue is lost. Third, the current modelling approach views deforestation as a title establishment strategy or an investment decision (Angelsen, 1999). This is because forest clearing and cultivation give some rights or claim to farmers. This contrasts with the social planner's viewpoint of deforestation as a form of disinvestment (Deacon, 1994) with regard to resource use decisions.

Fourth, Ghana abounds in natural resources, which have contributed significantly to the country's agricultural and industrial development since the attainment of independence. However, a point has been reached where it is necessary to balance

economic growth with rational management of resources to ensure that the resource base is not entirely eroded in the process of development. Ghana's Environmental Action Plan also makes this point (EPA, 1994).

Fifth, not only are forests home to some important plant species on earth, but they also play the vital role of climate regulation and carbon sequestration. Potentially, one of the most damaging effects of forest clearance is its impacts on the planet's climate through global warming and green house effects. Trees and other green plants absorb carbon dioxide and produce oxygen through photosynthesis whereas animals breathe in oxygen and breathe out carbon dioxide. The destruction of tropical forests therefore brings about a disastrous imbalance in the amount of carbon dioxide produced and recycled, leading to a greater build-up in the atmosphere and increased climatic change.

Sixth, forests contribute immensely to hydrological stabilisation. Once forests are cleared, topsoils are eroded making the soils unusable. This in turn could lead to devastating floods and desertification (Anderson, 1990). Perhaps, the greatest danger according to Buschbacher (1986) and Sunderlin and Resosudarmo (1999) due to this increased soil erosion, siltation and watershed damage, is the loss of genetic diversity.

Seventh, deforestation is changing the habitats of disease-carrying insects and creating conditions that may help to spread malaria, river blindness and other devastating diseases (Ted Case Studies, 1997). The worms that cause river blindness or

onchocerciasis are transmitted mostly by a blackfly known as *Simulium damnosum*. These cytoforms whose habitat is in the Savanna regions are now beginning to spread into areas of cleared forests in Ghana.

Eighth, deforestation is threatening yet another area linked to the well being of Ghanaians. Most Ghanaians have always opted for herbal treatment over Western medicine (Ted Case Studies, *ibid.*). A report by the Centre for Scientific and Industrial Research in Plant Medicine paints a gloomy picture that more than 250 indigenous trees and plants of herbal extracts and healing properties are in danger of extinction if trees continue to be cut indiscriminately from the forests (Ted Case Studies, *ibid.*).

Ninth, the reality of adverse impacts of structural change and economic development on the environment cannot be over emphasised. Lewis (1965, 1966) stands out among development economists who repeatedly called the world's attention to the serious problem of urban unemployment, but his analyses were qualitative rather than rigorous (Todaro 1969). Knerr's (1992) effort to analyse the socio-economic effects on deforestation in particular, in less developed countries, was analytical in nature. Other researchers have looked at deforestation in general (Gomez-Pompa *et al*, 1972, 1980; WRI 1985; Vincent *et al*, 1992) without considering the potential linkages between migration of agricultural labour and depletion of forest resources as a result of structural reforms and economic development.

Finally, the growing sustainable development literature seeks to identify development strategies that could lead to sustainable use of natural resources and the environment (Munasinghe, 1996). This suggests the need, *inter alia*, to analyse intersectoral labour mobility and how this influences deforestation. The present study which employs a quantitative modelling framework to analyse intersectoral labour mobility and deforestation in Ghana is therefore relevant.

1.5. Organisation of Study

The study is structured into five chapters. In Chapter 2, a review of the relevant literature is undertaken. The methodology formulated to generate the requisite data and the model required to achieve the set objectives are outlined in Chapter 3. The empirical econometric results relating to the effects of the determinants of labour mobility as well as the effect of labour mobility on deforestation in Ghana is presented in Chapter 4. Conclusions and recommendations are distilled in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

This chapter first reviews the literature on labour migration with particular emphasis on the types of migratory movements. Moreover, light is shed on the various theories of migration and the basic determinants of intersectoral labour mobility. The set of literature on deforestation in Ghana is reviewed. Definitions of forests and their classification are then provided, and the determinants of deforestation are also reviewed. The theoretical linkages between labour mobility and deforestation are also reviewed. The chapter also attempts to trace some of the empirical work on labour mobility and deforestation by paying attention to results, conclusions and recommendations from previous studies.

2.1. Labour Mobility

Labour migration and labour mobility have been used interchangeably in the literature on migration. Traditionally, migration has been viewed as an activity undertaken by an individual (Sahota, 1968; Falaris, 1979) or household (Stark, 1991; Shields and Shields, 1993) who, as a rational decision maker (Sjaastad, 1962; Beals *et al.*, 1967; Knight, 1972), moves from one location to another in search of job in response to income incentives (Greenwood and McDowell, 1991; Faini and Venturi, 1993) or cost of living differentials (Cebula, 1981, 1993) and location-specific amenities (Clark and

Cogrove, 1991). Diez-Canedo (1991) has observed that family migration in the U.S.-Mexico border region differs from typical international movements which portray migrants in the Third World cities as destitute and sometimes confronted with endemic political upheavals and violence (Morrison, 1993). Typical migrants therefore take migration as a last resort as they are forced out of their countryside where they had no alternatives (Breman, 1985, 1990; Chapman and Prothero, 1985; Parnreiter, 1995; Singh, 1995).

Modern economic development has invariably been accompanied by pronounced migration from rural and urban sectors of employment. Migratory movements in sub-Saharan Africa, apart from rural to urban, takes the form of rural to rural which has had implications for agricultural development in the region (Abdulai, 1999). Permanent migration in Ghana has been associated with movement of rural dwellers to either rural or urban areas for long periods of time (de-Graft-Johnson, 1974), whereas temporary or seasonal migration involves short-term movement of labour from the north to the south to take up temporary employment on cocoa plantations.

Theories and policies of economic growth and development have cited intersectoral or occupational mobility of labour from agricultural to the non agricultural sectors as a key instrument for promoting economic welfare (Ghatak and Price, 1996). Recent evidence seems to underline the case of adopting economic policies that would re-allocate labour from low productivity to high productivity areas, and promote factor

(labour and capital) mobility that would improve efficiency of the tradable sector as an engine of growth (World Bank, 1989; 1990).

In Ghana however, intersectoral labour mobility is also seen as an internal migration where domestic labour supply is reallocated between rural (agriculture) and urban (nonagricultural) sectors. While one mostly observes migration from rural to urban employment, there has been periodic brief interruptions marked by episodes of reverse migration from industry back to agriculture due to sharp economic downturns as it were in the United States during the 1920-21 recessions (Hatton and Williamson, 1994), and during the adjustment periods of Ghana in the 1980s (Ewusi, 1987; Fosu, 1989; 1996; Abdulai, 1999).

2.2. Labour Migration and Unemployment

The link between migration and unemployment has received significant research attention. The growth of the urban free-entry sector has been responsible for both the emergence of substantial urban poverty and labour misallocation (de Hann, 1997). In the words of Bencivenga and Rosenweig (1997), migration is often associated with significant urban underemployment. The pioneering work of Todaro (1969) which predicted that urban job creation will increase the size of the urban informal sector has been argued not to be true in some developing countries (Collier, 1979) and therefore provide inadequate and untested framework in which to analyse rural-urban labour

market interactions. Todaro (1969) believes that potential migrants have the choice between earning their marginal product in agriculture or of seeking employment by joining the urban unemployed and participating in search for wage employment.

If all jobs become vacant annually, then the average annual probability of gaining employment is equal to the proportion of jobs to the labour force. In the short run, the equilibrium expected income from job search will be determined by the existing stock of urban employed and the returns to job search schedule for the unemployed. Hence, the configuration of the volume of migration as a function of the level of expected income, which is determined by the stock of unemployed, is only true in the short run. In the long run, the equilibrium rate of migration determines the equilibrium level of unemployment. Since positive flow of migration with constant level of wage and unemployment will increase the stock of unemployed as the expected income is reduced (Collier, 1979).

Pissarides and Wardsworth (1989) view the effects of unemployment on migration in three different ways. Firstly, unemployment increases the propensity of an individual to move (Bailey, 1993; Herzog, Schlottmann and Boehm, 1993), particularly if he is the breadwinner for the household (Da Vanzo, 1978). However, high unemployment insurance (Goss and Paul, 1990; Antolin and Bover, 1993) and long unemployment duration (McHone and Rungeling, 1993) negate this effect. Secondly, regional unemployment differentials may encourage migration (Bentolila and Dolado,

1991) and for the risk averse worker, employment probabilities are more important determinants of migration than wage rate (Treyz *et al*, 1993). Thirdly, increases in the rate of unemployment may be a deterrent to potential first-time movers (Withers and Pope, 1985; Bentolila and Dolado, 1991).

2.3. Determinants of Intersectoral Labour Mobility

The basic determinant of intersectoral labour mobility is the existence of income differences between sectors (Mundlak and Larson, 1997). The influential Todaro (1969) model postulated that migration is an increasing function of expected differential between sectors and the probability of obtaining a job which is a push factor in migratory decisions. Emerson (1989) explains that those with comparative advantage in activities associated with migratory work are more likely to migrate than those without. The human capital paradigm of Sjaastad (1962) assumes that an individual locates himself spatially so as to maximise the present stream of returns he enjoys. The economic component in that particular case is the difference in the discounted present value of the expected incomes between source and receiving sectors and the net of the direct cost of moving. Labour therefore calculates the gross utility for remaining in a sector vis-à-vis the one for moving to the best alternative sector of their choice. A move takes place if the cost of migration does not exceed the gross gain of moving. Changing occupations and for that matter sectors is very costly.

Molle and van Mourik (1989) believe that ability to migrate depends not only on access to financial resources to cover direct costs of movement and acquisition of information, but also on the psychic costs such as the unwillingness to leave family, friends and a familiar culture and language at the origin and cultural diversities, eating habits and homesickness at the destination. According to Yap (1977), Beals *et al* (1967) and Borjas (1987) distance is introduced in every migration function to proxy for these costs. In the opinion of Beals *et al* (*ibid.*), distance is expected to be a deterrent to labour mobility.

Other determinants of labour mobility are couched under the laws of migration. The push factors originate mostly from rural areas such as the level of poverty and income inequality in the agricultural sector and outmoded land tenure systems (Banerjee and Kanbur, 1994; Sahota, 1968). The pull factors on the other hand include employment, education and urbanization. Urbanization per se, as remarked by Banerjee and Kanbur (1981), may not attract migrants but reflects the existence of amenities, better educational opportunities, degree of market orientation of the population and the quality of transport network.

The presence of self-selectivity in migratory stream suggests that migrants sort themselves into advantageous groups given their characteristics (Roy, 1951; Maddalla 1983). In support of this hypothesis, Mundlak and Larson (1997) believe that the younger generation and the better educated have a higher propensity to migrate since the

young can benefit from longer life time income as compared to the old while education enhances one's chance of getting employment in a sector.

The introduction of expectations which captures the probability of getting a job in a sector reveals the importance of unemployment in migration studies (Johnson, 1948; Todaro, 1969). Johnson reveals further that when the unemployment rate in a sector is high, the rate of labour mobility to that sector is likely to be small. Because of unavailability of immediate non-agricultural work, the issue of lifetime income becomes important since lower income in the period after migration may be compensated by higher income in future (Mundlak and Larson, 1997). Pissarides and McMaster (1990) who maintained that low unemployment regions are characterised by negative net migration buttress this point. According to Gordon (1985), the response of net migration to the unemployment ratio is that, in times of high unemployment, migration in general suffers.

Levy and Wadycki (1973) used the stock of previous migrants in a sector as an explanatory variable in macro migration functions to represent the family and friend contact. Salvatore (1981) was of the view that previous migration rate is inversely related to the cost of migration due to the fact that previous migrants can provide job information, cost of transportation, temporary shelter and subsistence to migrant relatives and friends.

Economic growth and the distribution of its benefits depend on how well the labour market mobilises human resources in new activities, locations and skills (Kannappan, 1988). Moreover, the development process of less developed country hinges very much on its ability to raise the level of productivity in the various sectors of the economy. Unfortunately, such countries are handicapped, since a large segment of the working force seem to be concentrated in the agricultural sector which contributes little in relationship to their size to growth in total product. Their country's population is therefore caught in a vicious circle of rural underdevelopment and urban unemployment. Gordon (1969) was of the view that underemployment in less developed countries could be tackled by limiting population growth, increasing agricultural output levels and reducing the agricultural working force by increasing job-opportunities in the non-agricultural sector.

When additional labour leave agriculture, the average agricultural surplus falls. The terms of trade turn further against the non-agricultural sector such that unless the industrial real wage is reduced, its exchange value will fall (Gordon, *ibid.*). It is therefore important to note that the levels of development and industrial composition are dictated by the extent of mobility rate between sectors. From orthodox economic analysis, one would expect the exodus of labour from agriculture to non-agriculture as soon as the economy experiences low marginal product in the latter sector as its supply curve flattens out. Balough (1962) has however observed that, the characteristics of West

African urban unemployed seem not to make this likely, particularly even after prolonged spells of unemployment.

Labour force that sought job in the formal sector has three options. Migrants could return to the villages whence they came or stay and contribute to urban unemployment or they could swell the ranks of the informal sector. Todaro (1985) and Kannappan (1983, 1985) argued that rural workers would migrate to the cities even if they were unlikely to find jobs and in that particular case earning nothing but with the hope of eventually securing employment in the formal sector. The chances of getting an urban job falls as more rural workers join the ranks of the unemployed, thus discouraging additional migration in excess of the rate at which new jobs are being created in the formal sector. Gelb *et al.* (1989) have demonstrated that in most developing economies, the diversion of capital into unproductive public employment does not reduce urban unemployment.

In many developing countries especially in sub-Saharan Africa, high population growth rates and increasing labour force participation rates continue to accelerate economic growth. These countries increasingly find themselves confronted with the task of achieving high rates of economic growth in order to absorb their growing labour force in productive employment. The situation is even more dramatic in countries which experience declining rates of economic growth and productivity (Abdulai, 1999). Increased supply of and reduced demand for labour in these countries have resulted in

declining employment and productivity of labour and high rates of intersectoral labour mobility, rising urban unemployment, and a shift to low income jobs in the informal sectors outside the organised urban labour market of the urban economy (Sabot, 1977).

Early writers such as Nurkse (1953) and Lewis (1954) cited zero or low marginal productivity of labour in agriculture and concluded that there was hardly any disguised unemployment in agriculture in West African countries. They maintained that food shortages in most West African countries in the second half of the 1960s was mainly caused by shortages of labour resulting from the high rate of migration of workers from rural areas where food is produced to towns. Beals and Menzes (1970) have also shown in their empirical study on migrant labour and agricultural output that temporary migration improves the allocation of resources and has contributed significantly to growth of output in Ghana.

2.4. Deforestation in Ghana

The population of Ghana stood at about 18 million during the 2000 population census. Ghana has a total area of 238,540 sq. km of which land area is estimated to be about 230,020 sq. km. Trends in the population density reveal an interesting scenario. Between 1984 and 2000, the percentage change in population density in the Ashanti, Brong-Ahafo and Western Regions where the country's remaining forest are concentrated were 52.5 percent, 51.2 percent and 59.2 percent respectively while in all

regions, the percentage change in the population density remained at about 49.7 percent (Ghana Statistical Service, Ghana Population Census, 2000). Land use distribution in Ghana as at 1997 was as follows: 5 percent arable land, 7 percent permanent crop, 15 percent meadow and pasture, 37 percent forest and woodland and others are 36 percent (FAO, 1997).

The scale of deforestation in the moist tropics has only recently been quantified on a worldwide basis. Data compiled by the FAO show that during 1980–85, the loss of tropical closed forests averaged 75,000 km² per year, an area roughly equivalent to the country Panama (WRI, 1986). Over the last 40 years, Africa alone has lost one quarter of its tree cover (WRI, 1989). The rate of deforestation in Ghana has increased by 50 percent over the last ten years (FAO, 2000). Since 1981, the annual rate of deforestation has been two percent per year or 750 hectares each year. Ghana's tropical forest area is now 25 percent of its original size. The devastation of Ghana's forest is further underscored by *The Ecologist*. Between 1937/38 and 1980/81, the area of closed forests in Ghana was reduced by 64 percent from 47,900 km to 17,000km and open woodland declined by 37 percent from 111,000km to 69,000km (*The Ecologist*, 50).

The Forestry Department of the Ministry of Lands and Forestry also estimated that in 1954, there was 1,544,000 hectares of unreserved forests constituting about 19 percent of the original forest cover in Ghana. By 1972, this had reduced to about 362,000 hectares and towards 1989, less than 5 percent of the original cover of high forest was

left outside the reserves while clearing continued at around 20,000 hectares per annum. An estimate by the World Bank indicates a deforestation rate of 75,000 hectares per annum in Ghana (World Bank, 1989).

According to Ruf (1997), the supply of cocoa seems very dependent on the clearance of tropical forests. In an effort to open up more area for cocoa production, trees are cut down. In addition, cocoa farmers slash and burn forest themselves or move on to land which has been commercially logged. Ghana has therefore started feeling the pain of the associated environmental imbalances. The impact of deforestation in Ghana is seriously jeopardising the country's future. Environmentalists believe that if the trend continues unchecked, there would be no forest cover in Ghana by the year 2020 and conservationists also predict that if the current wanton log extraction and reckless forest destruction continue, Ghana's forest would be gone in the next 45 years (Ted Case Studies, 1997). There is therefore the need to understand this phenomenon. Hence, the theme of the present study is relevant.

2.5. Definition and Determinants of Deforestation

The term tropical forests refers to an ecosystem with a minimum of 10 percent crown cover of trees and/or bamboo interspersed with wild flora and fauna and natural soil conditions which has not been subjected to agricultural activities (Singh, 1993; FAO, 1997). The FAO considers forests as a vegetation cover in which the woody

element is mainly a tree cover with a height of more than 17 metres. Kahn and McDonald (1994) categorise forests into "unprotected forests", "reserved forests" and "extractive reserved forests". The "unprotected forests" also termed "non-reserved forests" are those which, having suffered heavy encroachment in the absence of control over occupation, may become as Lambardini (1994) puts it, an open resource collectively open to public use resulting in degradation. "Reserved forests" or "intensively managed forests" which exclude all types of production activities and impose severe restrictions on public use, are considered to be better organised and in a state of maintenance (Lal, 1989). According to Chakraborty (1994), "reserved forests" have a high degree of area under dense forests of over 40 percent crown cover. "Extractive reserved forests" or "working forests" however allow certain types of production activities.

Natural forests may be grouped into virgin, primary and secondary forests. Other subcategories exist which make the definition of forests extremely difficult and in some cases country-specific. These include "logged-over forests", "undisturbed forests", "old-growth forests", "fragmented forests" and "clustered forests". Amelung and Diehk (1992) define "undisturbed forests" as forests, which for the last time have been logged 60-80 years ago. "Secondary forests" differ from "untouched forests" with respect to their ecological characteristics. "Closed forests" are characterised as having unbroken canopies whereas in "Open forests", the tree cover is broken with the trees growing further apart. Cropper and Griffiths (1994) refer to forests interspersed with agricultural

and other land use as "fragmented forests" whereas those with dense vegetative cover, devoid of agricultural and other land use activities as "clustered forests".

It is also important to distinguish between "deforestation" and "degradation". The FAO defines "deforestation" as the permanent conversion of forestlands into other uses (FAO, 1993). The FAO-UNEP definition however is a restrictive one, which defines deforestation as a decline in a closed tropical forest area. Panayotou and Sungsuwan (1994) explained deforestation as an abrupt change in forestland use from forestry to something else. They considered land previously under forest but now under shifting or permanent agriculture, plantation or crop as deforested even if the new land-use is more beneficial than forestry. In contrast, forest "degradation" is the gradual deterioration in the quality of the selective and destructive logging and uncontrolled bush fires.

"Degradation" may eventually lead to "deforestation" by either conversion to agriculture or other non-forestry uses, which may degenerate, into wastelands. The above definition is supported by Singh (1993) who referred to degradation as the changes occurring within both open and closed forests that negatively affect the stand or site and in particular, lower the productive capacity of forests. According to the FAO, deforestation is said to have occurred when the canopy is reduced to 20 percent or less and for tropical countries when the crown cover is depleted to less than 10 percent (FAO, 1997). However, any changes within the forest class which severely affect the

regenerative capacity of the forest is termed degradation instead of deforestation even if the crown cover is reduced to 30 percent.

The physical destruction of Africa's tropical forest has reached unimaginable proportion as the conflict between food production for subsistence survival and the preservation of forest resources deepens. The most seriously affected region is West Africa where the rate of deforestation through agricultural expansion on closed forest is believed to be six times higher than in Central Africa (Myers, 1989). Experience in Ghana shows that when the bearing life of cocoa trees is finished and the trees die as a result of old age, disease and damage, one of the choices available to the farmer include migrant forest degrading subsystem. This land use subsystem involves a search for new forest for new farms, which becomes unsustainable where forestlands are limited and population is increasing (Gyasi *et al*, 1993).

A number of factors have interacted to bring West Africa's rate of deforestation to the highest level. Angelsen and Kaimowitz (1999) classified the determinants of deforestation into immediate and underlying causes. While the immediate causes attribute tropical deforestation rates to agricultural prices, prices of inputs and credits, off-farm employment opportunities, technological progress in agriculture, accessibility and roads, the underlying causes link deforestation to population pressures, income level and economic growth, external debt, trade and structural adjustment, among others. Other authors look at it from the ecological perspective (Myers, 1984; WRI, 1985). The

political economy perspective of causes of tropical deforestation emphasises the role of public and private capital rates of deforestation (Hecht, 1985; Shane, 1986).

Higher prices of agricultural products stimulate forest clearing in that, as frontier agriculture becomes more profitable, both existing population and migrants from areas begin to shift resources into forest clearing. Higher fertiliser prices induce farmers to adopt more intensive production systems that use more land and less fertiliser. This hypothesis is also true for higher prices of agricultural inputs such as seeds, pesticides and hand tools (Ruben, Kruseman and Hengsdijk, 1994). Credit expansion could reduce the pressure on forests if intensive agriculture and forest management investments were to be pursued. However, it increases pressure on forest if it was used to finance activities that promote forest clearing (Angelsen, 1997; Pfaff, 1997). In addition, the activities of log-exporting timber firms, road construction and mining activities may open up previously forested areas where farmers could move on to cultivate.

According to Southgate (1990), technological changes that increase yields without significantly altering labour or capital requirements can be expected to increase deforestation. As population grows, the need for more land for food, fuelwood, timber or forest products may increase deforestation (Hafner, 1990; Panayotou and Sungsuwan, 1992). In Ghana, decades of spread of shifting cultivation promoted by large-scale logging operations and transformation of closed woodland into permanent tree crop mainly cocoa, have destroyed nearly all the tree cover of once forest-rich country

(Kneer, 1992). Policies that favour rural wage and generate off-farm employment opportunities for rural people should reduce deforestation and simultaneously conserve forest. Some analysts claim that government policies which affect migration such as road construction, colonisation policies, agricultural subsidies and tax incentives rather than population growth lead to deforestation (Panayotou and Sungsuwan, 1994). In their view, people migrate to forestlands because clearing of forests for agriculture has become economically attractive so the size of the population in that particular case cannot be considered as an independent variable in the deforestation model.

Evidence from several analytical and quantitative macroeconomic models reveal that policies which improve the terms of trade in favour of agriculture and structural adjustment policies in particular that tend to raise the prices received by farmers potentially increase deforestation (Cruz and Repetto, 1992; Jones and O'Neil, 1994,1995; Babier and Burgess, 1996). Moreover, policies designed to promote agricultural and forest product exports are likely to affect deforestation more than policies to promote production for domestic market. The relative incentive for the production of export crops like cocoa (Fosu, 1992; Amanor, 1994; Fosu, 1996; Fosu and Heerink, 1996) and other non-traditional agricultural exports like pineapples, coffee and medicinal plants (Jebuni *et al*, 1992) have contributed significantly to environmental degradation during the periods of Ghana's economic reforms.

2.6. Empirical Literature on Labour Mobility and Deforestation

The empirical study based on the original Todaro (1969) theoretical framework that migration is an increasing function of expected income differential between dual sectors is found to be true in most cases. Winkelmann (1966) had earlier observed in a study based on the United States that lower income to farmers speeds up the exodus of farm labour from the agricultural sector to the non-agricultural sector. Farm workers therefore seasonally migrate for agricultural work because of economic choice (Lucas and Stark, 1985; Taylor, 1987). These results are also consistent with what Banerjee and Kanbur (1981) obtained for Indian data and House and Rampel (1980) obtained for Kenya.

Mundlak and Larson (*ibid.*) also observed from their study of intersectoral labour mobility based on cross-country data that, the rate of migration is positively related to the ratio of income in non agriculture to agriculture and that labour supply from agriculture to non agriculture is upward sloping. They found out that as labour leaves agriculture, labour productivity increases, leading to a decline in both income differential and migration respectively. However, migration stops when the income is roughly equal across sectors, thus validating what Barnum and Sabot (1977) had earlier on observed in their study on rural-to-urban migration in Tanzania.

The choice of income or wage as an appropriate measure in migratory studies has been a bone of contention. Sahota (1968), Barnum and Sabot (1977), Falaris (1979) and Pissarides and McMaster (1990) employed wages in Brazil, Tanzania, Peru and Great Britain respectively. Beals, *et al* (1967) used income in their Ghanaian study but even here, limited their estimates to regional averages while other researchers like Knight (1972) and Mundlak and Larson (*ibid.*) have preferred GDP as a proxy for national income due to unavailability of good quality wage data. Moreover, economic advantage is better captured by income than by wages. Wage data do not provide an adequate picture of employment opportunities due to lack of seasonal variations in agricultural work. Also, when wage is used, agricultural non-wage income such as rent on land and returns to both physical and human capital, which constitutes an important component of total income, are neglected.

More recently, the importance of the informal sector as a base for job-search in the formal sector has been stressed (Thomas, 1992; Bhattacharga, 1993). Banerjee and Bucci (1994) found for India internal migrants that, workers currently in low income employment, the landless, and the better educated are the most likely to engage in on-the-job search; thus, invalidating Todaro's job-lottery and high unemployment view of urban labour markets in the developing world.

Distance sharply reduces migration (Sjaastad, 1962; Beals *et al*, 1967). Borjas (1987) therefore concluded that, distance is a strong deterrent to migration and can be used to proxy for both monetary and non-monetary costs of migration. Distance is an important variable in migration studies but some studies have tended to omit it from their empirical estimations citing a possible correlation with the time and regional dummies (Mundlak and Larson, 1979). Although it is difficult to estimate psychic costs associated with the feasibility of migration, Molle and van Mourik (1989) found significant and negative influence of psychic costs on migrations within Europe.

Empirical studies by Banerjee and Kanbur (1981) based on Indian data found inequality of land holdings to be positive which indicates, *ceteris paribus*, that the more unequal the land distribution is in the rural areas, the higher the rate of migration from that sector. Their study further reveals that the coefficient of the poverty index in the rural sector was negative, running counter to the idea of rural push which is supposed to encourage migration. Poverty in this case seems to be hindering migration probably due to the inability to finance migration expenditures. Factors affecting deforestation, the interaction between them and the magnitudes of their effects all vary significantly from one location to another. Global views, however, emphasise the similarities between countries and regions instead of differences. Empirical studies on deforestation have utilised both microeconomic and macroeconomic models. The micromodels seek to explain how individuals allocate their resources using standard economic variables such as background preferences, prices, institutions, access to infrastructure and services, and

technological alternatives. A major distinction is between models that assume that all prices are market determined and that farmers are fully integrated into perfect markets (Southgate, 1990; Bluffstone, 1995; Angelsen and Kaimowitz, 1999) and those that do not (Dvorak, 1992; Holden, 1993). Production decisions are studied as a profit-maximising problem. The macromodels on the other hand emphasise the relations among underlying variables, decision parameters and deforestation. Most of the models include interactions among different sectors such as subsectors of agriculture, forestry and manufacturing which make them useful in analysing the underlying causes of deforestation.

Ruben, Kruseman and Hengsdijk (1994) and Angelsen and Kaimowitz (1999) found less deforestation when agricultural prices were higher while models that assume profit-maximising behaviour show the opposite (Monela, 1995). Empirical regression models on Tanzania by Angelsen and Kaimowitz (1998) and on Thailand by Panayotou and Sungsuwan (1994) all found a positive correlation between higher agricultural prices and deforestation. The effect of changes in agricultural input prices on forest clearing however leads to an indeterminate conclusion and mixed empirical evidence especially in the case of fertiliser. Regression models used on South Africa suggest a positive correlation between fertiliser prices and deforestation (Monela, 1995; Holden, 1997) due to intensification. Other studies on Latin America by Babier and Burgess (1996) indicates a reduced deforestation as fertiliser prices increase, the reasons being that agriculture becomes less profitable when there is a higher cost associated with the

acquisition of fertiliser. Moreover, higher prices of inputs such as seeds, pesticides and hand tools reduce forest clearing (Ruben *et al.*, 1994; Monela, 1995). Although empirical studies on Africa and Asia have ignored the issue of credit availability, Monela (*ibid.*) found a positive relationship between credit availability and deforestation in Tanzania.

According to Nghiep (1986) and Holden (1997), technologies that make intensive production systems more profitable, reduces the demand for forestland to be converted to agriculture. From analytical and empirical models, greater access to forest and markets accelerates deforestation (Chomitz and Gray, 1996; Mortens and Lambin, 1997). All microeconomic models suggest that higher rural wages and greater off-farm employment opportunities reduce deforestation by making agricultural and forestry activities more costly (Holden, 1993; Ruben *et al.*, 1994; Bluffstone, 1995). Several multicountry regression models show a positive correlation between population density and deforestation but such results have been spurious and criticised as they rely on FAO Forest Resources Assessments based on population data (Palo, 1994; Rock, 1996). Although empirical evidence on the relation between population growth and deforestation has been weaker, other researchers like Kimsey (1991) and Rock (*ibid.*) obtained a positive relationship between them while Cropper and Griffiths (1994) found no effect. Studies on developing countries associate higher national per capita income with greater deforestation although the models have significant methodological weakness (Burgess, 1993; Krutilla *et al.*, 1995; Mainardi, 1996). Empirical evidence on the impact of economic growth rates on forest clearing is even weaker.

CHAPTER 3

METHODOLOGY

The long run and short-run effects of intersectoral labour mobility on deforestation are analysed by employing an econometric model comprising a system of simultaneous equations. The order of integration of the relevant variables are first established using the Augmented Dickey-Fuller (ADF) test. The Dynamic Generalised Least-Squares (DGLS) estimator, introduced by Stock and Watson (1993), is applied in the specification of the models after which the Iterative Three-Stage Least squares procedure is used to estimate the parameters of the simultaneous equations. The long-run causal flows from the explanatory variables to labour mobility and deforestation are examined with the Granger causality test. Having determined the existence of cointegration between the variables, the DGLS approach is finally applied to give the models error correction representations so that the short-run relationships could be analysed. The theoretical framework and the hypotheses validated in the study are first presented in this chapter. Next, the empirical econometric model is specified followed by the cointegration and error correction modelling procedures. Finally, the description of variables and the sources of data employed are indicated.

3.1. Theoretical Framework

The impact of intersectoral labour migration on the rate of forest decline in Ghana is analysed in the context of aggregate demand for forestland for conversion and aggregate supply of labour by agricultural households. Supply and demand functions of agricultural households in Ghana are specified under the assumption of a

competitive rural labour market (Abdulai and Delgado, 2000). The aggregate demand for forestland for conversion is formulated following Panayotou and Sungsuwan (1994), Lopez (1997, 1998), Cropper *et al.* (1999) and Barbier (2000). Here, agricultural production behaviour of a representative rural household with access to a stock of non-agricultural land such as forest area is assumed, following the existing literature (Barbier, 2000; Lopez 1997, 1998), in order to determine the derived demand by households for forestland conversion to agriculture. In Ghana, especially the indigene households in most rural areas happen to be the original landowners of family lands inherited through paternal or maternal lineage or sometimes inherited from the husband's family (Besley, 1993; Sakyi-Dawson, 2000). In addition, rural migrant households have access to stool lands or community lands through lease (rented lands), sharecropping and in some cases, through outright purchase (Sakyi-Dawson, *ibid.*).

Furthermore, the representative rural household is assumed to be a price taker in all markets for commodities and services it buys, consumes and produces, and profit and utility maximising decisions of households are determined. The optimal household production function is determined independently of consumption and leisure choices. The agricultural production function (Y) of the household is expressed as the product of the stock of arable land (in ha) A and agricultural productivity or yield per hectare, s . If agricultural productivity is assumed to be determined by the amount of purchased inputs X and household labour allocated to agriculture L^* , then the basic agricultural production technology is given by

$$Y = A \cdot s(X, L^*), s_x > 0, s_{xx} < 0, s_{L^*} > 0, s_{L^*L^*} < 0 \quad (1)$$

Where s_x denotes the first order partial derivative of $s(\cdot)$ with respect to X , s_{xx} denotes the second order partial derivative of $s(\cdot)$ with respect to X , and so on. The stock of agricultural land is not constant but grows by the amount of new land $n(L)$ brought into production by allocating some household labour L to convert forestland to agriculture. It is assumed that a proportion of agricultural land is taken out of production at each time in period t at a constant rate k . The net expansion of agricultural land is therefore given by

$$\frac{\partial A}{\partial t} = \dot{A}_t = n(L_t) - kA_t \quad (2)$$

where $n_L > 0$, $n_{LL} < 0$ and $A(0) = A_0$ and $k \neq 0$.

Maximising aggregate profits Π of the agricultural sector over an infinite time horizon, the relevant optimisation problem can be written as

$$\text{Max } J = \int_0^{\infty} \Pi_t e^{-rt} dt \quad (3)$$

subject to $\dot{A}_t = n(L_t) - kA_t$,

where r is the discount rate. The total endowment of household or hired labour D is used either for agricultural production L^* or land conversion L . Given an aggregate output price p , input price w , and cost function for the conversion of forestland $c(L)$, aggregate profits Π for households is given by

$$\Pi = pY - wX - c(L) \quad (4)$$

where $c_L > 0$ and $c_{LL} < 0$ and the time subscript t is suppressed for ease of exposition.

By definition,

$$L^* = D - L \quad (5)$$

Substituting (5) into (1), the production function of the household becomes

$$Y = A \cdot s(X, D - L) \quad (6)$$

By substituting (6) into (4), the aggregate profit function becomes

$$\Pi = pAs(X, D - L) - wX - c(L) \quad (7)$$

Therefore, the Hamiltonian for the solution of the intertemporal maximisation problem stated in (3) is given by (8):

$$H = pAs(X, D - L) - wX - c(L) + \Phi [n(L) - kA] \quad (8)$$

where X and L are control variables, A is the state variable and Φ is the corresponding co-state variable representing the shadow value of land in terms of additional agricultural profits.

The optimal path to steady-state equilibrium can be solved from the first order conditions which show how the prices of other factors influence both the rate of rural land use change ($\partial A / \partial t$) and demand for land A . The relevant first order conditions from (8) yield

$$pA s_x = w \quad (9)$$

$$\frac{\partial A}{\partial(w/p)} = -\frac{k}{s_x} \quad (10)$$

An equation for the optimal level of land use in each period $A(t)$ is derived by differentiating (9) with respect to time, thus giving

$$A(t) = \frac{1}{k} \left[n(L) + w \frac{s_{xx}}{p(s_x)^2} \dot{X} \right], \text{ where } k \neq 0 \quad (11)$$

$\frac{\partial A}{\partial(w/p)} < 0$ or $= 0$ or > 0 if $X > 0$ or $= 0$ or < 0 (see Appendix I for the derivation of equations 9 - 12). Notably,

$$\frac{\partial A}{\partial(w/p)} = -\frac{s_{xx}}{(s_x)^2} \dot{X} \quad (12)$$

Equation (11) shows that the demand for land for agriculture depends not only on the rate of land conversion $n(L)$ and the proportion of land following k , but also on the level of agricultural returns (p/w) , the rate of marginal productivity of purchased inputs $\frac{s_{xx}}{s_x}$, and the rate of input use over time $\frac{\partial X}{\partial t}$. Equation (12)

determines the impact of an increase in agricultural returns on land use $\frac{\partial A}{\partial(p/w)}$. If

input use is growing overtime, then agricultural land use will increase with rise in agricultural returns and vice versa. Mathematically, if $\frac{\partial X}{\partial t} > 0$ then $\frac{\partial A}{\partial(p/w)} > 0$, or

if $\frac{\partial X}{\partial t} < 0$ then $\frac{\partial A}{\partial(p/w)} < 0$. Equation (11) cannot be empirically estimated but

provides useful insights into how input use and prices influence the demand for land (Barbier, 2000).

The direct increase in the relative prices of agricultural products and decrease in the relative price of agricultural inputs stimulate farmers to increase output resulting in increased demand for land to be converted to agriculture (Panayotou and Sungsuwan, 1994; Barbier, *ibid.*). An increase in the price of agricultural food products on the other hand could lead to a temporary decline in the food purchasing power of agricultural wage (Abdulai, 2000). The indirect effects of agricultural on

area cleared for agriculture is captured through the increased profitability of frontier farming which, inter alia, stimulates labour displacement through migration to the agricultural sector. This on-farm migration could lead to increased population pressure on land resulting in increased production, extensification of agriculture and extensive deforestation (Boserup, 1965; Rothenberg, 1980). On the other hand, an increase in availability of off-farm employment and income will unambiguously reduce deforestation. Burger (2000) argues that population pressure can be met by enhanced migration out of the agricultural sector where there need not be more pressure on land. The analysis above suggests that land cleared for agriculture is a function of input and output prices, population pressure and a labour migration variable. The cleared land equation is thus specified as

$$A_c = A(I^P, O^P, P^R, M_N^A) \quad (13)$$

where A_c is the area cleared for agriculture or area deforested, I^P is a vector of prices of agricultural inputs like fertiliser, insecticides, fungicides and so on, O^P is a vector of prices of agricultural products such as cocoa and coffee, M_N^A is migration from agricultural sector to non-agricultural sector and P^R is population pressure. Notably,

$$\partial A_c / \partial I^P > 0, \partial A_c / \partial O^P > 0, \partial A_c / \partial P^R > 0 \text{ and } \partial A_c / \partial M_N^A < 0.$$

In formulating the supply of agricultural labour, some aspects of the Harris and Todaro (1970) framework are incorporated where intersectoral labour mobility occurs when expected real income in non-agriculture (urban sector) exceeds that in agricultural sector (rural sector). The change in out-migration in response to short-run increases in the income differential depends on the unemployment rate in the non-

agriculture sector. Migration stops when wages are equal across sectors (Mundlak and Larson, 1997). Because of general excess supply of urban labour in Ghana, urban wages are assumed to be exogenous to rural labour markets whereas rural wages are assumed to be endogenous to rural-urban migration (Abdulai, 2000).

The model is therefore postulated by endogenizing labour inputs (Angelsen, 1999). There is also interplay of the Malthusian effect which postulates that higher wages could lead to higher fertility and lower mortality rates. Natural growth rate of population due to high fertility or low mortality rates could stimulate migration. A dummy variable is included in the model to quantify the effect of the Structural Adjustment Programme on labour mobility rates (Barbier, 2000). The labour mobility model is specified as

$$M_N^A = m(W_N^A, P^R, U^{REM}, S^D) \quad (14)$$

where M_N^A is migration of labour from the agricultural sector to the non-agricultural sector, W_N^A is the expected income in agriculture relative to that in the non-agricultural sector, P^R is population pressure, U^{REM} is rate of unemployment in non-agricultural sector and S^D is structural adjustment dummy ($S^D = 1$ for 1983 – 99 and zero otherwise)

Notably, $\partial M_N^A / \partial W_N^A < 0$, $\partial M_N^A / \partial P^R > 0$, $\partial M_N^A / \partial U^{REM} < 0$, $\partial M_N^A / \partial S^D < 0$.

3.2 . Statement of Hypotheses

The null hypothesis is represented by H_0 and the alternative hypothesis by H_A . The hypotheses to be validated are:

- I. H_0 : Rural population pressure exerts no effect on intersectoral labour mobility, versus
 H_A : Rural Population pressure exerts a positive effect on intersectoral labour mobility (that is, from agriculture to non-agriculture).
- II. H_0 : Income in agriculture relative to that in non-agriculture exerts no effect on intersectoral labour mobility, versus
 H_A : Income in agriculture relative to that in non-agriculture exerts a negative effect on intersectoral labour mobility from agricultural to non-agricultural sector.
- III. H_0 : Unemployment rate in non-agricultural sector exerts no effect on intersectoral labour mobility, versus
 H_A : Unemployment rate in non-agricultural sector exerts a negative effect on intersectoral labour mobility from agriculture to non-agriculture.
- IV. H_0 : Structural Adjustment Programme exerts no effect on the rate of intersectoral labour mobility from agricultural sector to non-agricultural sector, versus
 H_A : Structural Adjustment Programme exerts a negative effect on the rate of intersectoral labour mobility from agricultural sector to non-agricultural sector.

- V. **H_0 :** Intersectoral labour mobility in favour of the agricultural sector exerts no effect on the rate of deforestation, versus
- H_A :** Intersectoral labour mobility in favour of the agricultural sector exerts a positive effect on the rate of deforestation.
- VI **H_0 :** Population pressure exerts no effect on the rate of deforestation, versus
- H_A** Population pressure exerts a positive effect on the rate of deforestation.
- VII. **H_0 :** Producer price of cocoa exerts no effect on the rate of deforestation, versus
- H_A :** Producer price of cocoa exerts a positive effect on the rate of deforestation.
- VIII. **H_0 :** Producer price of maize exerts no effect on the rate of deforestation, versus
- H_A :** Producer price of maize exerts a positive effect on the rate of deforestation.
- X. **H_0 :** Price of insecticides exerts no effect on the rate of deforestation, versus
- H_A :** Price of insecticides exerts a negative effect on the rate of deforestation.

3.3. Specification of the Empirical Econometric Model

The empirical simultaneous equation econometric model in two endogenous variables with the relevant a priori parameter signs is given by (15) and (16)

$$M_t^{AN} = a_0 + a_1 W_t^{AN} + a_2 R_t^{POP DN} + a_3 U_t^{REM} + a_4 SAP_t + e_{1t} \quad (15)$$

$$(-) \quad (+) \quad (-) \quad (-)$$

$$D_t^{AREA} = b_0 + b_1 M_t^{AN} + b_2 R_t^{POP DN} + b_3 P_t^{COCOA} + b_4 P_t^{MAIZE} + b_5 P_t^{INSECT} + e_{2t} \quad (16)$$

$$(-) \quad (+) \quad (+) \quad (+) \quad (-)$$

where M^{AN} denotes labour mobility from the agricultural sector to the non-agricultural sector, W^{AN} denotes income in agriculture relative to that in non-agriculture, $R^{POP DN}$ denotes population pressure in the rural areas, U^{REM} denotes unemployment rate in the non-agricultural sector, D^{AREA} denotes area deforested, P^{INSECT} denotes the price index of insecticides, P^{COCOA} denotes real producer price of cocoa, P^{MAIZE} denotes real producer price of maize, SAP denotes structural adjustment dummy ($SAP=1$ for 1983 – 99, 0 = otherwise), t denotes current time period and e denotes error term satisfying the classical normal regression assumptions (Judge *et al*, 1984).

The intercept terms capture factors affecting the rates of migration and deforestation which changes slowly overtime (Cropper and Griffith, 1994). In the deforestation model, such fixed factors may include closeness of forests to cities and rivers, the sizes and distribution of forests and other land uses (Cropper and Griffith, *ibid.*). Error terms are included to take account of possible omission of variables from

the functions and errors in the measurement and aggregation of the variables. The following approach is employed in the estimation of the parameters of the model.

3.4. Cointegration and Equilibrium Correction Modelling

Before any regression analysis on a time series is carried out, the order of integration of the variables has to be determined. This is because in practice, most economic time series tend to be generated by non-stationary stochastic processes (Tambi, 1999). Cointegration analysis begins with the determination of the order of integration of each of the relevant time series (Banerjee *et al*, 1993; Alogoskoufis and Smith, 1995). This is essential if spurious regression, which is normally associated with non-stationary series, is to be avoided (Granger and Newbold, 1974). A time series is stationary if its mean, variance and autocovariances are independent of time (Engle and Granger, 1987). Any series that is not stationary is said to be non-stationary and its variance is such that any stochastic shock may not return it to its mean level.

The necessary conditions for variables to be cointegrated are that the variables exhibit similar statistical properties of being of the same order of integration and that linear regression involving the levels of the series must be stationary. Many series are non-stationary in their levels but stationary in their first differences. This procedure of first differencing tends to reduce potential multicollinearity problems (Holden and Permon, 1994). A non-stationary series X , which can be transformed into a stationary series by differencing d times is said to be integrated of order d ; and this is denoted

by $X_t \sim I(d)$. The order of integration is the number of unit roots contained in the series or the number of differencing operations required to make it stationary. A stationary series is said to be integrated of order zero, that is $I(0)$.

Many procedures exist for identifying the order of integration to ascertain whether a given time series has unit root (Campbell and Perron, 1991; Kwiatkowski *et al.*, 1992; Silvapulle and Jaysuriya, 1994). The present study, however, employs the frequently used Augmented Dickey-Fuller (ADF) unit root tests to identify the order of integration of the economic variables. Given a time series Z_t , the Dickey-Fuller procedure involves the estimation of the regression

$$\Delta Z_t = \alpha + \gamma Z_{t-1} + U_{1t} \quad (17)$$

where $\gamma = \delta - 1$, α is a constant drift, δ is the coefficient to be tested and U_{1t} is a stationary random disturbance term. The ADF test however ensures that a lag length k is chosen which makes U_{2t} a white noise term:

$$\Delta Z_t = \alpha + \gamma Z_{t-1} + \sum_{i=1}^k \beta_i \Delta Z_{t-i} + U_{2t} \quad (18)$$

The Augmented Dickey-Fuller test statistic is the t -value for $\gamma = \delta - 1$ in equation (18) under a null hypothesis of $H_0 : \gamma = 0$ implying non-stationarity against $H_A : \gamma < 0$ implying stationarity, $I(0)$. When $\gamma = 0$, implying non-rejection of H_0 , a unit root test on ΔZ_t is run to verify whether Z_t is integrated of order one. When H_0 is rejected for ΔZ_t , then Z_t is $I(0)$. The statistical significance is arrived at by comparing the computed ADF test statistic to the appropriate critical value from Fuller (1976), Dickey-Fuller (1981), Engle and Granger (1987) and Phillip and

Perron's (1988) non-parametric method for controlling higher order serial autocorrelation in the series. In recent times, the statistical table of Mackinnon (1991) which permits the calculation of the Dickey-Fuller critical values for any sample size is frequently applied.

The null hypothesis of non-stationarity is rejected if ADF statistic exceeds the Mackinnon critical value at the 5 percent level of significance. The asymptotic distribution of the t-statistic under the null hypothesis depends on the assumption regarding the inclusion of deterministic terms like a trend or linear drift or both in the test regression. Although this complicates the testing procedure by increasing the number of cases to consider, Hylleberg and Mizon (1989) have shown that the standard normal critical values are likely to lead to frequent rejection of the null hypothesis even in large samples, unless the constant term is very large. As observed by Hamilton (1994), the general principle is to choose a specification that plausibly describes the data under both the null and alternative hypotheses.

Since lagged dependent variables are used in the ADF specifications, it is important to note that the reported Durbin Watson statistic is inappropriate for identifying the presence of serial autocorrelation in each series (Steward and Wallis, 1981). The Breusch-Godfrey (BG) test which is a Lagrange Multiplier (LM) test is used to test for higher order autocorrelation in the model (Maddala, 1992). The null hypothesis of no autocorrelation is tested against the alternative hypothesis of a p th order autocorrelation. The Breusch-Godfrey LM test statistic which is asymptotically $\chi^2(p)$ distributed is computed by conducting the following regression using the

Ordinary Least Squares approach:

$$e_t = \Phi_1 e_{t-1} + \dots + \Phi_p e_{t-p} + \beta_1^* X_t + \beta_2^* Z_t + \varepsilon_t \quad (19)$$

where the null hypothesis is identical to the hypothesis that $\Phi_1 = \Phi_2 = \dots = \Phi_p = 0$ and the test statistic of the BG-test is computed as $nR^2 \sim \chi^2(p)$, X_t and Z_t denote the explanatory variables, β_i^* denote estimated coefficients, e_t are the residuals, n is the number of observations and p is the order of autocorrelation.

Once the stationarity properties of the individual series are established, linear combinations of the integrated series are tested for cointegration. Cointegration analysis purports to describe long run or equilibrium relationships (Tambi, 1999). An equilibrium relationship exists when variables in the model are cointegrated. Engle and Granger (1987) emphasise that if there is a long run relationship between two non-stationary time series, then the cointegration test verifies whether deviations from the long run path are stationary.

Time series X_t and Z_t are said to be cointegrated of order (d, b) where $0 \leq b \leq d$, denoted by $X_t, Z_t \sim CI(d, b)$, if $X_t \sim I(d)$ and $Z_t \sim I(b)$ and $(X_t - \beta Z_t) \sim I(d-b)$. The two series cointegrated if their cointegration regression as specified in equation (20) produces a residual series U_t which is stationary:

$$X_t = \alpha + \beta Z_t + U_t \quad (20)$$

Various tests for evaluating the cointegrating properties of a pair of non-stationary series exist (Hendry, 1986; Engle and Granger, 1987; Johansen, 1988 and Johansen

and Juselius, 1990). Johansen's (1991) test procedure for example determines the number of cointegration relations or cointegration rank. In the Johansen framework, N endogenous variables each integrated of order one produce $(N-1)$ linearly independent cointegrating equations. If there are N cointegrating equations, it means that none of these series is actually integrated. Specification errors might be responsible if the test shows that the cointegrating rank is N . When such contradiction occurs, the relevant Vector Autocorrelation Regression (VAR) is reformulated in terms of the levels of all the series (Johansen and Juselius, 1990).

The Johansen framework also allows for consideration where cointegrating equations are known to have intercepts and deterministic trends. In the words of Ravallion (1986), the cointegration relation is useful because the short run and long run integration can be tested as nested hypothesis within a multivariate model. Boswijk and Franses (1992) emphasise that the results from VAR models are sensitive to the choice of the lag-length. They therefore suggest the application of the Johansen procedure for the determination of the different lag-lengths and to base the final choice of parameters on the absence of serial correlation in the residuals and the significance of parameters at higher lags using LR-tests.

Engle and Granger (1987) show that if two series are cointegrated, then there exists an error correction representation. In other words, models with data series, which have long run equilibrium relationship but have significant short run divergences can be given an error correction representation. The error correction

mechanism captures the short run dynamics while making them consistent with long run dynamics (Engle and Granger, 1987; Holden and Permon, 1994). Whilst various authors have applied the classical Engle-Granger approach in analysing the existence of long-run and short-run relationships between economic variables, the present study employs the Dynamic Generalised Least-Square (DGLS) estimator of Stock and Watson (1993). Recent studies have shown that the DGLS estimator provides efficient estimates of long-run parameters (Burger, Smit and Vogelvang, 2001). Saikkonen (1991) was the first to develop this method but he used the Dynamic Ordinary Least-Square (DOLS) estimation. Another advantage of using the DGLS estimator is that its formulation eliminates and corrects for serial correlation in the model (Burger, Smit and Vogelvang, 2001). The general notation of the model is specified as

$$y_t = \alpha + \beta' Z_t + \sum_{i=-k}^k \mu_i' \Delta Z_{t-i} + \varepsilon_t \quad (21)$$

where y_t is the dependent variable, α is the intercept, ΔZ_t are lags and leads specified in such a manner to eliminate residual autocorrelation β' is a vector of short-run effects and μ_i' , vector of long-run parameters. Following the DGLS estimator proposed by Stock and Watson (1993), the simultaneous equation models explaining the long-run relationships between deforestation and intersectoral labour mobility are specified as

$$M_t^{AN} = \beta_{10} + \beta_1' Z_{t1} + \sum_{i=0}^p \beta_{1i}' \Delta Z_{t-i,1} + \mu_{t1} \quad (22)$$

$$D_t^{AREA} = \beta_{20} + \beta_2' Z_{t2} + \sum_{i=0}^p \beta_{2i}' \Delta Z_{t-i,2} + \mu_{t2} \quad (23)$$

where β_{10} and β_{20} are intercepts and Z_{it} is the vector $[l_t, W_t^{AN}, R_t^{POPDN}, U_t^{REM}]'$, Z_{t2}

is the vector $\left[I_t, M_t^{AN}, R_t^{POPDN}, P_t^{INSECT}, P_t^{COCOA}, P_t^{MAIZE} \right]'$ with $I_t=1 \forall t$ in equations (22) and (23) respectively. β'_1 and β'_2 are the vectors of long-run coefficients, β'_{i1} and β'_{i2} are vectors of short-run effects that are included to enhance the efficiency of the estimator whereas sufficient lags of $\Delta Z_{t-i,1}$ and $\Delta Z_{t-i,2}$ are chosen to estimate equations efficiently (Burger, Smit and Vogelvang, 2001).

The short-run dynamics is considered in line with the error correction framework postulated by Engle and Granger (1987). For estimating the error correction models that converge to the equilibrium relationships in equations (22) and (23), the error correction terms are estimated as

$$ect_{t_1} = M_t^{AN} - \hat{a}_0 - \sum_{j=1}^n \hat{a}_j Z_{t_1,j} \quad (24)$$

$$ect_{t_2} = D_t^{AREA} - \hat{b}_0 - \sum_{j=1}^n \hat{b}_j Z_{t_2,j} \quad (25)$$

where \hat{a}_0 and \hat{b}_0 and \hat{a}_j and \hat{b}_j are estimated constant terms and vector of estimated coefficients. $Z_{t_1,j}$ and $Z_{t_2,j}$ are vectors of explanatory variables in equations (15) and (16) respectively and n is number of explanatory variables. The error correction models estimated be specified are specified as follows:

$$\Delta M_t^{AN} = \delta_0 + \sum_{i=0}^k \delta'_{i1} \Delta Z_{t-i,1} + \gamma_1 ect_{t-1,1} + u_{4t} \quad (26)$$

$$\Delta D_t^{AREA} = \delta_1 + \sum_{i=0}^k \delta'_{i2} \Delta Z_{t-i,2} + \gamma_2 ect_{t-1,2} + u_{5t} \quad (27)$$

Where k is the chosen lag lengths, δ_0 and δ_1 are constant terms, δ'_{i1} and δ'_{i2} are vectors of estimated coefficients, $\Delta Z_{t-i,1}$ and $\Delta Z_{t-i,2}$ are vectors of explanatory variables, $ect_{t-1,1}$ and $ect_{t-1,2}$ are the error correction terms and γ_1 and γ_2 are the coefficients of the error correction terms.

3.5. Description of Variables and Sources of Data

The data used in this study cover the period from 1970 to 1999. They are annual time series data on Ghana. In what follows, the definition and measurement of each variable in the present study are provided. The sources of all the data employed are also indicated.

Labour Mobility

Assuming that agriculture is the largest sector and the residual employer, labour mobility rate is measured as the magnitude of labour contributed by the agricultural sector to the rest of the economy. The Cownie (1974) structural transformation coefficient as quoted in Johnston and Kilby (1975) is employed in this study. This coefficient measures the absolute increase in the non-agriculture labour force per annum as

$$m(t) = \left(\dot{L}_t^N - \dot{L}_t \right) \left(\frac{L_{t-1}^N}{L_t} \right) \quad (28)$$

where $m(t)$ is the labour mobility rate in period t , $(\dot{L}_t^N - \dot{L}_t)$ is known as the Folke Doving coefficient of differential growth (Doving, 1959), \dot{L}_t^N is the growth rate of

labour force in the non-agricultural sector in period t and \dot{L}_t denotes growth rate of total labour force. Total labour force represents all persons aged 15 years and above engaged in or seeking employment in an economic activity in the agricultural sector or the non-agricultural sector. Labour force in agriculture refers to all economically active persons aged 15 years and above principally engaged in agriculture, forestry, hunting and fishing. The time series data on labour employed in agriculture and the whole economy are obtained from various issues of the *UN Food and Agriculture Organisation (FAO) Production Yearbook* and the *Quarterly Digest of Statistics published by the Ghana Statistical Service*.

Deforestation Rate

Various authors have relied on the availability of time series data on forest stock in the measurement of deforestation rate. Ehui and Hertel (1989) computed deforestation rate as the difference between the remaining forest stock for consecutive years. The present study however, discarded Ehui and Hertel's (ibid.) method because complete set of reliable quality annual time series data on remaining forest were not available during the time of the study (personal communication with the relevant personnel at the Department of Forestry at the Ministry of Lands and Forestry in Kumasi). The deforestation rate used in this study represents deforestation through agricultural activities. The variable was computed by finding the difference between the area under agricultural cultivation and other industrial activities like logging and mining for consecutive years. Notably, FAO defines deforestation as the permanent conversion of forestland to other uses. Data on deforestation are obtained

from various issues of the *FAO Production Yearbook*, the data files of the *Ghana Forestry Department* in Kumasi and the *Ministry of Food and Agriculture*.

Income

Total Gross Domestic Product (GDP) is used to proxy national income. Total GDP is made up of GDP in agriculture and GDP in non-agriculture. Non-agricultural GDP is the difference between total GDP and GDP in agriculture. These are used to proxy agricultural and non-agricultural incomes, respectively. The income variables used in the estimations are income per capita. Agricultural income per capita is the ratio of agricultural income to agricultural population and non-agricultural income per capita is the ratio of non-agricultural income to non-agricultural population. The income in agriculture relative to that in non-agriculture was derived as the ratio of agricultural income per capita to non-agricultural income per capita. The agricultural population and non-agricultural population data are obtained from the various issues of *FAO Production Yearbook*. The time series data on gross domestic product (GDP) in constant 1985 prices originating in the agricultural and non-agricultural sectors are obtained from the Ghana Statistical Service and the various issues of the *International Financial Statistics (IFS)* published by the *International Monetary Fund (IMF)*. Both GDP in current and constant 1985 prices are obtained. Dividing the nominal GDP (current) by the real GDP (constant) gave the GDP deflators (indexed to 1985=100).

Rural Population Density

Many writers, including Boserup (1965) have tended to equate population density with population pressure in rural areas. Gleave and White's (1969) analysis

of how agricultural systems in West Africa varies with population density also arrived at similar conclusions as that of Boserup. This variable is then derived as:

$$\text{Rural Population Pressure} = \frac{\text{Rural Population (millions)}}{\text{Area cultivated (ha)}} \quad (29)$$

Notably, the deflator is area under cultivation in forest regions. However complete reliable time series data were not available so area under maize cultivation was used in the empirical analysis as a proxy since maize is one of the major staple foods cultivated extensively in Ghana annually by rural farmers. Data on rural and urban populations in Ghana are taken from the various issues of the *FAO Production Yearbook* and *International Financial Statistics (IFS)* of the *IMF*. Time series data on annual cultivated land for various crops are obtained from the various issues of the *FAO Production Yearbook*.

Rate of Unemployment in Non-agricultural Sector

The rate of non-agricultural unemployment is defined as the ratio of the difference between total employment and agricultural employment to the difference between the economically active population and agricultural employment. This assumes that economically active population in agriculture is equal to the number employed in that sector. The sources of the employment data are the *ILO Yearbook of Labour Statistics* and the *FAO Production Yearbook*.

Price of Insecticides

Annual time series data on the price of insecticides measured in ¢ / litres of Gammalin 20 are employed. The relevant data are obtained from the Cocoa Services Division of Ghana COCOBOD.

Real Producer Price of Cocoa

Real producer price of cocoa is used in the present study. In view of the high significant correlation coefficient of 0.92 between the prices of cocoa and coffee (see Appendix II) and the coffee producer price is excluded from the model. Moreover in Ghana, farmers tend to clear more land for cocoa than coffee because of its relative greater export potential. The real producer price of cocoa is obtained by deflating the nominal price of cocoa to 1985 prices using the CPI. Annual time series data on producer price of cocoa in ¢ / bag were obtained from various issues of *Quarterly Digest of Statistics (QDS)* published by the Ghana Statistical Service and Ghana COCOBOD.

Real Producer Price of Maize

The real producer price of maize was similarly obtained by deflating the producer price of maize to 1985 prices with the rural CPI. Data on nominal producer price of maize were obtained from the Ministry of Food and Agriculture, Ghana.

CHAPTER 4

EMPIRICAL ECONOMETRIC RESULTS

The empirical results of the study are presented in this chapter. First, results of the relevant stationarity tests are presented, followed by the results of causality tests. The cointegration analyses are then performed. Finally, the results of the error correction modelling exercise are presented.

4.1. Stationarity Tests

Having applied the Augmented Dickey-Fuller test to the variables under investigation, the empirical results are presented in Table 1. The tests reveal that

Table 1. Results of Unit Root Test.

SERIES	LEVEL			DIFFERENCE			CONCLUSION
	ADF	MCV	LAG-LENGTH (S)	ADF	MCV	LAG-LENGTH (S)	
M^{AN}	-3.5218	-3.5867	2	-4.5320	-3.5943	2	$M^{AN} \sim I(1)$
D^{AREA}	-2.2342	-2.9750	1	-4.2993	-2.9798	1	$D^{AREA} \sim I(1)$
R^{POPDN}	-2.4108	-3.5867	2	-4.7865	-3.5943	2	$R^{POPDN} \sim I(1)$
W^{AN}	-3.2657	-3.5796	1	-4.1351	-3.5943	2	$W^{AN} \sim I(1)$
U^{REM}	-2.2075	-3.5943	3	-6.6206	-3.5867	1	$U^{REM} \sim I(1)$
P^{INSECT}	-0.7624	-3.5796	1	-4.3885	-3.5867	1	$P^{INSECT} \sim I(1)$
P^{COCOA}	-3.0828	-3.5796	2	-3.8110	-3.5943	2	$P^{COCOA} \sim I(1)$
P^{MAIZE}	-3.4228	-3.5867	2	-4.8609	-3.5943	2	$P^{MAIZE} \sim I(1)$

Note: All variables are in their raw form. The ADF technique tests $H_0: X_t \sim I(1)$ against $H_1: X_t \sim I(0)$. MCV are the asymptotic critical values or the Mackinnon critical values for rejection of hypothesis of a unit root and they are at the 5 percent level of significance. The ADF critical values are obtained from Mackinnon (1991). Each of the ADF equations includes a drift and a trend term.

M^{AN} denotes labour mobility from agricultural to non-agricultural sector, D^{AREA} denotes area deforested,

R^{POPDN} denotes population pressure in rural areas, W^{AN} denotes income in agricultural sector relative to that in non-agricultural sector, U^{REM} denotes unemployment rate in non-agricultural sector, P^{INSECT} denotes price of insecticides, P^{COCOA} denotes real producer price of cocoa and P^{MAIZE} denotes real producer price of maize.

Source: Author's computations.

while the levels of each of the series are non-stationary, the first differences are stationary. All the series became stationary when deterministic trend and drift term were included. The hypothesis of unit root could not be rejected at the levels for all the series because as the results indicate, none of the ADF t -statistics for each of the series exceeds its asymptotic critical value at the levels. The hypothesis of a unit root was however rejected at the 5 level of significance for all the series since their ADF t -statistics exceeded the relevant Mackinnon critical value (Mackinnon, 1991) after the first difference. The Breusch Godfrey Lagrange Multiplier test for second order autocorrelation shows the absence of serial correlation in the error term. The lag-length selected is the smallest without autocorrelation.

4.2. Granger Causality Tests

The existence of cointegration suggests Granger causality between the variables in one direction (Engle and Granger, 1987). The procedure for establishing causality as proposed by Granger (1969) involves regression of a variable on its lagged values and another variable. The general model for Granger causality test of two non-stationary variables y and z after their first difference is represented as

$$\Delta y = \sum_{i=1}^k \lambda_{11} \Delta y_{t-i} + \sum_{i=1}^k \lambda_{12} \Delta z_{t-i} + \varepsilon_t \quad (30)$$

where k is the number of lag-lengths. The null hypothesis $H_0 : \lambda_{12} = 0$ versus alternative hypothesis $H_A : \lambda_{12} \neq 0$ is tested. If the relevant computed F -statistic is greater than the critical F -value from statistical tables then the null hypothesis that z does not cause y is rejected in favour of the alternative hypothesis that z causes y , and

vice versa (see for instance, Pindyck and Rubinfeld, 1991). The results of the causality tests are shown in Table 2.

Table 2. Granger Causality Test Results.

<i>Null Hypothesis (H₀)</i>	<i>Lag-length</i>	<i>F- statistic</i>	<i>p - value</i>
$M_t^{AN} \not\Rightarrow W_t^{AN}$ $W_t^{AN} \not\Rightarrow M_t^{AN}$	2	1.25497 6.59363 ***	0.30389 0.00545
$M_t^{AN} \not\Rightarrow U_t^{REM}$ $U_t^{REM} \not\Rightarrow M_t^{AN}$	6	2.33435 16.1081 ***	0.10584 0.00007
$M_t^{AN} \not\Rightarrow R_t^{POPDN}$ $R_t^{POPDN} \not\Rightarrow M_t^{AN}$	7	0.80471 7.80916 ***	0.60629 0.00477
$D_t^{AREA} \not\Rightarrow M_t^{AN}$ $M_t^{AN} \not\Rightarrow D_t^{AREA}$	6	2.32965 2.83780 *	0.11370 0.07006
$D_t^{AREA} \not\Rightarrow R_t^{POPDN}$ $R_t^{POPDN} \not\Rightarrow D_t^{AREA}$	3	2.23009 3.24646 *	0.13126 0.05815
$D_t^{AREA} \not\Rightarrow P_t^{INSECT}$ $P_t^{INSECT} \not\Rightarrow D_t^{AREA}$	2	0.25215 8.06767 ***	0.77934 0.00236
$D_t^{AREA} \not\Rightarrow P_t^{COCOA}$ $P_t^{COCOA} \not\Rightarrow D_t^{AREA}$	4	2.66600 7.11050 **	0.17957 0.03770
$D_t^{AREA} \not\Rightarrow P_t^{MAIZE}$ $P_t^{MAIZE} \not\Rightarrow D_t^{AREA}$	1	0.36517 5.96879 **	0.55109 0.02197

Note: *** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level, $\not\Rightarrow$ means "does not Granger cause". All values are in their raw form (natural logarithms were not taken)

M^{AN} denotes labour mobility from agricultural to non-agricultural sector, D^{AREA} denotes area deforested, R^{POPDN} denotes population pressure in rural areas, W^{AN} denotes income in agricultural sector relative to that in non-agricultural sector, U^{REM} denotes unemployment rate in non-agricultural sector, P^{INSECT} denotes price of insecticides, P^{COCOA} denotes real producer price of cocoa and P^{MAIZE} denotes real producer price of maize.

Source: Author's computations.

The test is conducted first to determine the causality between M^{AN} and each of the variables W^{AN} , U^{REM} and R^{POPDN} using equation (24) and finally another test is conducted to examine the causal relationship between D^{AREA} and the variables M^{AN} , R^{POPDN} , P^{INSECT} , P^{COCOA} and P^{MAIZE} respectively. The results indicate that the hypothesis that a change in either W^{AN} , U^{REM} or R^{POPDN} does not cause a change in M^{AN} is strongly rejected in each case, while the hypothesis that M^{AN} changes do not cause changes in either W^{AN} , U^{REM} or R^{POPDN} cannot be rejected at the 1 percent significance level respectively at lag-lengths indicated in Table 2. This empirical result also suggests that the differences of W^{AN} , U^{REM} or R^{POPDN} are strongly exogenous at the given lags.

Similarly, the null hypothesis that a change in either M^{AN} , R^{POPDN} , P^{INSECT} , P^{COCOA} or P^{MAIZE} does not cause a change in D^{AREA} is rejected in favour of the alternative hypothesis and that they do cause D^{AREA} . On the contrary, a change in D^{AREA} does not cause a change in either M^{AN} , R^{POPDN} , P^{INSECT} , P^{COCOA} or P^{MAIZE} at the 1 percent, 10 percent, 1 percent, 5 percent and 5 percent respectively at the chosen lag-lengths. These imply that the differences of M^{AN} , R^{POPDN} , P^{INSECT} , P^{COCOA} and P^{MAIZE} at the given lags are strongly exogenous. These results further show that W^{AN} , U^{REM} and R^{POPDN} are Granger prior to M^{AN} , and that M^{AN} , R^{POPDN} , P^{INSECT} , P^{COCOA} and P^{MAIZE} are Granger prior to D^{AREA} .

4.3. Empirical Results of Long Run Relationship

The results from the Iterative Three Stage Least-Squares estimation of the long-run relationship are shown in Table 3 (It should be noted that, the explanatory variables in the general models were specified at the beginning with three lag lengths. See

Table 3. Results of Long Run Relationships

Dependent Variable = M^{AN}				
Variable	Coeff.	Std. Error	t-Stat.	Prob.
W^{AN}	0.0137	0.0073	1.8827*	0.0676
R^{POPEN}	0.1274	0.0579	2.2016 **	0.0340
U^{REM}	-0.0653	0.0225	-2.8975***	0.0063
SAP	-0.0073	0.0088	-0.8252	0.4146
Constant	-0.0484	0.0308	-1.5715	0.1246
R ² =0.6995		Std Deviation = 0.0254		
Adj. R ² =0.5729		Mean = -0.0016		
RSS=0.0052		S.E. of Regression = 0.0166		
BG (2) = 1.4721(0.4791)				
Dependent Variable = D^{AREA}				
Variable	Coeff.	Std. Error	t-Stat.	Prob.
M^{AN}	-26.2866	33.5285	-0.7840	0.4380
R^{POPEN}	19.5032	9.6098	2.0295 **	0.0496
P^{COCOA}	0.0002	6.24E-05	2.5409 ***	0.0038
P^{MAIZE}	0.0012	0.0035	0.3505	0.7280
P^{INSECT}	-0.0011	0.0004	-3.0840 ***	0.0038
Constant	-11.9106	7.0664	-1.6855	0.1003
R ² =0.6017		Std Deviation = 5.6992		
Adj. R ² =0.4025		Mean = 4.0231		
RSS =349.2977		S.E. of Regression = 4.4052		
BG (2)=1.7934 (0.1810)				

Note: *** Significant at 1 percent, ** significant at 5 percent, * significant at 10 percent. The variables are in their raw form.

M^{AN} denotes labour mobility from agricultural to non-agricultural sector, D^{AREA} denotes area deforested, R^{POPEN} denotes population pressure in rural areas, W^{AN} denotes income in agricultural sector relative to that in non-agricultural sector, U^{REM} denotes unemployment rate in non-agricultural sector, P^{INSECT} denotes price of insecticides, P^{COCOA} denotes real producer price of cocoa and P^{MAIZE} denotes real producer price of maize, SAP denotes structural adjustment programme.

Source: Author's computations.

Appendix III for the detailed specifications and empirical results of the long run relationships). Convergence was achieved after 26 iterations. The estimated coefficient of determination R^2 of 0.699 indicates that about 70 percent of the variation in intersectoral labour mobility from the agricultural to the non-agricultural sector are explained by the independent variables. Similarly, the R^2 of 0.60 for the deforestation equation implies that the independent variables explain about 60 percent of the variation in the area deforested. The *DW-statistics* cannot be used to determine if serial correlation exist in the residuals because of the inclusion of lagged-dependent variables in the models. The *Q-statistics* from the correlogram of the residual of the labour mobility model are not significant even at 10 percent. Further serial correlation test with the *Breusch-Godfrey LM* test gave a *BG (2)* value of 1.472 with a probability of 47.9 percent which is not significant so we do not reject the null hypothesis of no autocorrelation in the model. Similarly, serial correlation test with the *Breusch-Godfrey LM* test indicated a *BG (2)* value of 1.472 with a probability of 47.9 percent in the deforestation model and since this is not significantly different from zero, we do not reject the null hypothesis of no autocorrelation in the model.

In the labour mobility model, the estimated coefficient of income in agriculture relative to that in non-agriculture does not exhibit the postulated sign but is significantly different from zero at the 10 percent level. The coefficients of rural population density and unemployment rate in non-agricultural sector have the expected signs and are significant at the 5 percent and 1 percent levels, respectively. The results suggest that in the long run, intersectoral labour mobility increases by 0.0137 units and declines by 0.07 units when the rural population density increases by 1 unit and the

unemployment rate in the non-agricultural sector increases by 1 unit, respectively, *ceteris paribus*. The positive coefficient of agricultural income relative to non-agricultural income runs counter to the Todaro (1969) hypothesis where an increase in the relative agricultural income is expected to encourage people to stay in the agricultural sector. The rejection of the Todaro hypothesis in the empirical model could be explained as follows: perhaps more recently, non-agricultural opportunities probably have come to dominate mobility decisions (Booth and Sundrum, 1984). The negative and insignificant coefficient (even at 10 percent level) of the structural adjustment dummy reveals that its long-run effect on intersectoral labour mobility from agricultural to non-agricultural sector is minimal. Future research should examine these unexpected results in greater detail.

In the deforestation model, the coefficient of the intersectoral labour mobility variable bears the postulated sign but it is not significantly different from zero even at the 10 percent level. The rural population pressure, producer price of cocoa and insecticide price variables all carried the postulated signs and are significantly different from zero at the 5 percent, 1 percent and 1 percent levels, respectively. Although the producer price of maize has the expected positive sign, it is not significantly different from zero even at the 10 percent level. The empirical negative coefficient of intersectoral labour mobility from agricultural sector to non-agricultural sector seems to support what other studies (Jaegar, 1992; Abdulai, 1999) have observed. However, it is not statistically significant even at the 10 percent level. Substantial evidence in the relevant literature suggests that major intersectoral flow of workers since 1983 has been towards the agricultural sector especially due to the production of cocoa as targeted by

the Economic Recovery Programme (Fosu, 1989; Beaudry and Sowa, 1994). A unit increase in rural population density leads to a 19.5 unit increase in the area deforested through agricultural expansion in the long run. This empirical result confirms the theoretical underpinnings of the neo-Malthusian belief about the effect of growing human populations on natural resources (Sunderlin and Resosudarmo, 1999). With the increasing population pressure on land, as the present study indicates, the natural tendency is for people to clear more land as a result of food scarcity which indirectly leads to environmental problems (Brown, 1995).

The positive cointegration coefficient of 0.0002 of producer price of cocoa indicates that in the long run, a unit increase in the producer price of cocoa results in about 0.0002 unit increase in the area deforested. Although this change is small, the empirical finding is not surprising because between 1983 and 1987, the prices received by cocoa farmers have increased about sevenfold (Abdulai and Rieder, 1995). This profit margin of farmers might have encouraged them to increase output even though pesticides and fertiliser subsidies were curtailed during the stabilisation period of Ghana's ERP. The estimated coefficient of price of insecticides has the postulated negative sign and is significantly different from zero at the 1 percent level. This agrees with the empirical studies by Ruben *et al.*, (1994) and Monela (1995) in South Africa that reduced prices of inputs such as seeds, insecticides and hand tools increase forest clearing in the long run.

4.4. Short Run Effects

In this section, the analysis of the results of the short-run relationship between intersectoral labour mobility and its determinants and short-run relationship between area deforested and its determinants are undertaken. The short-run effects are captured by the estimated coefficients. The models which are estimated by applying Hendry's general to specific modelling start from a general model from economic theory and are then narrowed down to an acceptable specification, given the data (Hendry *et al.*, 1984).

Table 4 presents results of the short-run relationships after application of Iterative Three Stage-Least Squares to the simultaneous equations (26) and (27). $\Delta (\cdot)$ denotes the first difference of the respective variable at the current time t and it would be noted from Table 4 that lagged first differences at the current time are reported (The independent variables in the general model of the short run relationships were specified with three lag lengths before arriving at the results presented in Table 4. See Appendix III for detailed information on the final specifications and results from the estimation of the short run relationships). In the short-run relationship, convergence was achieved after 36 iterations.

The R^2 of 0.56 in the labour mobility model implies that 56 percent of the variation in the intersectoral labour mobility is explained by its independent variables whereas the R^2 of 0.78 in the deforestation model indicates that about 78 percent of the

Table 4. Results of Short Run Relationships

Dependent Variable = ΔM^{AN}				
Variable	Coeff.	Std. Error	t-Stat.	Prob.
ΔW^{AN}	0.0021	0.0129	0.1659	0.8693
ΔR^{POPDN}	0.1136	0.5066	0.2242	0.8242
ΔU^{REM}	-0.2373	0.0489	-4.8542 ***	0.0000
ΔSAP	0.0073	0.0249	0.2948	0.7702
$ect_{t-1,1}$	-1.1051	0.3718	-2.9719 ***	0.0059
Constant	0.0106	0.0103	1.0320	0.3106
R ² = 0.5641		Std Deviation = 0.0388		
Adj. R ² = 0.3945		Mean = 0.0002		
RSS=0.0164		S.E. of Regression = 0.0302		
BG (2) = 1.7194(0.1898)				
Dependent Variable = ΔD^{AREA}				
Variable	Coeff.	Std. Error	t-Stat.	Prob.
ΔM^{AN}	-28.4015	14.2044	-1.9995 *	0.0550
ΔR^{POPDN}	-33.0634	85.9614	-0.3846	0.7033
ΔP^{COCOA}	-0.0003	0.0001	2.1738 **	0.0380
ΔP^{MAIZE}	0.0005	0.0019	0.2674	0.7911
ΔP^{INSECT}	-0.0007	0.0004	-1.9875 *	0.0564
$ect_{t-1,2}$	-0.8303	0.2445	-3.3958 ***	0.0020
Constant	2.2429	1.4445	1.5528	0.1313
R ² = 0.7763		Std Deviation = 3.7097		
Adj. R ² = 0.4915		Mean = 0.2215		
RSS=76.9783		S.E. of Regression = 2.6454		
BG (2) = 1.6987 (0.4267)				

Note: *** significant at 1 percent level, ** significant at 5 percent level, * significant at 10 percent level. All values are in their raw form.

ΔM^{AN} denotes difference of labour mobility from agricultural to non-agricultural sector, ΔD^{AREA} denotes difference of area deforested, ΔR^{POPDN} denotes difference of population pressure in rural areas, ΔW^{AN} denotes difference of income in agricultural sector relative to that in non-agricultural sector, ΔU^{REM} denotes difference of unemployment rate in non-agricultural sector, ΔP^{INSECT} denotes difference of price of insecticides, ΔP^{COCOA} denotes difference of real producer price of cocoa, ΔP^{MAIZE} notes difference of real producer price of maize, ΔSAP denotes difference of structural adjustment programme and ect denotes error correction term.

Source: Author's computations.

variation in the dependent variable is explained by the independent variables. Because of the inclusion of lagged-dependent variables in the model, the *DW*-statistics cannot be used to determine if serial correlation exist in the residual. Serial correlation test with the *Breusch-Godfrey LM* test shows that the *BG (2)* value of 1.7194 with a *p-value*

of 0.1898 is not significant so the null hypothesis of no autocorrelation cannot be rejected in the labour mobility model. Similarly, the *Breusch-Godfrey LM* test for the deforestation model gave a *BG (2)* value of 1.6987 with a *p-value* of 0.4267 which is also not significantly different from zero so we do not reject the null hypothesis of no autocorrelation in the model.

The empirical results show that the income in agriculture relative to that in non-agriculture again has the wrong positive sign in the short-run but unlike the long-run relationships, it is statistically not significant. The rural population density variable in the intersectoral labour mobility model has the expected positive sign but in this case failed to be significantly different from zero in the short-run. The coefficient of unemployment rate in the non-agricultural sector variable has the hypothesised negative sign and is statistically significant at the 1 percent level. This empirical finding lends support to the view that as the unemployment rate in a sector increases, labour migration to that sector decreases (Collier, 1979; Bencivenga and Rosenweig, 1997). Similar to the long run effects, the Structural Adjustment dummy is statistically insignificant. Surprisingly, this quantitative empirical result seems to contradict the effects of structural adjustment in some analytical studies on Ghana (Jaegar, 1992; Abdulai, 1999). One of the reason for the reverse labour migration to the agricultural sector during the structural adjustment period then may be attributed to the expansion of the cocoa production zones as asserted by Beaudry and Sowa (1994).

In terms of postulated signs, the short-run dynamics did not differ very much from the long run dynamics in the deforestation model. However, the intersectoral

labour mobility variable has the hypothesised negative sign and it is significantly different from zero at the 10 percent level in the short-run. The price of maize and producer prices of cocoa again carried the correct signs in the short-run model but only the producer price of cocoa is statistically significant at the 5 percent level as it happened in the long-run estimations.

The inclusion of inputs in deforestation models highlights the fundamental difference that has existed between population and market approaches in explaining their effects on deforestation (Angelsen, 1999). The population approach contends that lower input prices such as price of insecticides will reduce deforestation, as insecticides are substituted for land in agricultural extensification. Under the market approach however, lower input prices will augment the profitability of frontier farming and therefore increase deforestation under intensification. The negative coefficient of 0.0007 of insecticide prices at the 10 percent significant level implies that in the short-run, a proportionate decline in the price of insecticides leads to 0.0007 percent increase in the area deforested. Although this effect is minimal because of the small coefficient, the latter thesis seems to give credence to the present empirical finding that reduced price of agricultural inputs encourages area expanded for agriculture. The coefficients of the error correction terms have the expected negative signs. Though the sizes of the coefficients of the error correction terms in both the intersectoral labour mobility and deforestation models are comparatively small, they are statistically significant at the 1 percent respectively, indicating that last periods equilibrium error of intersectoral labour mobility from agricultural to non agricultural sectors has a significant impact on subsequent changes in the amount of area deforested through agricultural expansion.

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

5.1 Summary

This study has analysed the long run and short-run relationships between intersectoral labour mobility and area deforested in Ghana over the period 1970–99. The Dynamic Generalised Least Squares Estimator (DGLS) is used to specify a system of simultaneous equations involving labour mobility and its determinants and area deforested and its determinants in the framework of supply of agricultural labour and demand for land for agricultural expansion. Having checked the identifiability status of the two equations and found them to be overidentified, the Iterative Three Stage Least Squares approach is used to estimate the model. With the presence of cointegration established, the relevant Error Correction Models which incorporate the long-run equilibrium and short-run dynamics are estimated.

The results of the study show that rural population pressure and the rate of unemployment in the non-agricultural sector exert a strong positive and negative effects respectively, on intersectoral labour mobility from agricultural to non-agricultural sector in the long run. These results seem plausible since policies which tend to increase rural income would encourage more people to stay in the rural areas but in the long-run, if rural population density continues to increase, then this benefit

would be neutralised. On the other hand, policies which suppress urban incomes and lead to high unemployment rate where the bulk of non-agricultural work is concentrated in Ghana would discourage labour from staying in that sector, as it is believed to have happened in the late 1980s and early 1990s.

In addition, the study observes that intersectoral labour mobility from the agricultural sector to the non-agricultural sector has had a significant effect on the area deforested through agricultural expansion in the short-run. The empirical result is consistent with appropriate macroeconomic and sector-specific policies. Exodus of labour to the agricultural sector due to non-existence of off-farm job opportunities would encourage people to clear more land for subsistence and survival which would inadvertently lead to adverse environmental effects. Finally, area deforested tends to increase when the real producer prices of cocoa increases. The results also reveal that lower price of insecticides could increase the area cleared for agricultural expansion.

5.2 Policy Recommendations

The study suggests that when unemployment rate in the non-agricultural sector increases, the intersectoral labour mobility from the agricultural sector to the non-agricultural sector slows down. Therefore rural development policies such as establishment of cottage industry and small-scale industries, which encourage the creation of jobs in the rural sector, must be pursued. Small-scale and affordable irrigation projects must be given a further boost in the drier parts of the country in order to absorb the surplus agricultural labour from the rural sector. Moreover, rural

population pressure could be reduced if policies that remove the bottlenecks in the rural and urban markets are initiated so that there would not be more pressure on land. The empirical results also suggest that lower input prices of insecticides will augment the profitability of frontier farming in line with the market approach framework. The implication of this negative relationship between agricultural deforestation and price of insecticides requires that land conversion for agriculture must be pursued in a manner, which encourages agricultural intensification.

The study further reveals that increased price of cocoa leads to a significant increase in the area deforested due to extensification. To prevent deforestation through agricultural activities, there is the need to promote productivity increasing technologies in the cocoa sector, which would slow down the increasing pressure on land by farmers. This policy initiative should be applied to maize production as well since it is one of the staple food crops mostly grown by farmers in Ghana.

5.3. Limitations of the Study and Suggestions for Future Research

The causality between unemployment rate in the non-agricultural sector and population pressure was not investigated and since population pressure is assumed to be exogenous in the study, it is recommended that future studies examine this linkage.

Due to data construction problems, the study looked only at area deforested through agricultural expansion. It would be useful if future studies examine

deforestation as a whole, to include the activities of log-exporting timber firms, road construction, mining and other industrial activities.

The present study used the Granger causality tests to find out whether the empirical model is characterised by strong exogeneity in the regressors. The literature (Johnston and Dinardo, 1997; Judge *et. al*, 1988) suggest further that it is possible for the model to be characterised by weak and/or super exogeneity. Therefore, future studies should address the issue of weak and super exogeneity in dealing with themes similar to the present study.

The overall performance of the model suggests that Ghanaian secondary time series data despite its measurement errors could be useful in the analysis of labour migration and deforestation rates provided adequate specification and estimation procedure are used. However, it is recommended that future investigations should go beyond this and utilise micro surveys of rural employment and demographic characteristics of agricultural labour in particular to perform such an exercise.

APPENDIX I

INTERTEMPORAL MAXIMISATION PROBLEM

The Hamiltonian for the intertemporal maximisation problem is given by

$$H = pAs(X, D - L) - wX - c(L) + \Phi [n(L) - kA] \quad (\text{A.1})$$

The first order conditions are as follows:

$$\frac{\partial H}{\partial X} = pAs_x - w = 0 \Rightarrow w = pAs_x \quad (\text{A.2})$$

$$\frac{\partial H}{\partial L} = -pAs_L - c_L + \Phi n_L = 0 \Rightarrow \Phi n_L = c_L + pAs_L \quad (\text{A.3})$$

$$\frac{\partial H}{\partial A} = ps(X, D - L) + \Phi(-k) = -\dot{\Phi} \Rightarrow ps(X, D - L) - \Phi k = -\dot{\Phi} \quad (\text{A.4})$$

$$\frac{\partial H}{\partial \Phi} = n(L) - kA = \dot{A} \quad (\text{A.5})$$

From (A.2)

$$A = w/ps_x \quad (\text{A.6})$$

Substituting (A.6) into (A.5) gives

$$\dot{A} = n(L) - \frac{kw}{ps_x} \quad (\text{A.7})$$

$$\therefore \frac{\partial \dot{A}}{\partial w} = -\frac{k}{ps_x} < 0 \quad (\text{A.8})$$

$$\frac{\partial \dot{A}}{\partial p} = \frac{kw}{p^2 s_x} > 0 \quad (\text{A.9})$$

$$\frac{\partial \dot{A}}{\partial(w/p)} = -\frac{k}{s_x} < 0 \quad (\text{A.10})$$

The optimal use of land in each period A (t) is derived by differentiating (A.6) with respect to time:

$$\frac{\partial A}{\partial t} = \frac{w}{p} (-1)(s_x)^{-2} s_{xx} \frac{\partial X}{\partial t} \Rightarrow \frac{\partial A}{\partial t} = -\frac{w}{p(s_x)^2} s_{xx} \dot{X} \quad (\text{A.11})$$

From (A.5) and (A.11)

$$n(L) - kA = -\frac{w}{p} \frac{s_{xx}}{(s_x)^2} \dot{X}$$

$$kA = n(L) + \frac{w}{p} \frac{s_{xx}}{(s_x)^2} \dot{X}$$

$$A(t) = \frac{1}{k} \left[n(L) + \frac{w}{p} \frac{s_{xx}}{(s_x)^2} \dot{X} \right] \quad (\text{A.12})$$

$$\frac{\partial A}{\partial(w/p)} = \frac{s_{xx}}{(s_x)^2} \dot{X} < 0 \text{ or } = 0 \text{ or } > 0 \text{ if } \dot{X} > 0 \text{ or } = 0 \text{ or } < 0 \quad (\text{A.13})$$

APPENDIX II

CORRELATION MATRIX

	D^{AREA}	M^{AN}	P^{COCOA}	P^{COFFEE}	P^{FERT}	P^{INSECT}	P^{MAIZE}	SAP	U^{REM}	W^{AN}
D^{AREA}	1.0000	-0.0168	0.5555	0.7875	0.6293	0.3445	-0.5012	0.3898	0.7001	-0.3492
M^{AN}	-0.0169	1.0000	-0.0227	0.0123	0.0063	-0.0872	0.0696	-0.1690	-0.2122	0.1889
P^{COCOA}	0.5555	-0.0227	1.0000	0.9199	0.9873	0.9422	-0.6760	0.4196	0.6900	-0.4549
P^{COFFEE}	0.7874	0.0123	0.9199	1.0000	0.9281	0.8286	-0.6754	0.4320	0.7510	-0.4460
P^{FERT}	0.6293	0.0062	0.9873	0.9281	1.0000	0.8841	-0.6906	0.4186	0.7210	-0.4387
P^{INSECT}	0.3445	-0.0872	0.9422	0.8286	0.8841	1.0000	-0.5884	0.3504	0.5943	-0.3671
P^{MAIZE}	-0.5013	0.0696	-0.6761	-0.6750	-0.6906	-0.5884	1.0000	-0.3450	-0.5873	0.4855
SAP	0.3898	-0.1693	0.4196	0.4320	0.4186	0.3504	-0.3453	1.0000	0.4502	-0.3707
U^{REM}	0.7001	-0.2121	0.6900	0.7510	0.7210	0.5943	-0.5872	0.4502	1.0000	-0.0639
W^{AN}	-0.3492	0.1889	-0.4549	-0.4460	-0.4387	-0.3671	0.4855	-0.3710	-0.0639	1.0000

APPENDIX III

LONG RUN RELATIONSHIPS

1. System of Simultaneous Equations

Migration Equation $M^{AN} = C(1) + C(2) * W^{AN} + C(3) * R^{POPDN} + C(4) * U^{REM} + C(5) * SAP + C(6) * D(U^{REM}) + C(7) * D(U^{REM}(-1)) + C(8) * D(R^{POPDN}(-1)) + C(9) * D(W^{AN}(-1))$ (1)

Observations 28

Deforestation Equation $D^{AREA} = C(10) + C(11) * M^{AN} + C(12) * R^{POPDN} + C(13) * P^{COCOA} + C(14) * P^{MAIZE} + C(15) * P^{INSECT} + C(16) * D(M^{AN}(-1)) + C(17) * D(P^{COCOA}(-1)) + C(18) * D(P^{MAIZE}(-1)) + C(19) * D(P^{INSECT})$ (2)

Observations 28

Instruments $C \ W^{AN} \ U^{REM} \ SAP \ D(U^{REM}) \ D(U^{REM}(-1)) \ D(R^{POPDN}(-1)) \ D(W^{AN}(-1)) \ P^{COCOA} \ P^{MAIZE} \ P^{INSECT} \ P^{COCOA} \ D(M^{AN}(-1)) \ D(P^{COCOA}(-1)) \ D(P^{MAIZE}(-1)) \ D(P^{INSECT})$

Estimation Method Iterative Three-Stage Least Squares

Sample 1970 -1999

Continuation of Appendix III

2. Empirical Results of Long-run Relationships

Determinant residual covariance 0.001308
 Convergence 26 iterations

Dependent Variable = M^{AN}				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.048374	0.030781	-1.571516	0.1246
W^{AN}	0.013745	0.007301	1.882650	0.0676
R^{POPDN}	0.127367	0.057851	2.201647	0.0340
U^{REM}	-0.065288	0.022533	-2.897450	0.0063
SAP	-0.007271	0.008812	-0.825193	0.4146
$D(U^{REM})$	-0.174929	0.026525	-6.595005	0.0000
$D(U^{REM}(-1))$	0.046329	0.024170	1.916794	0.0630
$D(R^{POPDN}(-1))$	-0.454806	0.263071	-1.728833	0.0922
$D(W^{AN}(-1))$	0.002725	0.006263	0.435038	0.6661
R-squared = 0.699464			Mean dependent var. = - 0.001634	
Adjusted R-squared = 0.572922			S.D. dependent var. = 0.025411	
S.E. of regression = 0.016607			Sum squared resid. = 0.005240	
Durbin-Watson stat = 2.047442			BG (2) = 1.4721 (0.4791)	
Dependent Variable = D^{AREA}				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-11.91066	7.066402	-1.685534	0.1003
M^{AN}	-26.28664	33.52852	-0.784008	0.4380
R^{POPDN}	19.50320	9.609848	2.029501	0.0496
P^{COCOA}	0.000159	6.24E-05	2.540919	0.0154
P^{MAIZE}	0.001235	0.003523	0.350469	0.7280
P^{INSECT}	-0.001114	0.000361	-3.084027	0.0038
$D(M^{AN}(-1))$	-10.53657	16.65397	-0.632676	0.5308
$D(P^{COCOA}(-1))$	0.000151	0.000106	1.422699	0.1632
$D(P^{MAIZE}(-1))$	-0.005110	0.003035	-1.683362	0.1007
$D(P^{INSECT}(-1))$	0.000324	0.000212	1.530292	0.1345
R-squared = 0.601699			Mean dependent var. = 4.023056	
Adjusted R-squared = 0.402548			S.D. dependent var. = 5.699152	
S.E. of regression = 4.405159			Sum squared resid. = 349.2977	
Durbin-Watson stat = 1.200074			BG(2) = 1.7934 (0.1810)	

APPENDIX IV

SHORT RUN RELATIONSHIPS

1. System of Simultaneous Equations

Migration Equation

$$\begin{aligned}
 D(M^{AN}) = & C(1) + C(2)*D(W^{AN}) \\
 & + C(3)*D(R^{POPDN}) + C(4)*D(U^{REM}) \\
 & + C(5)*D(SAP) + C(6)*D(W^{AN}(-1)) \\
 & + C(7)*D(R^{POPDN}(-1)) \\
 & + C(8)*ect_1(-1)
 \end{aligned} \tag{1}$$

Observations 26

Deforestation Equation

$$\begin{aligned}
 D(D^{AREA}) = & C(9) + C(10)*D(M^{AN}) + C(11)*D(R^{POPDN}) \\
 & + C(12)*D(P^{COCOA}) + C(13)*D(P^{MAIZE}) \\
 & + C(14)*D(P^{INSECT}) + C(15)*D(M^{AN}(-1)) \\
 & + C(16)*D(R^{POPDN}(-1)) + C(17)*D(P^{INSECT}(-1)) \\
 & + C(18)*D(P^{MAIZE}(-1)) + C(19)*ect_2(-1) \\
 & + C(20)*D(D^{AREA}(-1)) + C(21)*D(M^{AN}(-2)) \\
 & + C(22)*D(D^{AREA}(-2)) \\
 & + C(23)*D(P^{COCOA}(-2))
 \end{aligned} \tag{2}$$

Observations 26

Instruments

$$\begin{aligned}
 & C \ D(W^{AN}) \ D(R^{POPDN}) \ D(U^{REM}) \ D(SAP) \ D(W^{AN}(-1)) \\
 & D(R^{POPDN}(-1)) \ ect_1(-1) \ D(P^{COCOA}) \ D(P^{MAIZE}) \ D(P^{INSECT}) \\
 & D(M^{AN}(-1)) \ D(D^{AREA}(-1)) \ D(D^{AREA}(-2)) \ D(M^{AN}(-2)) \\
 & D(P^{COCOA}(-2)) \ ect_2(-1)
 \end{aligned}$$

Estimation Method Iterative Three-Stage Least Squares

Sample 1970 -1999

Continuation of Appendix IV

2. Empirical Results of Short Run Relationships

Convergence 36 iterations
 Determinant residual covariance 0.001677

Dependent Variable = $D(M^{AN})$				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.010630	0.010300	1.032005	0.3106
$D(W^{AN})$	0.002138	0.012884	0.165975	0.8693
$D(R^{POPDN})$	0.113592	0.506645	0.224204	0.8242
$D(U^{REM})$	-0.237339	0.048894	-4.854172	0.0000
$D(SAP)$	0.007343	0.024905	0.294840	0.7702
$D(W^{AN}(-1))$	0.011464	0.012865	0.891101	0.3802
$D(R^{POPDN}(-1))$	-0.664088	0.494022	-1.344249	0.1893
$ect_1(-1)$	-1.105070	0.371836	-2.971930	0.0059
R-squared = 0.564060			Mean dependent var. = 0.00016	
Adjusted R-squared = 0.394528			S.D. dependent var. = 0.03882	
S.E. of regression = 0.030207			Sum squared resid. = 0.01643	
Durban-Watson stat. = 2.138634			BG (2) = 1.7194 (0.1898)	
Dependent Variable = $D(D^{AREA})$				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	2.242947	1.444459	1.552794	0.1313
$D(M^{AN})$	-28.40153	14.20435	-1.999495	0.0550
$D(R^{POPDN})$	-33.06335	85.96141	-0.384630	0.7033
$D(P^{COCOA})$	0.000275	0.000127	2.173789	0.0380
$D(P^{MAIZE})$	0.000511	0.001911	0.267352	0.7911
$D(P^{INSECT})$	-0.000722	0.000363	-1.987485	0.0564
$D(M^{AN}(-1))$	43.37855	14.83109	2.924840	0.0066
$D(R^{POPDN}(-1))$	-138.6542	89.33927	-1.551996	0.1315
$D(P^{INSECT}(-1))$	-0.000119	0.000251	-0.473725	0.6392
$D(P^{MAIZE}(-1))$	0.000853	0.002054	0.415437	0.6809
$ect_2(-1)$	-0.830368	0.244532	-3.395752	0.0020
$D(D^{AREA}(-1))$	0.665320	0.276324	2.407757	0.0226
$D(M^{AN}(-2))$	53.86831	12.33478	4.367190	0.0001
$D(D^{AREA}(-2))$	0.028389	0.159706	0.177756	0.8602
$D(P^{COCOA}(-2))$	-0.000181	9.52E-05	-1.907088	0.0665
R-squared = 0.776258			Mean dependent var. = 0.22153	
Adjusted R-squared = 0.491496			S.D. dependent var. = 3.70972	
S.E. of regression = 2.645379			Sum squared resid. = 76.9783	
Durban-Watson stat. = 2.012534			BG (2) = 1.6987 (0.4267)	

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