

Financial Viability of Rubber Production: Empirical Evidence from Ghana

Elikem A. Adanu¹, John K. M. Kuwornu², George T-M. Kwadzo^{1,2}

Abstract

This study examined the financial viability of rubber production in the Ahanta West District in the Western Region of Ghana. Multistage sampling technique was used to solicit primary data on costs and returns associated with rubber production from smallholder rubber farmers whose farms are in latex production. Secondary data regarding climatic and soil conditions were solicited to augment the primary data. Discounted Cash Flow analysis revealed that rubber production was financially viable at the Rubber Outgrower Unit's loan interest rate of 11.5% per annum while production was not financially viable at the Agricultural Development Bank's loan interest rate of 30% per annum. The constraint analysis revealed that uncompetitive rubber price was the most constraining institutional factor while high cost of labour was the most constraining production factor. The study recommends that, in order for farmers to benefit from rubber production, farmers should obtain loans from the Rubber Out grower Unit as loans offered by the Commercial Banks were associated with interest rates higher than the Internal Rate of Return of 13%.

Keywords: Financial Viability, Rubber Production, Smallholder Rubber Farmers, Ahanta West District, Ghana

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ความน่าเชื่อถือทางการเงินของการผลิตยางพารา: หลักฐานเชิงประจักษ์จากกานา

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บทคัดย่อ

การวิจัยครั้งนี้เป็นการศึกษาความเป็นไปได้ทางการเงินของการผลิตยางพาราของอำเภอฮันตาตะวันตก ในภูมิภาคตะวันตกของประเทศกานา เทคนิคการสุ่มตัวอย่างหลายขั้นตอนถูกนำมาใช้เพื่อเก็บข้อมูลด้านประมุขของต้นทุนและผลตอบแทนจากการผลิตยางพาราของเกษตรกรรายย่อยและข้อมูลด้านทุติยภูมิของภูมิอากาศและสภาพดินถูกนำมาใช้ศึกษาร่วมกับข้อมูลปฐมภูมิที่ได้ จากผลการประเมินความเป็นไปได้ด้วยวิธีคิดลดกระแสเงิน พบว่า การผลิตยางพารามีความสามารถทางการเงินในอัตราดอกเบี้ยเงินกู้ของหน่วยเกษตรกรผู้ปลูกยางพารา 11.5% ต่อปี ในขณะที่การผลิตยางพาราไม่สร้างความเป็นไปได้ทางการเงินในอัตราดอกเบี้ยเงินกู้ธนาคารเพื่อการพัฒนาการเกษตร 30% ต่อปี จากผลการวิเคราะห์ข้อจำกัด พบว่าที่ราคายางพาราไม่สามารถแข่งขันได้ เนื่องจากข้อจำกัดของสถาบันและมีต้นทุนแรงงานที่สูง เพื่อให้เกษตรกรผู้ผลิตยางพารารายย่อยได้รับประโยชน์จากการผลิต จึงควรให้เกษตรกรได้รับเงินกู้จากหน่วยงานเพื่อผู้ปลูกยางพารา เนื่องจากสินเชื่อกาธนาคารพาณิชย์มีอัตราดอกเบี้ยสูงกว่าอัตราผลตอบแทนภายในของหน่วยเกษตรกรผู้ปลูกยางพาราถึง 13%

คำสำคัญ: ความเป็นไปได้ทางการเงิน, การผลิตยางพารา, เกษตรกรผู้ผลิตยางพารารายย่อย, อำเภอฮันตา ตะวันตก, กานา

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1. Introduction

Rubber (*Heveabrasiliensis*), is a native tree crop of the Amazon river basin of South America and has become an economic tree that is grown commercially and offers important socio-economic life support to many tropical developing nations as it is a source of employment to many (Afolayan & Ajibade, 2012).

The two types of rubber commonly used today are natural and synthetic rubber. Natural rubber comes from the rubber tree. *Heveabrasiliensis* has been considered as the major source of natural rubber that can meet the demand of a rapidly expanding automobile industry, due to its ability to renew its bark within a short period to ensure sustained production (Ogbebor, 2013). Harvested rubber is the basic component of many products used in the industrial, transportation, consumer and medical sectors due to its toughness, resilience and elasticity (Evans & Turnbull, 2004).

In order to increase rubber production and alleviate poverty in rubber producing areas in Ghana, the Ministry of Food and Agriculture in 1995 launched the smallholders' plantation project as part of Ghana's agriculture diversification programme, with support from the French Development Agency (AFD) (Delarue, 2008). The French Development agency (AFD) provides financial assistance while the Ghana Rubber Estate Limited (GREL) provides technical assistance in the form of technical extension services, inputs and equipment for rubber production. The rubber market in Ghana is currently a monopsonistic one since the Ghana Rubber Estate Limited is the only buyer of rubber produced.

World rubber production forecast shows that global rubber consumption will reach 30.4 million metric tons by 2019, but production is estimated to reach merely 14 million metric tons implying a future deficit of 16.4 million metric tons. This shortage in supply of rubber serves as an opportunity for new rubber producing countries with available land and resources to increase their production (International Rubber Study Group (IRSG), 2010; Jumpasut, 2004).

Even though Ghana is one of the countries that can benefit from this future gain, there is not sufficient analysis of the rubber industry to provide the needed information and statistics on the present state of the rubber market in Ghana. Data gaps relating to costs and returns and the challenges associated with rubber production in Ghana are needed to assess the financial viability of rubber production and to reinforce the general perception that rubber production is an investment potential with good returns.

The objectives of the study were threefold. First, it examined climatic and soil conditions making the Ahanta West District of Ghana suitable for rubber production. Second, it estimated the financial worth of rubber production in the Ahanta West District of Ghana. Third, it identified and ranked

challenges faced by rubber farmers in the Ahanta West District of Ghana.

In commercializing agriculture, farmers are concerned about returns to their investment (Manivong & Cramb, 2007). It is therefore necessary for a prospective rubber investor to have reliable information on the resource requirements, cost and returns structure and challenges or risks associated with rubber production. This study therefore serves as a source of information for prospective investors regarding the financial viability as well as resource requirements and challenges associated with rubber production. The study will help assess the present state of the rubber industry and also serve as a source of information for policy makers and relevant stakeholders.

2. Literature Review

Rubber production

Rubber is an important commercial crop and its economic significance is well recognized because of its ability to produce latex (Akpan et al., 2007). The total area of rubber plantations all over the world has increased by 1.71 % per annum, thus from 3.88 million hectares in 1961 to 11 million hectares in 2006 (Rantala, 2006). As the demand for rubber and rubber wood products remain high, there is the will to ensure sustainable and enough future supply of rubber products (Rantala, 2006).

Rubber is grown mainly to produce latex which is obtained through the process of tapping. Tapping is a carefully controlled process of peeling off a small amount of the bark of the rubber tree to open the latex vessels (Kinnaman, 1997). The latex yield is influenced by climatic and soil conditions as well as the genotype planted. Rubber wood is considered as a secondary product of the rubber tree. Recent improvements in wood technology have resulted in the rubber tree being considered as an important source of wood products (Evans & Turnbull, 2004).

Tapping normally commences when the tree reaches a girth of 45cm or 7 years after planting. When tapping is started before the tree reaches the girth of 45cm, the growth rate of the tree and latex production is reduced (Purnamasari et al., 1999). The amount of latex produced is more when tapping is done very early in the morning due to high pressure in the latex vessels in the early hours of the morning (Opeke, 1982). Tapping latex during late hours of the day results in low amounts of latex extracted. Latex produced increases gradually from year 7, reaches full productivity in year 12, stabilizes from year 12 to year 32 and begins to decline (Grist et al., 1998). Decline in latex production makes further tapping of the tree less profitable (FAO, 2001). The trees are removed and replaced with new seedlings when the decline makes tapping unprofitable.

Climate has a direct impact on the factors of production, such as soil moisture and fertility. Adverse climatic conditions can affect farm outputs at any stage from cultivation through to the final

harvest (Molua & Lambi, 2007). The Rubber Board of India (2005) states that the most suitable area for rubber planting is the humid tropical zones and is not likely to thrive well in drier or colder areas. For rubber to thrive well, there is the need for consistent even distribution of rainfall of 1,750 - 2,500 mm (Kochhar, 1981). There should be no severe dry season and with 125-150 annual rainy days (Rao & Vijayakumar, 1992). The nature of rainfall distribution is very crucial because even if there is sufficient rain its irregularity can have an adverse effect on yields (Rudolf & Hermann, 2009). Kimengsi and Muluh (2013) indicates that high rainfall before maturity of the rubber tree increases soil moisture that provides a medium for nutrient dissolution and the decay of biomass that boost the production of latex. However, high rainfalls during the maturity or harvesting stage can be detrimental to latex produced as latex is washed out of the cups after tapping (Mesike & Esekhide, 2014).

According to Rao and Vijayakumar (1992), the most favourable conditions necessary for optimal growth of rubber include a maximum temperature of about 29-34 °C, minimum of about 20 °C and a monthly mean temperature of 25-28 °C. A high atmospheric humidity of about 80% with moderate wind, and bright sunshine for about 2000 hours in a year, at the rate of six hours a day in all months is also required. Sangsing (2004) states that, when plants encounter high temperatures in the absence of rainfall their rate of transpiration increases which in turn leads to moisture stress. Low temperatures result in low growth rates and cold damage (Rodrigo, 2007). In addition, Kimengsi and Muluh (2013) revealed that an increase in temperature with rainfall held constant exerts a negative effect on rubber output. The negative effect, which is a decrease in rubber output, is because high temperatures increase the rate of spread of diseases as well as plant dehydration.

Rubber can be grown on many soils; the best options being well drained deep clayey soils or well-drained fairly deep loamy soil (Lemmens et al., 1995). Growth can be restricted where there are rocky surfaces, heavy drainage or soil pH values above 6.5 or below 4.0 (Krishnakumar & Potty, 1992).

Rubber has an advantage over other cash crops because it can be grown in many areas that are unsuitable for other commonly cultivated cash crops such as coffee, coconut and oil palm since it requires a modest level of soil nutrients (Royal Forestry Department, 2000). Akpan et al. (2007) indicates that soils with sand fraction values higher than the desirable range of texture (50 - 70%) are not suitable for rubber cultivation since they are prone to higher porosity, which could enhance nutrient leaching and reduce water holding capacity of the soil. A study by Amalu (1992) demonstrates that where K, Ca, Mg values are below 0.2 cmol kg⁻¹, 5 cmol kg⁻¹ and 1 cmol kg⁻¹ respectively, the growth and latex yield of rubber is low.

In cultivating rubber there are two phases involved. The first phase, which is the establishment or immature phase, begins from planting through to the seventh year after planting. During this period there is expenditure on planting and maintenance of rubber with no returns since latex production begins in the seventh year (Manivong & Cramb, 2007). Returns are realized during the second phase which is considered the maintenance or production phase (when latex production begins). There are two main costs incurred throughout the life of rubber plantation establishment and maintenance, these are material and labour costs. The cost of planting materials, fertilizers, and labour for weeding are the major cost components of the establishment stage. Materials used during the maintenance phase include a small knife and a medium knife for weeding. In the mature period, the materials used are for tapping which include cups, spouts, tapping knife, pans, sharpening stones and hangers (Arshad et al., 1997).

According to Barlow and Tomich (1990) rubber cultivation requires intensive labour use since it is the main input apart from land. Labour cost incurred in the immature period of rubber cultivation are for land clearing, lining, terracing, holing, planting, fertilizing and hand weeding.

The main activities during the harvesting or mature period are tapping, collection of latex and felling of the trees at the end of their productive life (Manivong & Cramb, 2007). According to Arshad et al. (1997) latex is the main product obtained from rubber, however selling of rubber wood can increase the total productivity.

A study by Mesike and Esekhade (2014) to determine the variability of rainfall and its effect on rubber plantations in Nigeria, collected time series data from 1971 to 2009 on mean annual rainfall. Maximum and minimum rainfall, mean rainfall over the period and the coefficient of variation were analysed. Kimengsi and Mulu (2013) in conducting a comparative assessment of the effects of climatic variations on Cameroon Development Corporation's (CDC) rubber, oil palm and banana obtained secondary data on Climatic conditions. The climatic data constituted rainfall and temperature over a 16 year period (1995 - 2010). The maximum and minimum temperature and rainfall were analyzed as well as the coefficient of variation.

Financial Analysis

In choosing the appropriate method of analyzing data collected, various methods of analysis used in similar works were reviewed from literature. Manivong and Cramb (2007) also used the Discounted CashFlow (DCF) approach as the framework for assessing the returns from the investment of household resources in smallholder rubber production in Northern Laos, Northeast Asia. The Discounted CashFlow approach was used with the reason that rubber production is a long - term investment hence the stream of net-benefits will occur over a long period of time. The Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost Ratio (BCR) were used.

A study conducted by Wongnaa and Awunyo - Vitor (2013) on the profitability of cashew production in the Wenchi Municipality used discounted measures of project worth for data analysis indicated that cashew production is profitable in the Wenchi Municipality. Sensitivity analysis was carried out to assess the stability of the profitability indicators subject to various changes in the costs and benefits structure. Results from the sensitivity analysis indicated that cashew production in the municipality was still profitable even with a 10% increase in cost of labour, 10% decrease in output prices and a 10% increase in lending rate. Assumptions employed in the estimation of profitability include a project life of 25 years, since average life span of cashew plants is 25 to 30 years as stated by Sekar and Karunakaran (1994) and a discount rate of 25% based on the assumption that Cashew farmers are financed by borrowing. The lending rate of the Agricultural Development Bank (ADB) to Agriculture and Forestry was used. Also calculations were done in constant prices with the current cropping season of the study used as the base year; prevailing environmental and climatic conditions were assumed to be favourable and no taxation of any kind on items sold. It was also assumed that Cashew trees are sold after twenty-five (25) years to charcoal burners to be used to produce charcoal.

Papenfus (2000) used the NPV in evaluating the profitability of oil palm production over a project life of 25 years. Cash outflows were grouped into establishment costs and production costs. Establishment costs included expenditures on all labour (land clearing, field preparation and planting and field management). Labour was estimated by man-days/ha/year and purchased input (tools, seedlings, fertilizer, chemicals). Returns were estimated using current prices of oil palm in the study area. At a discount rate of 20% which is the market lending rate to Agriculture in the study area, the study concluded that small holder oil palm production in Sumatra, Indonesia is financially viable. It was also observed that, the oil palm growers begin to realize positive cash flow in the fifth year after planting.

Afari et al. (2010) made use of the NPV, BCR AND IRR in assessing the profitability of three different cocoa production systems over a 20 year production period. Production systems considered were low input landrace cocoa, high input no shade cocoa, high input medium shade certified cocoa. In analyzing the cash flows, cash outflows were split into expenditures incurred during the establishment period up to 4 years and those incurred during the harvest period, thus from the 5th year upwards. Expenditure was further split into those incurred on labor and physical inputs such as planting materials, agrochemicals, tools and equipment. Average labour requirements were estimated for the various activities per hectare. Expenditure on inputs was estimated using current prices of the inputs on the market. Returns were estimated using current prices for cocoa as well as the wood produced. A discount rate of 20% was used.

Oseini and Adams (2013) in comparing the profitability of conventional and certified cocoa production in Ondo State Nigeria used the NPV, BCR AND IRR. Investment costs considered include costs incurred in acquiring the land materials and labour. The various types of labour used were considered and values imputed for family labour using wage rates in the study area. Operating costs involved the annual maintenance costs incurred. A discount rate of 24% which is the prevailing bank interest rate in Nigeria was used in discounting costs and benefits.

Constraints

According to Legendre (2010) The Kendall's coefficient of concordance is used to measure the degree of agreement among rankers who are ranking a given set of constraints. In doing this, the total rank score for each constraint is computed and the constraint with the least score is ranked as the most pressing. The F statistic is then used to test for the significance of concordance. The null hypothesis states that there is no agreement among rankings produced by rankers. The alternative states that there is agreement among rankings produced by rankers.

In ranking production constraints of rubber production in the Niger Delta Region of Nigeria, Giroh et al. (2013) used the likert scale. The constraints were scored as follows: very serious (3), serious (2) and not serious (1). The benchmark used in determining the significance of the various constraints on production was by summing up assigned values and dividing by the number of occurrence. The result arrived at, was then used as the decision score to determine significant constraints to production.

Anang et al. (2011) analyzed constraints of Ghana's cocoa sector reform using the Kendall's Coefficient of Concordance in analyzing constraints in order to assess the degree of agreement among constraints. Giroh et al. (2013) in a study on constraints of rubber production in the Niger Delta Region of Nigeria, obtained data mainly from primary source using structured questionnaires.

From literature the procedures for data collection vary depending on the type of data being collected. For instance, Manivong and Cramb (2007) in analyzing the economic potential of rubber production in Northern Laos, obtained data on soil characteristics from the Soil Survey and Land Classification Centre of the National Agriculture and Forestry Research Institute of Luangnamtha province and collected data on the costs and returns through interviews with the farmers. Data was collected over two periods. The first period considered information about the village and this was done through focus group discussions with the village authorities. This was to help understand the general conditions and situations in the study area. During the second period information was obtained about rubber plantations. This was done using questionnaires pre-tested by having interviews with three rubber farmers. The first part of the questionnaire was about general household information including household members, land resources and income sources. The second part focused on

information about rubber production such as plantation areas, sources of capital, technical aspects, challenges, marketing as well as outputs from rubber production. The total number of rubber farmers in the study area is 102 and out of this number, 95 were interviewed due to the unavailability of 7 farmers at the time the interview. In estimating the labour costs incurred in production, Manivong and Cramb (2007) collected data on the labour requirements for rubber establishment, maintenance and production over the life of the plantation and estimating the opportunity cost of labour. Latex yields over the life of the investment were estimated using the Bioeconomic Rubber Agroforestry Support System (BRASS), which according to Grist et al. (1998) is the best available tool for modelling latex yields from smallholder rubber production. The BRASS is made up of a biophysical component and an economic component. The biophysical module incorporates many variables including climate, topography and soil and rubber management to estimate latex yields. The economic component incorporates the total annual cost of materials and labour as well as the total annual revenue from latex produced. The revenue was determined by multiplying the estimated latex yields from the biophysical component with prices.

A study conducted by Giroh et al. (2013) on the constraints of rubber production in the Niger Delta Region of Nigeria, made use of the multi-stage sampling technique. The first stage involved the purposively selecting six rubber growing areas in the Niger Delta State. The second stage of the sampling involved obtaining the list of 407 rubber farmers from the selected locations from Tree Crop Units and Ministry of Agriculture and Natural Resources. The final stage involved randomly selecting a total of 300 rubber farmers by using the proportionality factor which was adopted by Adebayo and Olayemi (2005). Thus the selection of farmers was done by dividing the sample size by the total number of rubber farmers in the selected areas. Giroh et al. (2013) indicates that the major challenges affecting rubber farmers include pests and diseases, inadequate credit, shortage and high cost of labour, inadequate farm machineries, lack of market information, inadequate research/extension support services, storage facilities problem and land tenure problems. Shortage and high cost of labour was ranked as the major challenge faced by farmers. This is due to the fact that the rubber growing belt is in the oil belt of Nigeria where active population are attracted, leaving rubber cultivation to the older and aged population resulting in reduction in hectareage under cultivation and declining productivity.

Inadequate credit was ranked as the second most significant constraint of rubber farmers. The reason given being that Rubber production is both labour and capital intensive and therefore requires large capital outlay. Poor rubber prices was the third most constraining factor of rubber production. The fourth most constraining factor was storage facilities and this in agreement with Uraih et al. (2006).

Agwu (2006) identified high cost of labour, poor road network, problem of low yield due to unavailability of improved planting materials, small farm size and high cost of planting materials were among the major challenges faced by rubber farmers in the South West Agricultural zone of Nigeria. A study by Osiebe (1999) indicated lack of good marketing channels, poor organization of the rubber sector, lack of capital and lack of government incentives are some of the major constraints facing farmers in rubber production in Ethiopie West Local Government Area of Delta State. Abolagba et al. (2003) notes that fluctuations in the international price of rubber, especially low prices, affect the production of rubber significantly since most of the product is often exported. Banmeke and Omoregbee (2009) state the major factors affecting rubber production are fluctuating rubber prices and unavailability of land.

3. Materials and Methods

3.1 Study Area, Sampling, Data Collection and Data Analysis

Study Area

The Ahanta West District is located at the southernmost point of Ghana and the entire West African Sub-Region with its capital AgonaNkwanta also known as AgonaAhanta. According to the 2000 Population and Housing Census report, the District has a total land area of 591 square kilometres and is occupied by 95,140 people. It is bounded on the East by the SekondiTakoradi Metropolitan Assembly (STMA), on the West by the Nzema East Municipal, and the North by MpohorWassa East and TarkwaNsuem Districts and the Gulf of Guinea to the South. The Ahanta West District is made up of 19 towns and the major economic activity in the district is agriculture which employs about 59% of the population. Most of the inhabitants are small-scale farmers with coconut, oil palm and rubber as the main cash crops cultivated. The soils in the district are generally very fertile and range from loose sand to clay. With an arable land of about 350 sq. km, good soils and generally favourable weather the district possesses the requisite conditions favourable for agricultural development (Ahanta West District Assembly, undated).

Data Collection

Estimation of Costs of Production

The cost of rubber cultivation is in two parts, the establishment cost and maintenance cost. The establishment cost spreads over the first six years whiles maintenance costs are incurred when latex tapping begins. In situations where resources were provided by the farmer or family, values were imputed for these resources using current 2014 prices. Costs considered include cost of land, equipment used, inputs and labour. Equipment used for planting includes hoe and mattock,

cutlasses were used for weeding, and wellington boots were used as protective gear. Tapping equipment includes the tapping knife, spouts, hangers, sharpening stone, pans, cups and ground sheets. Inputs include the rubber stumps, fertilizer, termiticide and fungicide. Cost of labour was made up of cost of land preparation, planting, fertilizer application, pruning, slashing, disease control, tapping and transportation of rubber latex (cup lumps). Costs were estimated by considering initial cost, cost at onset of latex production and cost at peak production. Adjustments were made for periods before and after peak production based on number of times (rounds) operations were carried out in the respective years in which they occur. For cost of equipment, working life of the equipment was considered. Current 2014 prices were used in quantifying cost of production.

Estimation of Revenue

Secondary data on actual latex yield of farmers interviewed was obtained from the Rubber Outgrower Unit (ROU). Data was collected for each year from onset of production (year 7) to the first year of the peak period (Year 12). Year 12 data was maintained till year 32, and yields for the remaining years were estimated using the estimated yield curve (Figure 1) obtained from the Rubber Outgrower Unit (ROU) of the Ghana Rubber Estates Company Limited (GREL). Latex yields decrease by 15% in year 33 and further decreases by 35% from year 34 to 35 as can be seen in Figure 1. Benefits in year 35 comprise of revenue from latex and salvage value of the lumber. Revenue was quantified using current 2014 prices of rubber and lumber.

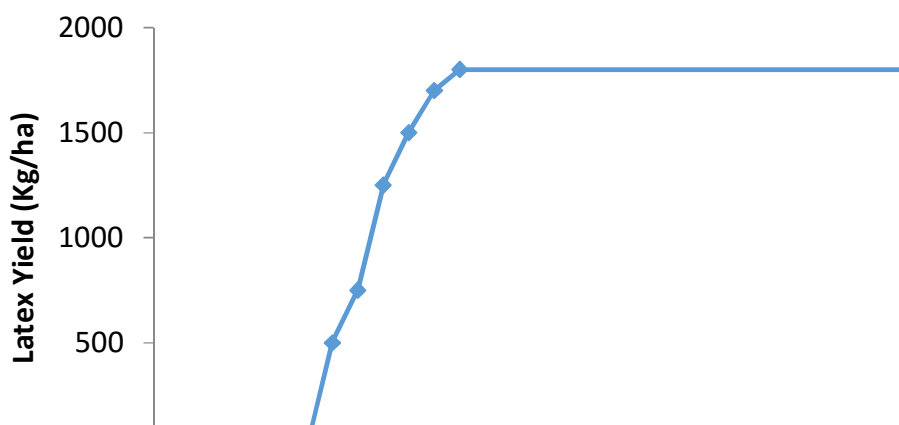


Figure 1: Estimated yield curve for rubber in kg/ha over time.

Source: Rubber Outgrower Unit, Ahanta West District.

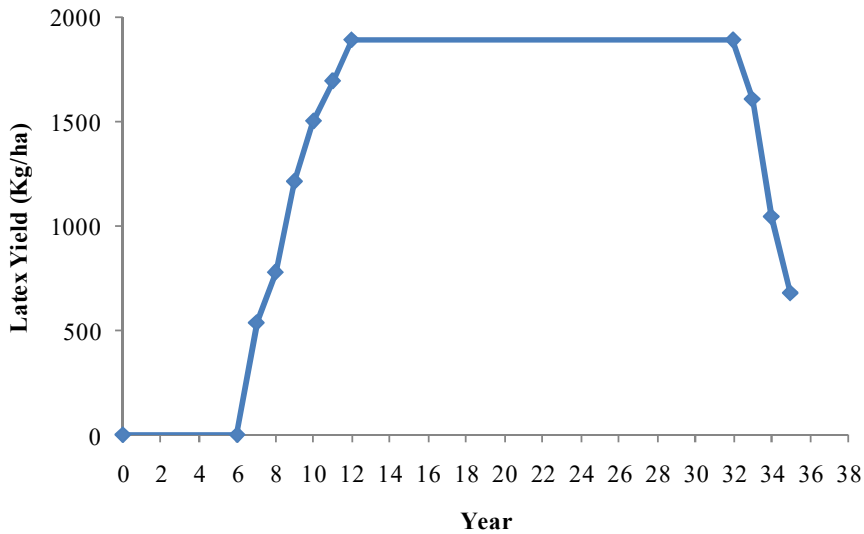


Figure 2: Actual latex yield per hectare.

Source: Computation from authors' field data, 2014.

It is worth noting that actual yield curve (Figure 2) obtained from the authors' field data approximately matched the estimated yield curve provided by the Rubber Outgrower Unit (Figure 1).

Primary Data

Primary data on the costs associated with coagulated latex production was collected from respondents using well-structured questionnaires as well as personal interviews. Secondary data on the weather conditions in the District was collected from the Meteorological Services Department and data on soil types in the District was reviewed from literature by Issaka et al. (2012) on assessment of the fertility of soils in the Ahanta West District. Secondary data on the latex yields was extracted from a document prepared by the Rubber Outgrower Unit of the Ghana Rubber Estates Limited.

Sample Size

In estimating the sample size (n) to be selected from the population the Miller and Brewer (2003) formula for calculating sample size was used. The formula is given below as:

$$n = \frac{N}{1+N(\alpha)^2} \quad (1)$$

Where n denotes sample size; N denotes total population of rubber farmers in the eight communities (545) and α denotes the margin of error (5%). This yielded a sample size of 231 rubber farmers that were interviewed.

Sampling Technique

The multi - stage sampling technique was used to select the respondents for the study. This entails three (3) stages. The first stage was to purposively select the Ahanta West District of the Western Region since rubber is one of the major cash crops grown there. The second stage involved purposive selection of eight (8) communities in the District namely Agona, Abura, Ajumako, Princess Town, Adiewoso, Bansa, Cape Three Points and Maampehia where rubber is produced. The third stage was the random selection of 231 rubber farmers out of the total population of 545. This was done using the lottery system where the names of all rubber farmers in the production stage in each community was written on pieces of papers, folded and randomly picked. This method eliminates biases since every farmer has a chance of being selected. We conducted interviews by meeting farmers on their farms, homes and at the quarterly farmers' meeting organized by the Rubber Outgrower Unit for rubber farmers in the District.

The methods used to determine the financial viability of rubber production were based on a per hectare rubber plantation over a total of 35 years. Economic life of rubber was considered to be 35 years (Rao and Vijayakumar, 1992). Data obtained from the field survey were used to estimate relative costs and returns of rubber production. Cost benefit analysis was done using the discounted cash flow approach. This approach involves the following measures: Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR), and Sensitivity Analysis (Asante & Kuwornu, 2014; Agbeja, 2004). The Discount Rate used was the market lending rate (Perkins, 1994). The interest rate of the Rubber Outgrower Unit, which is subsidized for rubber farmers with support from the French Development Agency (AFD), and the interest rate of the Agricultural development Bank (ADB) were used in order to compare the viability of rubber production under both scenarios. Sensitivity Analysis was used in treating uncertainties associated with projects (Agbeja, 2004). It helps to assess how responsive costs and benefits associated with the investment are to factors such as changes in price, costs of production as well as interest rate. In this study, sensitivity of the financial viability of rubber production was analyzed with respect to changes in cost of production and price of rubber latex.

The constraints associated with smallholder rubber production were analyzed by first identifying and pre-testing the constraints faced by the farmers. The final lists of constraints were prepared and the respondent rubber farmers ranked the constraints in order of importance from the most pressing constraint to the least pressing constraint. The Kendall's Coefficient of Concordance was used to assess the degree of agreement among the rankings. The Kendall's Coefficient of Concordance is a measure of agreement among several judges who are assessing a given set of objects (Legendre, 2005).

4. Results and Discussion

Climatic and soil conditions for rubber production

Optimal conditions for growth of rubber include a maximum temperature range of 29 - 34°C, minimum of 20°C, monthly relative humidity of about 80% and an annual rainfall distribution of 1,750 - 2,500 mm (Rao & Vijayakumar, 1992).

Monthly average relative humidity data obtained from the Meteorological Services Department over the period from 2004-2014 ranged from 70% to 83%; with August recording the highest monthly average of 83.57% and the lowest value was recorded in January (70.83%).

Rainfall and temperature data obtained from the Meteorological Services Department revealed an average rainfall of 1,835 mm, mean minimum temperature of 24.4°C and mean maximum temperature of 29.9°C, over the eleven year period (2004 to 2014) which fall within the acceptable range required for optimal growth of rubber. Mean minimum and maximum temperatures for the individual years all fall within the acceptable range. Annual rainfall varied considerably with a coefficient of variation of 23.4%. Temperature was however more stable with a very low coefficient of variation of 0.098% and 1.3% for mean minimum and mean maximum temperatures respectively.

Rainfall is less in January but increases gradually from February through to May, reaches the peak in June (503.57 mm) and begins to decline. Generally high rainfall amounts are recorded from May to July and the lowest is recorded in August (37.76 mm).

The condition of soils in the District was obtained from literature (Issaka et al., 2012). The literature revealed that soils range from well-drained loose sand to well-drained clayey soils. The following are the conditions of the soil: pH (4.4); Organic Matter (g/ Kg), (22.8); Total N % (1.7); Ca (cmol/kg), 2.4; Mg (cmol/kg), 1.5; K (cmol/kg), 0.15; Available P (Mg/kg), 1.6.

Well - drained clayey soils in the District are suitable for rubber production (Lemmens et al., 1995). However, where soil pH values are above 6.5 or below 4.0 the growth of rubber can be restricted (Krishnakumar & Potty, 1992). Also critical limit of total nitrogen (N) for good growth of rubber is 1% while that of available phosphorus (P) is 11 mg/ kg (Chan et al., 1984).

It is worth noting that the soil pH value of 4.4 and Mg level of 1.5 cmol/ kg fall within the acceptable range, whereas Ca and K levels were lower than the requirement for rubber production. Total nitrogen level of 1.7% is above the required critical limit of 1% whereas the level of available phosphorus of 1.6 mg/kg is lower than the required limit of 11 mg/kg.

The financial viability of rubber production was assessed by computing the total cost, total revenue and net benefits associated with production. The NPV, BCR and the IRR were then used to determine whether or not it is worth investing in rubber production given two scenarios. Two discount

rates were considered; an 11.5% per annum discount rate which is the subsidized interest rate offered to rubber farmers by the Rubber Outgrower Unit (ROU) with support of the French Development Agency (AFD) and a 30% per annum discount rate which is the Agricultural Development Bank's lending rate to agriculture. Following Viswanathan (2005) the two rates were considered in order to compare the financial worth of producing rubber using the Rubber Outgrower Unit's subsidized loan rate and the Agricultural development Bank's loan rate.

Microsoft Excel was used to compute the estimates of total costs and returns of production. A summary of computed costs and returns is presented in Table 1 and details are shown in Table 2.

Table 1 Estimated Total Costs and Returns of Production/hectare¹

	Item	Amount (GHS)	Total (GHS)
Cost	Equipment	2,611.25	52,709.50
	Contingencies	261.13	
	Inputs	2,527.30	
	Labour	46,809.82	
	Land	500.00	
Revenue	Latex	90,373.32	138,716.96
	Salvage value of lumber	48,343.64	

Source: Authors' survey data, 2014.

The total cost of rubber production was GHS 52,709.50, with the cost of labour representing 88.81%, cost of equipment representing 4.95%, inputs representing 4.79% and contingencies representing 0.50%. The total cost incurred in the year of planting (year 0) was GHS 3,018.95. Cost of labour increased from year 7 onward due to the cost associated with tapping and transportation of cup lumps to the factory (Table 2).

¹ 1 USD = GHS 3.215 at the time of data collection in December 2014.

Table 2 Cost of cultivating a hectare of rubber from year 0 to 35 years

Years	Equipment used per hectare (GHS)	Contin - gencies (GHS)	Equipment used per hectare (GHS) + contingencies	Input requirements per hectare (GHS)	Labour requirements per hectare (GHS)	Cost of Land (GHS) per hectare	Total (GHS)
0	151.50	15.15	166.65	1,463.25	889.05	500.00	3,018.95
1	45.00	4.50	49.50	567.65	316.65		933.80
2	45.00	4.50	49.50	380.90	270.99		701.39
3	45.00	4.50	49.50	3.50	248.33		301.33
4	45.00	4.50	49.50	3.50	245.13		298.13
5	45.00	4.50	49.50	3.50	196.48		249.48
6	45.00	4.50	49.50	3.50	195.95		248.95
7	323.68	32.37	356.05	3.50	1,495.41		1,854.96
8	61.82	6.18	68.01	3.50	1,495.41		1,566.92
9	61.82	6.18	68.01	3.50	1,495.41		1,566.92
10	76.82	7.68	84.51	3.50	1,495.41		1,583.42
11	61.82	6.18	68.01	3.50	1,495.41		1,566.92
12	61.82	6.18	68.01	3.50	1,495.41		1,566.92
13	76.82	7.68	84.51	3.50	1,495.41		1,583.42
14	61.82	6.18	68.01	3.50	1,495.41		1,566.92
15	61.82	6.18	68.01	3.50	1,495.41		1,566.92
16	76.82	7.68	84.51	3.50	1,495.41		1,583.42
17	61.82	6.18	68.01	3.50	1,495.41		1,566.92
18	61.82	6.18	68.01	3.50	1,495.41		1,566.92
19	76.82	7.68	84.51	3.50	1,495.41		1,583.42
20	61.82	6.18	68.01	3.50	1,495.41		1,566.92
21	61.82	6.18	68.01	3.50	1,495.41		1,566.92
22	76.82	7.68	84.51	3.50	1,495.41		1,583.42
23	61.82	6.18	68.01	3.50	1,495.41		1,566.92
24	61.82	6.18	68.01	3.50	1,495.41		1,566.92
25	76.82	7.68	84.51	3.50	1,495.41		1,583.42

Table 2 Cost of cultivating a hectare of rubber from year 0 to 35 years (continued)

Years	Equipment used per hectare (GHS)	Contin - gencies (GHS)	Equipment used per hectare (GHS) + contingencies	Input requirements per hectare (GHS)	Labour requirements per hectare (GHS)	Cost of Land (GHS) per hectare	Total (GHS)
26	61.82	6.18	68.01	3.50	1,495.41		1,566.92
27	61..82	6.18	68.01	3.50	1,495.41		1,566.92
28	76.82	7.68	84.51	3.50	1,495.41		1,583.42
29	61.82	6.18	68.01	3.50	1,495.41		1,566.92
30	61.82	6.18	68.01	3.50	1,495.41		1,566.92
31	76.82	7.68	84.51	3.50	1,495.41		1,583.42
32	61.82	6.18	68.01	3.50	1,495.41		1,566.92
33	61.82	6.18	68.01	3.50	1,495.41		1,566.92
34	76.82	7.68	84.51	3.50	1,495.41		1,583.42
35	61.82	6.18	68.01	3.50	2,575.65		2,647.16
Total	2,611.25	261.13	2,872.38	2,527.30	46,809.82	500.00	52,709.50
%	4.95	0.50	5.45	4.79	88.81	0.95	

Source: Computation from authors' field data, 2014.

The cost of labour was calculated using the amount charged for the various operations per hectare instead of man-days/ha since the contract system of pricing is practiced in the District.

Cost of equipment was highest in year 7 due to the purchase of tapping equipment set. Tapping equipment which are replaced annually include the tapping knife and sharpening stone. Ground sheets and pans are replaced every 3 years while other tapping equipment such as cups, spouts and hangers are used from year 7 through to year 35. The cutlass and wellington boots are replaced annually from the year of establishment through to year 35. The cost of equipment remained constant from years 8 to 35 except for years in which pans for collection of cup lumps were replaced, after every 3 years.

Cost of inputs was highest (GHS 1,463.25) in the year of planting due to purchase of rubber stumps, while for years 1 and 2 the cost of fertilizer was the major component of input cost. Inputs used in subsequent years were mainly fungicides for treatment of corynespora leaf spot and formes root diseases (Table 2).

A summary of the discounted costs and benefits are presented in Table 3. Costs and returns were discounted in order to tackle the effects of time on their values in a long-term business like rubber production.

Table 3 Discounted Costs and Benefits

Costs and Benefits	@ 11.5% per annum Discount rate	@ 30% per annum Discount rate
Discounted Costs	12,071.52	5,642.35
Discounted benefits	13,292.35	1,579.40
NPV	1094.92	-3,125.35
BCR	1.10	0.28
IRR	13% for the life of the project	13% for the life of the project

Source: Authors' computations from field data, 2014.

Discounting the costs and benefits at the Rubber Outgrower Unit's subsidized rate of 11.5% per annum, the discounted costs and benefits were GHS 12,071.52 and GHS 13,292.35 respectively with NPV of GHS 1,094.92, BCR of 1.10 and an IRR of 13% for the life of the project.

These results revealed that with a positive NPV of GHS 1,094.92, BCR of 1.10 which is greater than 1 and an IRR of 13% for the life of the project which is greater than cost of capital (i.e. 11.5% per annum), rubber production at the Rubber Outgrower Unit's loan rate (i.e. 11.5% per annum) was financially viable.

On the other hand, discounting costs and benefits at the Agricultural Development Bank's rate (i.e. 30% per annum) gives discounted costs and benefits of GHS 5,642.35 and GHS 1,579.40 respectively, a negative NPV of GHS 3,125.35, BCR of 0.28 and an IRR of 13% for the life of the project. With a negative NPV of GHS 3,125.35, BCR of 0.28 which is less than 1 and an IRR of 13% for the life of the project which is lower than the cost of capital of 30% per annum, rubber production at the Agricultural Development Bank's loan rate (i.e. 30% per annum) was not financially viable (Table 3).

Sensitivity Analysis

The sensitivity analysis is presented in Table 4. In order to examine issues of uncertainties associated with rubber production, sensitivity analysis was carried out to assess the stability of the viability of the project to various changes in the costs and benefits structure. The results revealed that a 10% increase in cost of production, discounted at the Rubber Outgrower Unit's lending rate of

11.5% per annum resulted in an NPV of 12.27, BCR of 1.00 and IRR of 12%. Thus rubber production will still be viable at the Rubber Outgrower Unit's subsidized lending rate of 11.5% per annum.

Table 4 Sensitivity Analysis

Scenarios	Assumption	NPV	IRR	BCR
A	10% increase in cost of production	12.27	12%	1.00
B	10% increase in price of rubber	2287.06	14%	1.21
	10% decrease in price of rubber	-1.18	11%	1.00

Source: Authors' survey data, 2014.

However, any increase in cost of production above 10% will make production not financially viable given the prevailing prices of rubber. A 10% increment in the price of rubber, thus from GHS 1.85 to GHS 2.04 per kilogram when discounted at the Rubber Outgrower Unit's lending rate of 11.5% per annum gave a positive NPV of GHS 2287.06, BCR of 1.21 and an IRR of 14% which is still lower than the Agricultural Development Bank's lending rate of 30% per annum. It was noted from further computations that a decrease of 10% (that is GHS 1.67) or more in rubber prices when discounted at the Rubber Outgrower Unit's lending rate of 11.5% per annum would make rubber production not financially viable (Table 4).

Ranking of Constraints

Constraints were grouped into institutional and production constraints. The Kendall's coefficient of concordance was used to assess the degree of agreement among ranking of constraints and the chi-squared test was used to test for significance of the Kendall's coefficient of concordance. The institutional and production constraints are presented in Table 5.

For the institutional constraints, uncompetitive rubber price was ranked first with a mean score of 2.19 and poor road network was second with a mean score of 2.24. The poor nature of roads results in difficulties in transporting rubber latex from the field to the factory especially in the rainy season. These results are consistent with previous research (Agwu, 2006). Furthermore, land tenure problem was ranked third with a mean score of 2.77, high cost of inputs was fourth with mean score of 3.81 and inadequate extension services ranked fifth with mean score of 3.98. With Kendall's coefficient of concordance of 0.291 and chi-square calculated of 269.317 which is greater than chi square critical of 9.488, the null hypothesis is rejected. This implies that there is no agreement among the rankings.

For production constraints high cost of labour was ranked first with a mean score of 1.67. This finding is consistent with previous study (Abolagba & Giroh, 2006). Incidence of pests and diseases was second with mean score of 2.01 and incidence of bush fires was ranked third with a mean score of 2.32. The high cost of labour is attributed to the predominance of small scale mining activities in the District which is considered more lucrative compared to working on rubber plantations. With Kendall's coefficient of concordance of 0.109 and chi square calculated 50.404 greater than chi-square critical of 5.991, the null hypothesis is rejected. This implies that there is no agreement among the rankings.

Table 5 Institutional and Production Constraints

Institutional Constraints			Production Constraints		
Constraints	Mean Score	Rank	Constraints	Mean Score	Rank
Uncompetitive rubber price	2.19	1 st	High cost of labour	1.67	1 st
Poor roads	2.24	2 nd	Incidence of pests and diseases	2.01	2 nd
Land tenure problem	2.77	3 rd	Incidence of bush fires	2.32	3 rd
High cost of inputs	3.81	4 th			
Inadequate extension services	3.98	5 th			
N = 231 Kendall's W = 0.291			N = 231 Kendall's W = 0.109		
χ^2 calculated = 269.317 df = 4			χ^2 calculated = 50.404 df = 2		
χ^2 critical = 9.488 Asymp. Sig = 0.000			χ^2 critical = 5.991 Asymp. Sig = 0.000		

5. Conclusions

The empirical results from the study indicated that generally average rainfall and temperature conditions in the Ahanta West District fall within the acceptable range required for optimal growth of rubber. Soil conditions are favourable except for calcium (Ca), potassium (K) and available phosphorus (P) levels. Total nitrogen level of soils would have to be improved upon.

Rubber production in the District was financially viable at the Rubber Outgrower Unit's loan rate of 11.5% per annum whereas at the Agricultural Development Bank's loan rate of 30% per annum, rubber production in the District was not financially viable.

The results of the sensitivity analysis suggest that any increase in cost of production above 10% will result in rubber production not being financially viable even at the 11.5% per annum loan rate. A decrease of 10% or more in rubber prices will also make the project not financially viable.

The institutional constraints analysis revealed that uncompetitive rubber price was the most pressing constraint followed by poor nature of road network in the District. Problems with the acquisition and ownership of land were ranked third, high cost of inputs fourth and inadequate extension services as the last institutional constraint.

High cost of labour was the most pressing production constraint and is attributed to the prevalence of small - scale mining activities in the District which is more lucrative. Incidence of pests and diseases was ranked second and incidence of bush fires ranked as the last production constraint.

The study provides the following recommendations. Calcium and phosphorus levels of soils in the Ahanta West District should be improved upon by applying amendments such as rock phosphate which helps in fixing phosphorus, calcium and magnesium. Total nitrogen level of soils can be improved upon by growing leguminous cover crops such as pueraria. To ensure farmers benefit from rubber production, it is recommended that farmers obtain loans from the Rubber Outgrower Unit since loans offered by the commercial banks currently are associated with high interest rates. Furthermore, to help the rubber farmers benefit from rubber production, it is important that interest rates on loans from the credit market be reduced to the level of the rate being offered by the rubber Outgrower Unit. This would enable the rubber farmers to access enough capital at the desirable rate to be able to expand their production activities. In addition, rubber farmers should lobby their District Assembly for improvement of road network in production areas since poor roads was ranked as the second most constraining institutional factor. Furthermore, extension services should include training of farmers on good record keeping practices since it was observed from the study that most of the farmers do not keep records of their farm operations. Extension officers should also educate farmers on good agronomic practices such as weed control and early detection of disease symptoms in order to

minimise occurrence and spread of diseases. This is because the incidence of pests and diseases was ranked as the second most constraining production factor.

The limitations of the study and suggestions for future research are as follows. First, results from this study can only be generalized for rubber cultivation as a monocrop since this is the current practice in the study area. Hence, further research should be conducted considering the profitability of intercropping rubber with food crops as well as comparing the profitability of both practices. Second, the study is based on data from Rubber Outgrowers in the Ahanta West District of Ghana. Therefore, future studies should explore the profitability of latex production of outgrowers in other regions of Ghana. Third, research should be conducted on the impact of latex production on the livelihood of rubber farmers and rubber growing communities as a whole to ascertain whether the Rubber Outgrower Plantations Project (ROPP) aim of alleviating poverty in rubber growing areas is being achieved. Finally, the trend of the yield of rubber may change in the context of intensified global warming, and this may influence the feasibility of the rubber production business.

6. References

- Abolagba, E. O., Aigbekaen, E. O., & Omokhafe, K. O. (2003). Farm gate marketing of natural rubber in the South East rubber growing zone of Nigeria. *Nigerian Journal of Agriculture and Rural Development*, 6, 40 - 48.
- Abolagba, E. O., & Giroh, D.Y. (2006). Constraints to sustainable development of rubber industry, Nigeria. *Moor Journal of Agricultural Research*, 7(1), 42 - 48.
- Adebayo, E. F., & Olayemi, J. K. (2005). Application of goal programming to resource allocation behaviour of dairy producers in Adamawa State, Nigeria. *Journal of Sustainable Development and Environment*, 1, 60 - 69.
- Afari, S. V., Gockowski, J., & Dziwornu, A. K. (2010). *Economic cost-benefit analysis of certified sustainable cocoa production in Ghana*. 3rd Conference of African Association of Agricultural Economists, Africa and the Global Food and Financial Crisis. Cape Town, South Africa.
- Afolayan, O. S., & Ajibade, L. T. (2012). Temporal variation in perennial cash crops production in Ondo State, Nigeria. *Asian Journal of Natural & Applied Sciences*, 1(3): 72 - 78.
- Agbeja, B. O. (2004). *Valuation of investment on teak plantation establishment on a 15-year-rotation for intending small holders in Nigeria*. International Workshop on Small-Holder Timber Production. World Agroforestry Centre (ICRAF), United Nations Avenue, Girigi, Nairobi, Kenya.

- Agwu, A. E. (2006). Enhancing natural rubber (*Heveabrasiliensis*) production through extension service delivery in South West Agricultural Zone of Nigeria. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 5(2), 7 - 16.
- Ahanta West District Assembly (undated). (n.d.). *Ahanta West District Profile*. Retrieved December 14, 2014, from Ghana Districts, <http://www.ghanadistricts.com>.
- Aigbekaen, E. O., & Alika, J. E. (1984). Analysis of the socioeconomic factors associated with rubber tappers and their productivity in some selected rubber estates in Nigeria. *Journal of Plantation Crops*, 12(1), 47 - 55.
- Akpan, A. U., Edem, S. O., & Ndaeyo, N. U. (2007). Latex yield of rubber (*Heveabrasiliensis*, Muell Argo) as influenced by clone planted and locations with varying fertility status. *Journal of Agriculture and Social Sciences*, 3(1), 28 - 30.
- Amalu, U. C. (1992). Survey of properties and constraints of the acid sands of Mid-West Nigeria to higher yields of Rubber (*Heveabrasiliensis*, Muell Argo) Trees. *Nigerian Journal of Agricultural Science*, 6, 34 - 40.
- Anang, B. T., Adusei, K., & Mintah, E. (2011). Farmers' assessment of benefits and constraints of Ghana's cocoa sector reform. *Research Journal of Social Sciences*, 3(4), 358 - 363.
- Arshad, N. L., Mohamad Hassan, M. J., Ibrahim, A. G., Mahayana Bongkik, D. Y., & Wahab, M. A. (1997). *Viability of Hevea plantation for wood production*. Seminar on Commercial Cultivation of Teak, Sentang, Acacia and Hevea for Timber, Forest Research Institute Malaysia, Kuala Lumpur.
- Asante, M. K., & Kuwornu, J. K. M. (2014). A comparative analysis of the profitability of pineapple-mango blend and pineapple fruit juice processing in Ghana. *Applied Studies in Agribusiness and Commerce*, 8(2 - 3), 33 - 42.
- Banmeke, T. O., & Omoregbee, F. E. (2009). Farmers perception of the factors militating against rubber production in Edo and Delta States of Nigeria. *International Journal of Agricultural Economics and Rural Development*, 2(2), 33 - 39.
- Barlow, C., & Tomich, T. (1990). *Indonesian agricultural development: the awkward case of smallholder tree crops*. Department of Economics, Research School of Pacific Studies, Australian National University: Canberra.
- Chan, H. Y., Yew, F. K., & Pushparajah, E. H. (1984). *A soil suitability, technical grouping system for Hevea (3rd ed)*. Asian Soil Conference. Kuala Lumpur, Malaysia.
- Delarue, J. (2008). *Developing smallholder rubber production: Lessons from AFD's Experience Vietnam report*. Evaluation and Capitalisation Series Unit, AFD.

- Evans, J. & Turnbull, J.W. (2004). *Plantation forestry in the tropics. Role of silviculture, and use of planted forests for industrial, social, environmental and agroforestry purposes* (3rded). edition, Oxford, UK, Oxford University Press.
- FAO. (2001). *Non-Forest Tree Plantations*. Working Paper FP/6, Food and Agriculture Organisation, Forestry Department.
- Giroh, D. Y., Adebayo, E. F., & Jongur, A. A. (2013). Analysis of labour productivity and constraints of rubber latex exploitation among smallholder rubber farmers in the Niger Delta Region of Nigeria. *Global Journal of Agricultural Research*, 1(3), 16 - 26.
- Grist, P., Menz, K., & Thomas, M. (1998). *Modified BEAM rubber agroforestry models: BRYIELD and RRECON*. ACIAR Technical Reports Series No.42, ACIAR, Canberra.
- International Rubber Study Group-IRSR. (2010). *Statistical summary of world rubber*. Retrieved December 12, 2014. Form <http://www.rubberstudy.com/statistics.aspx>.
- Issaka, R. N., Senayah, J. K., Andoh-Mensah, E., & Ennin, S. A. (2012). Assessment of fertility status of soils supporting Coconut (*Cocosnucifera*) cultivation in Western and Central Regions of Ghana," *West African Journal of Applied Ecology*, 20(1), 47 - 56.
- Jumpasut, P. (2004). *Global natural rubber and synthetic rubber development in the next decade: focus on new Asia*. The International Rubber Conference, 1.
- Kimengsi, J. N., & Muluh, N. G. (2013). A Comparative assessment of the effect of climatic variations on the crops of the Cameroon Development Corporation (CDC). *Adaptation Options Environment and Natural Resources Research*, 3(1), 144 - 156.
- Kinnaman, B. (1997). *History of Rubber*. Retrieved December 19, 2014. From <http://www.immune.com/rubber/index.html>.
- Kochhar, S. L. (1981). *Tropical crops: A textbook of economic botany*. London: Macmillan.
- Krishnakumar, A. K., & Potty, S. N. (1992). Nutrition of Hevea. In Sethuraj, M. R., and Mathew, N. M. (Eds.) *Natural Rubber: Biology, Cultivation and Technology. Developments in crop science*. Elsevier, Amsterdam, Netherlands, pp. 239 - 263.
- Legendre, P. (2005). Species associations: the Kendall Coefficient of Concordance Revisited. *Journal of Agricultural, Biological and Environmental Statistics*, 10(2), 226 - 245.
- Legendre, P. (2010). Coefficient of Concordance. In N. J. Salkind, *Encyclopedia of Research Design*. 1, p. 1776. Los Angeles: SAGE Publications Inc.
- Lemmens, R. H., Soerianegara, I., & Wong, W. C. (1995). *Timber trees: minor commercial timbers. Plant resources of South-East Asia, (PROSEA)*, Backhuys Publishers.

- Manivong, V., & Cramb, R. A. (2007). *Economics of smallholder rubber production in Northern Laos*. Contributed Paper 51st Annual Conference Australian Agricultural & Resource Economics Society, Queenstown, New Zealand, 13 - 16 February.
- Mesike, C. S., & Esekade, T. U. (2014). Rainfall variability and rubber production in Nigeria. *African Journal of Environmental Science and Technology*, 8(1), 54 - 57.
- Miller, R. L., & Brewer J. D. (2003). *A-Z of social research*. SAGE Publication Limited: London.
- Molua, E. L., & Lambi, C. M. (2007). *Economic impact of climate change on agriculture in Cameroon*. Policy Research Paper No.4364, 51-55, World Bank, Washington D.C.
- Ogbebor, O. O. (2013). *The Sustainability of agriculture in Nigeria using rubber as a case study*. (Master Thesis, East Tennessee State University). <http://dc.etsu.edu/etd/2312>.
- Opeke, L. K. (1982). *Tropical Tree Crops*. New York: Wiley.
- Oseini, J. O., & Adams, A. Q. (2013). *Cost benefit analysis of certified cocoa production in Ondo State, Nigeria*. Invited Paper at the 4th International Conference of the African Association of Agricultural Economists. Hammamet, Tunisia.
- Osiebe, P. E. (1999). *Reasons for the rapid decline in rubber production in Ethiopie West Local Government Area of Delta State*. (B. Agric Thesis, University of Nigeria, Nsukka).
- Papenfus, M. M. (2000). *Investing in oil palm: an analysis of independent smallholder oil palm adoption in Sumatra, Indonesia*. Southeast Asia Policy Research Working Paper, 15.
- Perkins, F. (1994). *Practical cost benefit analysis: basic concepts and applications*. Melbourne: Macmillan Education Australia.
- Purnamasari, R., Cacho, O., & Simmons, P. (1999). *Management strategies for Indonesian smallholder rubber production in South Sumatra: A bioeconomic analysis*. Working Paper Series in Agricultural and Resource Economics No.99. Graduate School of Agricultural and Resource Economics, University of New England: Armidale.
- Rantala, L. (2006). *Rubber plantation performance in the Northeast and East of Thailand in relation to environmental conditions*. University of Helsinki, Finland, Viiki Tropical Resources Institute (VITRI).
- Rao, P., & Vijayakumar, K. R. (1992). Climatic requirements, In Sethuraj, M. R. and Mathew, N. M. *Natural Rubber: Biology, Cultivation and Technology*. *Developments in crop science*, Elsevier, Amsterdam, Netherlands, pp. 200 - 220.
- Rodrigo, V. H. (2007). Ecophysiological factors underpinning productivity of *Heveabraziliensis*. *Brazilian Journal of Plant Physiology*, 19(4), 245 - 255.
- Royal Forestry Department. (2000). *Status of rubberwood utilization and marketing in Thailand*. Technical Report, Executing Agency, Forest Research Office, Royal Forest Department, p. 90.

- Rubber Board of India. (2005). *Rubber and its Cultivation*. Rubber Board India (RBI), Government of India, Ministry of Commerce and Industry, Kottayam.
- Rudolf, W., & Hermann, W. (2009). *Climate Risk and Farming Systems in Rural Cameroon*. University of Hannover, Institute of Development and Agricultural Economics, Hannover, 21 - 24.
- Sangsing, K. (2004). *Carbon acquisition and plant water status in response to water stress of rubber (Heveabrasiliensis)*. (Ph.D. thesis, Kasetsart University).
- Sekar, C., & Karunakaran, K. R. (1994). Economic Analysis of Cashew Plantations Under Forestry Conditions of Central Tamil Nadu. *Journal of Tropical Forest Science*, 6, 523 - 528.
- Uraih, O. B., Abubakar, M., Balogun, F. E., Giroh, D. Y., Ogbemor, O. J., & Okwu, U. N. (2006). Assessment of Rubber Quality Consciousness Among Smallholder Rubber Farmers in Farm Settlements of Edo and Delta States of Nigeria. *Journal of Sustainable Tropical Agricultural Research*, 19, 46 - 51.
- Viswanathan, P. K. (2005). Emerging smallholder rubber farming systems in india and Thailand: a comparative economic analysis. *Asian Journal of Agriculture and Development*, 5(2), 1 - 16.
- Wongnaa, C. A., & Awunyo-Vitor, D. (2013). Profitability Analysis of Cashew Production in Wenchi Municipality in Ghana. *Botswana Journal of Agriculture and Applied Science*, 9(1), 19 - 28.

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