Supply Response of Coffee in Papua New Guinea

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Abstract

This paper is presented in twofold. The first part of the paper summarizes the field survey results, which provide a descriptive analysis of the factors that affect coffee production and export supply in Papua New Guinea. From the survey, it was established that there are many non-price factors that are pivotal in determining the production and export supply of coffee in Papua New Guinea. The survey highlighted a lot of variables that were influential in affecting production and export supply of coffee in Papua New Guinea. Due to data limitations; the second part of this paper uses variables that have available time series data to establish an Error Correction Mechanism (ECM) model to establish a supply response function for the coffee industry in Papua New Guinea. According to the model results, developments in international price of coffee does not have any influence on the production and export supply of coffee in both the short and long-run. Trade weighted income levels of major coffee trading partner countries have a long-run effect on the production and export supply of coffee in Papua New Guinea. A percentage change in the income level of trading partner countries would result in a 0.21 percent increase in the production and export supply of coffee in the long-run. In the short-run, previous period production level and national elections affect the production and export supply of coffee. A percentage increase/decrease in previous period production would result in 0.86 percent increase/decrease in production and export supply of coffee in the current period, while during election period production and export supply of coffee on average declines by 0.136 percent.

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1.0 Introduction

The aim of this paper is to establish the causal effect of changes in the price of coffee to the production and supply of coffee, a major source of employment and income for growers and foreign exchange earnings of Papua New Guinea (PNG). Furthermore, other factors that impinge on coffee production in PNG will also be highlighted in the study. In this study, both quantitative and qualitative analyses were done to examine the causal impact of international price movements and other variables on the production and export supply of coffee in PNG.

Coffee in PNG is produced mainly by smallholders, block-holders and a few plantations. A cross section data study was done on smallholder producers, block-holders and plantations in major coffee producing provinces to establish the variables that affect production and supply of coffee. Study results showed that a wide variety of factors influence coffee production and supply in Papua New Guinea. It was established that other economic and non-economic variables directly or indirectly affect the production of coffee. Factors such as the need for revenue to meet community obligations like compensation, school fees, food, bride price payments, infrastructure like roads and bridges, labor, land, state of technology, age and stock of coffee trees, etc. affect the volume of coffee production by producers. An Error Correction Mechanism (ECM) model confirmed the cross sectional data analysis for the coffee industry, with coffee production and supply in both the short and long-run not responding to international price movements but to other non price variables that can not be quantified.

A number of studies have been done on coffee production in PNG on all producer levels. Various publications by Coffee Industry Corporation (CIC) have alluded to the existing literatures. There is however, only few known publications on 'Supply Response of coffee", i.e. by McLaren and Fleming (1999) on *Coffee Supply Responsiveness to price and exchange rate in Papua New Guinea: Tree crop policy options project in Papua New Guinea.* They use coffee prices, exchange rate and the price of fruits and vegetables as the main economic variables to determine supply response in PNG. There are other papers by International Coffee Organization (ICO) (1958) and, Beaummont and Fukunaga (1958) which alluded to weather as one factor that can cause production to fluctuate.

This paper is organized as follows: the first section discusses the economics of coffee supply in PNG, a descriptive overview of the coffee production and export supply. The second section looks at the survey results and discussions, dissecting factors that affect coffee production and supply in PNG, followed by the section on the major constraints that challenge the productive capacity of the coffee industry. Since time series data is not available for all the variables discussed as major determinants of coffee supply, the next section will use those variables that have available time series data to develop a model for the coffee industry supply response function. This will be followed by conclusion, recommendations and highlight areas of future study.

2.0 Economics of Coffee Production and Supply in PNG

Coffee is one of the leading agricultural export commodities and an important commodity for the producers. It generates employment and income for the producers. It also affects PNG's terms of trade (TOT), exchange rates and provides a sustainable income base for the growers. It has supported PNG's economy since it was first grown commercially in the 19th century. The production and export of coffee fluctuated over time, mainly attributed to a number of very important factors, like the price of coffee, prices of other alternative cash/marketable commodities, fluctuations in the exchange rates and changes in lifestyles of the producers plus many more. The important role played by coffee in creating employment, income, determining the terms of trade and exchange rates, has interested the Bank of PNG to survey major coffee-producing provinces in the country in 2009, 2010 and 2011 to collect data on the patterns of coffee production by smallholders, block-holders and plantation estates and get their views on other factors that affect their decision to produce, apart from the price of coffee. It was found that price of coffee has little or no impact on the production and supply of coffee. Non-price factors, however are the main determinants of coffee production and supply in PNG. Smallholder producers also respond positively to the demand for revenue to meet community obligations (customs, pride price payments, compensations), school fees and food by increasing production of coffee.

"There are mainly two types of coffee grown in PNG, Arabica and Robusta. The Arabica variety is grown mainly at high altitudes in Morobe, Eastern Highlands, Chimbu, Enga, Southern highlands and Western highlands provinces and account for almost 95 percent of total production, while Robusta is grown in the lowlands, mostly in the Sepik region, Milne Bay and East New Britain, which account for only 5 percent of total production in PNG" *(CIC various publications)*.

Smallholders account for almost 85 percent of the total coffee production in PNG. There are currently over 2.5 million people in fifteen provinces in the country benefiting directly or indirectly with the production of both Arabica and Robusta coffee. Each smallholder owns at least 2 hectares[1] of coffee plots, which produces on average 850 kilograms[2] annually. The smallholders produce cherries to parchment using simple hand pulpers, sun drying and sell the parchment to roadside buyers and factories. *Plantations* produce around 10 percent of total coffee production in PNG. Currently there are about 15,000 hectares of coffee plantations with individual plantation covering an average area of over 50 hectares, with some having more than 220 hectares. The established stock of coffee trees existed for many years and replacements took place frequently to maintain the same level of coffee trees or expand into new areas. Plantations established both wet and dry processing facilities and sell directly to an exporter if they do not hold an export license. However, those who have export licenses are able to export directly to buyers overseas and are able to fetch premium prices. Almost a third of the plantation sector is integrated through

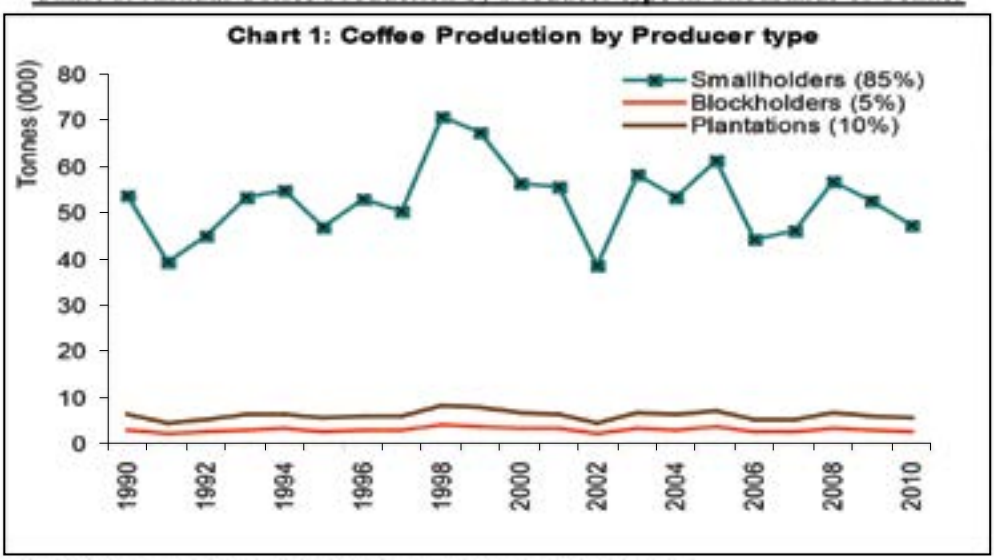
[1] Studies from CIC indicate that the size of smallholder plots averages 0.34 hectares which ranges from 0.05 – 5 hectare.

[2] CIC also indicated that Yields range from 0.06 tonnes to 1.15 tonnes with an average of 0.7 tonnes per hectare per year.

to the export stage. The last group of coffee producers are the Block-holders, which produces around 5 percent of total coffee production. The Block-holder scheme was established through the *'20 hectare block'* scheme administered by the Agriculture Bank (now called National Development Bank), with funding support from the World Bank in the 1970s. The block-holder scheme is not popular today, but there are some, still active and able to produce coffee. Their structure is somewhat different from both smallholders and plantations.

The price[3] smallholder producers receive is less than the premium price exporters receive; producers complained about the distorted market price they receive and not according to world market price movements, and this act as a major disincentive to produce more. This is a case of price distortion and is evident in the coffee industry, where there are a number of middle-men in the supply chain. The middle-men get their cuts, while reducing the price the coffee producer receives at the farm gate. The supply chain of coffee starts from the coffee producer, coffee cherry buyers, road-side parchment buyers, processors, roasters to exporters. This is where coffee price seemed to get distorted with extra's charged for transport and service fees. Each of the player in the supply chain have unique role and they want their role to be compensated. For example, the primary coffee producers' job is to take care of the coffee garden and pick the cherries. He/She may decide to sell the coffee in the form of cherry or hand-pulp and dry the coffee to sell as parchment to roadside buyers.

Chart 1: Annual Coffee Production by Producer type in Thousands of Tonnes



Source: CIC various publication and BPNG Quarterly Economic Bulletin

The road side coffee buyers play important roles in the coffee supply chain from the farm gate through to the factory and export. They provide a link between the

[3] CIC indicated that producers of coffee receive 60-70 percent of the FOB price of coffee, which is similar to what producers in other countries receive. CIC's current observation is that the marketing margin tends to increase as price of coffee increase.

smallholder coffee growers and the processors and factories. Most of the factories are located close to the main highways, some kilometers away from the bulk of the village-based smallholder producers, whose coffee blocks are located in their respective villages. It is the coffee buyers, who act as the middle men, buying coffee from the smallholders and reselling them to the factories and exporters. There are currently 84 coffee processors in the country, which buy coffee cherry and parchment from buyers or smallholders. Some of the plantations have their own processors. A standard processor has a throughput capacity of 25,000 bags, but there are some, which can process up to 100,000 bags (CIC various publications).

The consistent production and export of coffee in PNG is not an easy task, due to the varying geographical features of each province, bad weather and deteriorating physical infrastructures like roads and bridges, all of which play important roles in determining the continuous production and effective supply of coffee for exports. Coffee export has been the highest earner in foreign exchange income of agriculture commodities until 1999, when oil palm[4] took over and became the highest foreign exchange income earner for the country. Coffee export remains somewhat stable and combined with fluctuations in production and prices, its contribution to export earnings declined. However, in 2005, for the first time after five years, coffee briefly took over again as the major export earner, helped by improved price and production.

Previous studies by McLaren and Fleming (1999) on the supply responsiveness to international price movements have shown that coffee supply respond positively to movements in price, with lagged responses. Smallholders supply response seemed to be larger than the plantations, with alternative crop prices having minimal effect on the supply of coffee. Besides the price of coffee, exchange rates and prices of alternative agricultural crops, other non-economic variables also affect production of coffee. If these factors affect the short run and long run production of coffee in PNG, they are significant to affect employment, income and export earnings.

The PNG coffee industry, despite its challenges, maintained a degree of competitiveness at the world market. During the early 2000s world coffee prices were at historical lows, but the depreciation of the kina and high demand for coffee helped to prop up the kina returns to PNG growers. In 2011, in association with adverse weather conditions in Brazil and an upturn in the normal coffee price cycle, Arabica prices reached their highest level since 2005, with the World Bank predicting coffee prices to remain high relative to the previous years.

Fundamental changes in the world coffee market and changes in government support towards the coffee industry will have major implications for the future of the overall coffee industry in PNG. Since the late 1990s, world coffee industry has grown strongly at the retail level but remained stagnant at the producer level. In the early 1990s the retail value of the world coffee industry was about US$30 billion; it has now exceeded US$70 billion, but the growers' share of profits has fallen from 40 percent to 10 percent (Bourke, R.M. and Harwood, T. (eds) (2009). The future success of exporting countries like PNG depend on being able to adjust to this new reality and especially smallholder

[4] Discussed in the Working Paper on supply response of Oil Palm.

producers should be assisted and encouraged to tap into this.

In addition, there has been a huge increase in the output of low-quality Robusta coffee from Vietnam and medium-quality Arabica coffee from Brazil. The abundant availability of low-priced coffee has brought about a permanent shift in demand. If PNG's coffee industry is to remain competitive and viable in the longer term it must produce more, better-quality coffee. This can be done through a number of mechanisms including grower groups, where members are committed to producing higher grade coffee, who in return are rewarded with higher prices for their products. It was discovered in the survey that the smallholder growers in PNG are organizing themselves into growers association and groups to tap into this high market by producing coffee according to the specific requirements by the market. The PNG Government has set a production target of 90 000 tonnes by 2016. However, achieving these levels is likely to be constrained by limited areas of suitable land in the highlands, ongoing pressure on land associated with population growth, low world prices, inadequate road access for many producers, and lack of proper government assistance, high input costs, and uncertainty in weather patterns associated with global climatic change. Coffee berry borer (CBB) is a serious insect pest currently present in Irian Jaya (Indonesian boarder) and require urgent quarantine action along the border to prevent it from moving into PNG. If the CBB enters and establishes itself in PNG, it is likely to have a severe effect on coffee production.

Table 1. Export Prices and Volume of Coffee

Period	Coffee Export Prices (All Grades)	Export Volume ('000 tonnes)	Export Earnings (million kina)	Share of Total Agricultural Exports (%)
2001	3,771	65	246.6	30.7
2002	4,384	45	276.6	25.5
2003	4,337	69	298.5	21.5
2004	4,514	63	283.8	16.8
2005	6,533	72	471.0	24.2
2006	6,444	52	337.0	20.4
2007	7,493	55	408.4	17.8
2008	7,772	67	520.2	17.5
2009	7,260	62	460.3	20.7
2010	9,179	56	521.0	18.9

Source: Bank of PNG

3.0 Survey Description

The Bank of PNG conducted a field survey in major coffee-producing provinces in the country in 2009, 2010 and 2011 to collect data on the production and supply of coffee by smallholders, block-holders and plantation estates and collect their views on the factors that affect their decisions on how much and why they produce coffee. This is to investigate the long-held view that, production of coffee in PNG is sensitive

to movements in the prices of coffee. It was shown by (McLaren and Fleming (1999)) that changes, whether an increase or a decrease in the price of coffee tend to have a positive correlation with the production and supply of coffee. External price shocks can drastically affect production of coffee in PNG. However, the change in prices is not the only factor; there are also other economic and non-economic factors that affect the production of coffee in PNG. The project team visited smallholders, block-holders and some plantations to collect cross-sectional data, including the reasons that drive producers to produce coffee.

3.1 Survey Results and Discussions

The following discussions are based on the interviews carried out with various important stakeholders/players in the coffee industry, including the CIC, a number of plantations, block-holders and various smallholder producers across the major coffee-producing provinces; Eastern Highlands, Western Highlands and Jiwaka. The survey results showed clearly why coffee producers produce coffee and at the same time are able to produce other alternative cash crops and garden produce. The results also showed problems faced by the producers vary in each geographical location, affecting the production and movement of coffee to the nearest market. For example, the problems faced by a producer in Okapa are not the same as the problems faced by a producer in Kainantu or Karamui.

3.2 What determines Coffee Production and Supply?

The survey found that coffee is produced in PNG for varying reasons, which also highlighted the key driving forces that affect production. The objective of the coffee producer plays an important role in determining what to produce, why they do so and how much to produce. The smallholders and block-holders produce coffee to maintain their income and sustain their livelihood, while the plantations' produce coffee for commercial purposes, profit maximization, and adding value to the shareholders. The producer may aim either at maximising money income from the sale of coffee, or maximising non-monetary income such as earning goodwill or building-up his/her reputation as a producer in the society. Out of these two objectives, money income is more common in the coffee growing segments in PNG. The amount supplied will depend upon which objective a producer pursues and differ greatly in both cases. At the same price, the amount supplied may be smaller when coffee is produced as an income earning commodity, while it could be larger if the producer produces for reasons other than income, like prestige or reputation.

As a cash crop, coffee is grown by most households in the coffee growing provinces, and forms an important basis for direct/indirect employment and regular income for the families involved, including the block-holders and plantations. One of the many important element that influence the production of commodities for sale in PNG, including coffee, is the returns to labor and capital investment; that is, how much a person can earn with his/her inputs of labor, tools, equipment and machines. Also

the demand for revenue to meet certain obligations like school fees, bride price payment, compensation, improving living standards, improving people's wealth and participation in traditional customs and traditions, etc. compels people to work on their coffee plots to earn the income they need to meet these obligations. Coffee generated more income than any other commodity in the past. However, price incentives, access to land, credit and appropriate inputs, public investments in roads and transport and extension services, are some of the key factors in improving production and are virtually absent in some of the coffee growing regions renown for producing quality coffee.

In the survey, it was established that the following factors affect the producer's decisions on how much, when and why they produce: price of coffee; prices of other commodities; cultivation of other crops; state of technology used; labor input and return on labor; number of producers; management skills and time management; customs/ traditions; inputs and prices of inputs; land accessibility; size and quality; coffee tree stock and age; coffee seasons; assistance and weather patterns.

3.2.1 Price of Coffee

The price of coffee plays a crucial role in determining how much coffee a producer produces. The world market price of coffee is determined by the interaction of world market fundamentals of supply and demand for coffee. If the world market supply is low as a result of natural calamities like frost and drought in major coffee producing countries, and speculation by market players of possible risks associated with the natural disasters could force demand for coffee to increase, overtaking supply. This will result in high price of coffee around the world. The vice versa is true for an increase in world coffee supply overtaking the demand for coffee, resulting in the fall in international price of coffee.

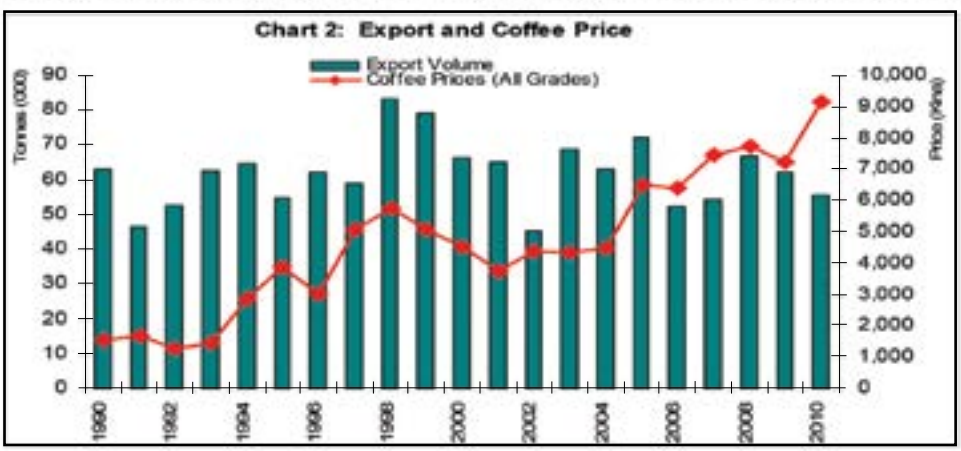
Coffee prices at display at one of the buying points: Photos: Aba (2011)

Does the price of coffee has a bearing on the amount of coffee produced in anyone time in PNG? Studies by McLaren and Fleming (1999) using a static Nerlovian partial adjustment model shows that supply of coffee especially by smallholders has an

elasticity of 0.23, which means that a kina change (increase or decrease) in the price of coffee will result in a 0.23 percent change (increase or decrease) in the supply of coffee. Aside from other factors, the price of coffee tends to have a positive relationship with supply. This was confirmed by the survey carried out by the Bank of PNG that producers respond positively to changes in price of coffee. Almost 100 percent of the producers interviewed indicated that change in coffee price affect their decisions to produce coffee. That means, the quantity of coffee supplied over a certain period of time is directly related to its price. That is, the quantity supplied increases as price increases and decreases as price decreases.

The interaction of the forces of supply and demand at the international market, exchange rate fluctuations and any levies or bounties imposed by CIC, determines the final price a smallholder coffee producer receives in PNG. The final price determines whether or not a smallholder coffee producer in PNG will still be able to produce coffee at that price to sustain themselves and meet the demand for coffee. For example, in the Highlands, a decline in coffee price is a major disincentive resulting in producers switching to other cash commodities like sweet potato, sugar cane and other fresh food, which earn higher return in the short run than coffee. This is because almost 90 percent of people in coffee producing areas live in areas where they can still earn an income from selling fresh garden produces.

Chart 2: Annual Export Volumes in Thousands of tonnes and Coffee Price

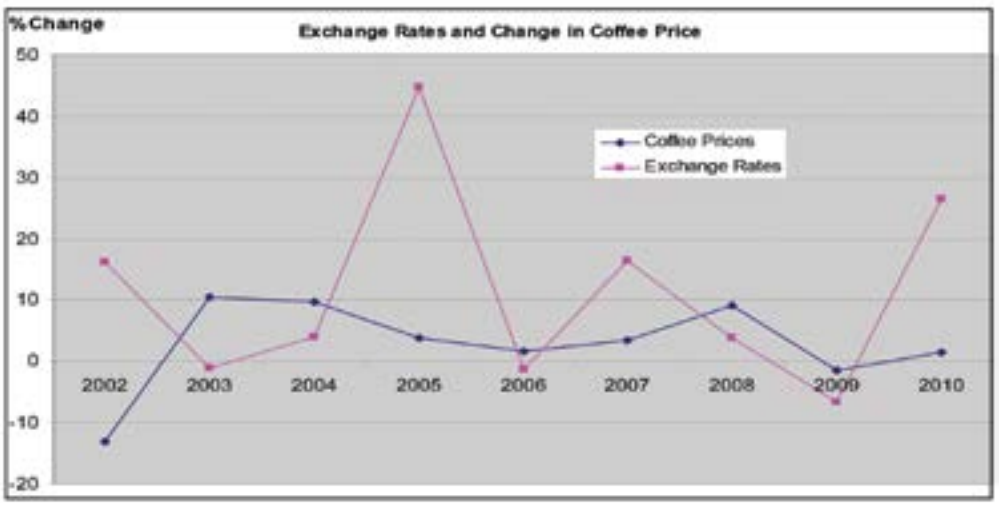


Source: Bank of PNG

The developments in the exchange rates, an appreciation or depreciation, also determine how much a coffee producer gets in kina. In the paper by Kauzi and Sampson (2009), they found that the international prices of PNG's export commodities, including coffee, have a significant impact in determining the value of the kina. These results showed that producers in PNG are vulnerable to external coffee price shocks. This view was also confirmed in the BPNG survey that all the producers interviewed

confirmed that exchange rate fluctuations are affecting the kina price they receive. Since the kina was floated, coffee and other agricultural commodities producers have received higher return in kina, compared to the 'hard kina policy' period from 1975 - 1994. Some of the plantations surveyed expressed that after the exchange rate was devalued and floated, PNG coffee exports were competitive at the world markets and improved greatly the prices producers in the village and plantations receive.

Chart 3: Exchange Rates and Annual Percentage change in Coffee Price



Source: Bank of PNG

3.2.2 Prices of Other commodities

As the prices of other competing farm produces (which the producer is willing and can produce) rise, it becomes worthwhile for the producer to shift some of his/her resources, including labor to the production of that commodity. The producer has the choice of producing other commodities that could earn him more income in the short run and consequently little attention is given to the coffee garden, resulting in the fall in production and supply of coffee. For example, in the highlands, if the prices of coffee drops or remain stagnant, while the prices of other cash crops like sweet potato, English potato, cabbage, carrots, etc. increase, people tend to switch and concentrate their labor on producing them, while their coffee gardens suffer from lack of adequate attention. The sale of fresh food provide cash income to more households than any other activity because more than 90% of rural villagers live in households where income is derived from the sale of fresh food. Therefore, there is an inverse relationship between the price of other fresh farm food and the supply and production of coffee. This was confirmed through the BPNG survey that 80 percent of the coffee producers interviewed expressed that when the price of other commodities that they grow increase, for example, sweet potatoes, they tend to move into production of more

sweet potatoes and less attention is given to coffee. This clearly shows that prices of other agricultural commodities do affect people's decision on how much coffee to produce and hence have an overall impact on total production.

3.2.3 Cultivation of other crops and Intercropping

Coffee is also intercropped with other trees, plants and staple garden foods. Casuarina, which is a legume tree, harboring nitrogen fixation bacteria that converts and assimilate nitrogen into neighboring plants, which is essential for growth and development is planted together with the coffee trees for shade and nitrogen intake. Apart from coffee, other marketable commodities are produced in the same blocks, which they can consume and sell at the local markets. All the producers surveyed reported that they grow banana, sugar cane, sweet potato, variety of vegetables, taro, yam, alongside coffee plots. Some of the produce is for domestic consumption, while surplus is sold for extra income. The time and the amount of labor spent into the production of these other commodities differ between coffee seasons. During the peak coffee seasons, the entire family labor force is employed in the coffee blocks, while in the afternoon one or two members of the family attend to their garden to harvest food for dinner. A number of the other commodities are not available in full supply during coffee season. These crops also compete with coffee for nutrients and can affect the overall production.

Other Cash crops like banana, sugar cane, cabbage, carrots, beans and more generally garden foods are grown alongside with coffee. Photos: Irau and Aba (2011)

3.2.4 State of technology

The type of technological input varies with producer type and level. For example, a simple coffee producer uses simple garden tools and hand pulper to produce coffee

while, the block-holders and plantations use more advanced and improved equipment and technology. With improved technological input into the production of coffee, the total cost is likely to fall and this will lead to a rise in the quantity of coffee supplied. On the other hand, if the technology is poor, the total cost may rise and this will result in a fall in the quantity supplied. For example, hand coffee-pulper is being used by almost all the smallholder coffee growers and if there is a change to an electric coffee pulper with improved drying sheds, could lead to an increase in coffee parchment. Also, coffee is hand picked in all plantations and blocks in PNG. Some of the plantations are old and all the equipment they have are also very old. For example, the Anego Coffee Limited was established in the 1960s and machines and equipment that they use are as old as the coffee factory itself. Currently, the spare parts and equipment to replace these aging items are very expensive. Also the Baroida coffee plantation in Ombura/Waninara district in Eastern Highlands province is also very old and the machines and equipment they have are also very old but functioning as a result of good management.

These are the kind of plant and equipment that are used to process coffee from cherry through to the export. It was mentioned to the team that some of them are very old and need replacement but the parts are very expensive. Photos by: Irau and Aba (2011)

3.2.5 Labour and return on Labor

One of the important reasons for the producers to produce coffee is the return on labor investment. If the income they get from producing coffee is high, they will concentrate their labor in producing coffee. From the survey, it was found that there is a direct relationship between high returns to labor and high levels of participation in the production of a commodity. Where returns to labor for coffee are lower than expected per person per day; production of coffee takes the form of 'target' amount. People can produce up to the point where they earn their target amount then stop producing more coffee. Furthermore, producing coffee by the smallholders is a hard and tedious work, which requires commitment; therefore, to attract producers into producing more coffee, the returns to their labor should be attractive.

In the smallholder sector, the family unit, averaging around ten, forms the basis of

labor input into the production of coffee. The family unit consists of the father, mother, and their children and to some extent, extended family members. The amount of labor and time spent on the coffee gardens varies with each family unit. It depends on the size of the coffee gardens and blocks and alternative chores. Here division of labor is evident, where most families prefer to split their labor so that the other members take care of non-coffee activities, while the core family members attend to coffee. This means the total manpower hour dedicated to coffee is reduced. They attend to their coffee gardens in the morning when it is cooler to do the hard manual work and spend the afternoons to do other activities. A bigger sized coffee garden needs more labor to clean and pick the coffee cherries during peak coffee seasons from the extended family members. The labor is booked and everyone is notified in advance, in which they appoint a certain day when everyone agrees to chip in their help. Income from casual labor can be moderately high for some rural people in the highlands during the coffee harvest season, particularly when prices are high.

The family unit forms the basis of labor input into the production of coffee and producers are sensitive to the returns they get from their production. Photos: Irau, Aipi and Aba (2011)

In the survey, it was found that 49 percent of the total labor force is adults, comprising of the head of the family (15 percent), spouses (13 percent), and children who are above 15 years old (21 percent). The rest of the labor force, around 51 percent, comprises children, between the ages of 10-14 years old (11 percent), less than 10 years old (21 percent), adult relatives who are above 15 years old (3 percent), other relatives and employees consist of 16 percent. The number of children in each family unit constitutes the bulk of the labor force, especially during the harvest season. Coffee production and income received from it are considered to be part of the overall family wealth. In some of the coffee producing societies, wealth is measured in the number of livestock (chicken, goats, pigs, sheep, cattle) trade stores and PMVs or even the size of the

coffee gardens and the number of bags harvested. Most family interviewed at least has one or two traditional wealth indicators, like pigs, goats or chickens, while some even have trade stores and PMVs. Producers can lift the yield of coffee by increasing the use of labor, and other inputs like natural fertilizer (organic material) and other methods such as upgrading/pruning on existing stock of trees in the short run.

3.2.6 Number of producers

The higher the number of producers producing coffee, the larger the amount of coffee supply. For smallholders, a standard family unit that consists of 10 members can have up to 2-3 hectares of coffee plots. If the producer sees that the area is big, he/she decides to employ other people, mainly extended family or relatives, to work in the coffee garden and harvest during coffee season and pay them in kind or cash. Coffee production also increases when settlers from other non-coffee areas migrate to coffee growing areas. For instance, the recent increase in the price of coffee lured a good number of people from tea picking areas to coffee. The number of smallholder producers varies from time to time, depending on their mood and need to involve in coffee growing and production. However, with the blocks and plantations, the situation is different; the number of producers is fixed over a certain period of time. For example, it can take long period of time and hard work for a smallholder to become a block holder or a company to enter the plantation sector. The reasons for the entry of new producers differ but the fact remains, the higher the number of coffee producers, and the larger the amount of coffee being produced for sale. If the number of producers increases without expanding the existing acreage, total production will remain stagnant or could decline.

The number of producers depends on how large a family is or attractive the incentives a grower give to its employees. Producers listening to CIC and BPNG officers at Bena Korofegu and Lufa in EHP. Photos: Aba & Irau (2011).

3.2.7 Management skills/ Time Management

Good management practices are an ingredient to improving productivity of any commodity, including coffee. Most of the smallholder growers lack fundamental skills to manage their blocks, time, returns from coffee blocks, and income from other alternative cash crops. Most of the incomes are mismanaged through gambling or drinking so there is nothing left to reinvest back to the coffee blocks or other investments. This limits the ability of producers to expand or invest in other areas. Despite the assistance from CIC, they also lack knowledge on management and control of pests and diseases, which affect production.

Time management has become a critical factor in the production process. Management of time by out-growers is non-existent. They divide their time among other activities, including tending to food gardens and engage in customary discussions and gatherings. They do not commit 100 percent of their time to managing coffee blocks. The smallholders and to some extent the block-holders are not time conscious, they work in their coffee blocks whenever they wish or when they need cash. The good use of time and the management skills that they acquire and posses could result in increasing production of coffee in the long run.

3.2.8 Customs/Traditions

It was learnt that customary practices play a pivotal role in the production process. The demand for cash associated with bride price payment, compensations, 'head' pays, funeral expenses, etc. normally compels smallholder coffee producers to look for ways to earn money to contribute for these events. They are obliged through their customs to be involved in such practices through cash contributions. All the coffee producers interviewed explained that the demands for cash in such circumstances force the people to work on their coffee plots to raise enough money to meet these obligations, as well as their immediate personal and family needs. Also for example, fears of sorcery and reprisals can lead to absence from work in the coffee blocks, which can also affect production. The people believed to practice sorcery are chased out from their blocks and the blocks are abandoned or taken over by someone else. Customs and traditions also play an important role in determining how much coffee a producer can produce.

3.2.9 Inputs and Prices of Inputs

To enhance the production of coffee and maintain the same level of production, appropriate inputs are needed, including access to financial capital. The coffee producers use inputs such as land, fertilizers, herbicides, knapsack sprayer, spades, bush knives, pruning tools, labor, wheel barrows, tractors, trucks etc. to enhance production. The use of inputs differs among the three types of producers. For example, the smallholder producers mainly use hand tools such as spades, grass knives, hand pulper, knap-sack spray, canvas, and wheel barrow. The block-holders and plantations

use complicated inputs, including labor. They use trucks, tractors, electric pulpers, canvas etc. However, the cost of these inputs have increased significantly over time and make it expensive and almost impossible for smallholder producers to buy, for example, a bag of fertilizer to enhance production. Some of the inputs, especially hand tools that they use are very old and are costly. For the block-holders and plantations, cost of labor has gone up, infrastructure like roads and bridges are falling apart, spare parts and maintenance cost have increased. The increases in cost have forced some of the plantations to operate at break even point and some have shut down due to landownership issues and continuous neglect of infrastructure like roads and bridges.

Prices of the factors of production also determine why and how much coffee a producer can produce. As the factor prices increase the total cost rises too and the producer is inclined to reduce the supply of coffee. Similarly, as the factor prices decline the total cost falls and the producer is inclined to increase the supply of coffee. The factors of production available to the smallholder producer are their customary-owned land, their own labor and basic garden tools like grass knives, spades, pruners, saw, knap sack sprayers, herbicides, natural fertilizer (legume trees) etc. If the prices of garden tools increase, the producer cannot buy that tool with his/her limited income, so will choose not to work in his/her coffee garden, thus allowing the weeds to take over coffee gardens. Some of the tools such as spades and bush knives are also for other household chores like breaking firewood and is not available full time. Almost 99 percent of the smallholder producers who were interviewed said any increase in the prices of tools and other inputs will stop them from buying them. Financial capital is not easily available to the smallholders, 70 percent have never done banking and access to finance through the banks is not an option for them. The story for block-holders and plantations is different; they obtained land through the government's lease-lease back system or sometime outright purchase from customary land owners. The payment for the land is done at the beginning with this method of land acquisition. However, with the lease-lease back method, they continue to pay rentals to the government. They employ laborers and pay them wages. When the minimum wages increase, it increases the total costs of production for plantations so they have the choice to reduce cost and lower production by laying off some laborers. Plantations are in a better position to access financial capital from finance companies or other sources and can purchase capital equipment to enhance production. However, the technological input that they use is advanced and pricey. Because of the different methods and behavior of the three coffee producing agents, their needs for inputs differ as well. Public infrastructures such as roads and bridges are also important for the coffee growers to transport their produce to the market. With the use of appropriate inputs, lower prices of inputs and good conditions of roads and bridges, coffee production can be enhanced.

Tools and equipment such as the above are used in all the coffee producing areas in PNG. The tools range from simple hand tools to very complicated equipment and machinery. Photos: Irau and Aba (2011)

3.2.10 Accessibility of fertile Lands, its use and size

There is limited information on the total land area used to plant coffee in PNG, because there are no records of the changes that take place, such as new planting, extensions and abandoning of coffee gardens. However, there is a 1999 estimate (see Mike Bourke and Tracey Harwood, 2009) that coffee takes up on average 78,000 hectares of land, of which 57,000 hectares are occupied by smallholder plantings, with the remainder (13,000 hectares) used by the 20 hectare blocks and plantations.

Accessibility to good fertile lands, its use and size determines the amount and quality of coffee that can be produced. Geographical variations make it impossible for producers to have the same quality of lands. Photo: Irau and Aba

All the smallholder producers have access to their customary land and grow their coffee on these lands. The customary land ownership centers on communal land ownership and rights, which are usually scattered around different locations. The average size of a land that is allocated for coffee planting is around 2 hectares but varies across the provinces that produce coffee. For example, smallholders in Western Highlands, Jiwaka and Eastern Highlands provinces have access to much bigger, flatter, and fertile lands than the producers in Chimbu, who have rugged terrains, water-logged, arid and infertile lands. This is also reflected in the quality and quantity of coffee produced in these provinces. Coffee growers also grow casuarinas and other leguminous trees to maintain and enhance soil fertility to increase coffee production. A smallholder, who is willing to extend his coffee plots can obtain extra land through direct acquisition (buy out) or through negotiations with traditional family ties. The plantations are mostly on Government leased land, while the 20-hectare blocks and smallholders are on customary land and have free and wider access to land for expansion programs.

A coffee producer can produce more in a new fertile land than in an old used land. The quality of land determines the amount of coffee each tree can produce. All the coffee producers interviewed mentioned that coffee grown in new lands bear much bigger cherries than coffee grown in over-used land.

The increase in population is putting a lot of pressure on families to look for more land to cultivate coffee. For example, a father who has three sons can subdivide his coffee blocks equally to his sons. Each son has a piece of his father's block. However, the problem arises when these three sons have children. They will have to subdivide again or look elsewhere for more land to cultivate coffee. The level of production does not change here because the size of the land does not change. They can only increase production by acquiring more land. Production per hectare of land per season is estimated to be 450 kilograms annually for one single smallholder producer and his immediate family. This production will still be the same after the producer subdivide his coffee blocks among his children. Accessibility to good fertile land can assist in increasing the yield and overall production.

3.2.11 Coffee Tree Stock

The stock and age of coffee trees determine the amount and quality of coffee that will be produced per coffee tree. Coffee trees that are planted in a new land and well looked after could bear more cherries than those abandoned and not looked after properly. Old and bad coffee trees are uprooted and replaced with new seedlings. From the survey, it was found that 100 percent of coffee trees removed are replaced with new seedlings, though it takes some time for it to flower and bear cherries. This will affect production because it takes three years for the new coffee seedlings to bear cherries. The first year harvest is not always full year harvest. Due to this, there is always a variation in production between the time the coffee trees are uprooted and replanted, and the time of first and second harvest.

The average coffee tree each producer has depends on whether the producer is a smallholder, block-holder or plantation. The smallholders have on average 1,200 trees per producer in an area of 2.0 hectares of land. A block-holder has up to 16,000 trees on a 20 hectare piece of land, while a typical plantation will have on average 50,000 trees on a 50 hectare land, with some having bigger land area and high number of coffee trees. The amount of coffee trees a producer has also depends on the land topography. For instance, coffee planted in water-logged areas and arid infertile land will not last, even if they grow, the production per tree will be lower. A small-holder producer in Chimbu who plants coffee seedlings on a dry and stony 2.0 hectare piece of land will produce less than a producer in Western highlands on the same area. For plantations, all coffee trees are cared for and replacement of bad trees are frequently done by full time employees. A healthy coffee tree grown in a good fertile land can yield more coffee cherries and increase the overall level of production.

It was found during the survey that coffee producers' calculations on production involve their decisions on whether to postpone replanting and continue tapping the current trees depends on current profitability. Some producers may decide against planting coffee because they may envisage other profitable crops to grow in the early years. Other producers may be more interested about their future position. This may be a function of the age of the decision makers themselves; for example, older producers are less likely to place high value on future expected income than are younger producers. Besides age, the life cycle of producers may also be important: for middle-aged producers new tree planting may guarantee them income without much family labour at later ages; the discount factors may also depend on the age of the producer.

The stock of coffee trees varies in ages and differs from place to place. Some of the trees are very old, while others are newly planted. Photos: Irau and Aba 2011

3.2.12 Age of Coffee Trees

Coffee trees can last up to fifty years if well taken care of. Seventy percent of the coffee tree stock that is currently with the smallholders is more than 15 years old, while some are between 30 and 40 years old. The age of coffee trees varies from smallholder growers, block-holders and plantations. For the smallholders, the age of coffee trees does not matter, as long as the tree can still bear cherries. The tree can only be replaced if it dies naturally. CIC is currently running a program with the smallholders and block-holders to rehabilitate some of these old coffee trees to maintain or increase the level of production. For plantations and some block-holders, there is a requirement that every tree should produce certain amount of coffee cherry. As the coffee trees grow older, the coffee stem grow bigger and much of the soil nutrients is being consumed by the stem and the cherry receive minimal amount of nutrient and produce very tiny cherries. Therefore, the pruning of older coffee trees to standard sizes is normally practiced by some plantations. In this way, the stem consumed minimal nutrients while the bulk of the nutrient is transferred to the cherry.

Some of the existing stocks of coffee trees are very old and some are even as old as 50 years old. However the producers take care of these trees will determine how much each tree will produce. Photos: Irau, Aba and Aipi

Coffee begins to yield three years after planting and has a production life of up to ten years (CIC various publication). The yield varies with the timing of planting, soil fertility and technological input. During the first and second years of harvest, yield is usually low, followed by maximum yield in the three to seven years, and yield start to fall during eight year of production, depending on how well the coffee trees are looked after.

It was found in the survey that 85 percent of the coffee trees are above 8 years old confirming that most of the producers have stock of coffee trees, which could be as old as 20-30 years. New plantings and trees less than a year old constitutes only 0.3

percent, 1-4 years old constitute 2.6 percent, while 5-8 years constitute 12.5 percent. Almost 100 percent of coffee trees removed are replaced with new seedlings but there is a delay in the production by at least 3- 4 years. This means the producers are harvesting the coffee their grandparents and their parents planted. Even some of the blocks and plantations are as old as 40-50 years. There is increase in the uprooting of dead and old trees and replacing them with new ones, as well as the use of extra acreage. The age of coffee trees have significant impact on the overall level of coffee production.

3.2.13 Seasonal factors (March – June, September – December)

Coffee is a seasonal cash crop, which has its peak season between March and September year round. If the seasonal factors are favourable, market supply of coffee becomes larger. For example, if the harvest is good because of good rain, adequate sunshine, etc. the market supply of the coffee would be bigger. According to the survey, due to a combination of adequate rainfall and sunshine, combined with the usual three-year rotational coffee cycle, there was a bumper season in 2011. Experiences in Highlands and other coffee producing provinces have shown that extreme drought in 1997 resulted in very low production of agricultural commodities, including coffee during that year[5]. Also unusual weather patterns such as too much rainfall or sunshine also affect production. These are natural factors; the producers do not have any control over. Global warming also has an impact on weather patterns, including rainfall and sunshine, could have a severe impact on the total coffee production. The direct influence of weather on the crop, particularly excessive or inadequate rainfall and sunshine, also cause fluctuations in production of coffee.

There is also a three-year coffee cycle. A coffee tree that produces very good cherries in one coffee season may not produce the same results in the next year. The coffee trees are let to recover in the next year and if the producer is able to look after the coffee trees very well, it will produce good cherries again in the following year. This three year coffee cycle, results in some fluctuations in coffee production.

It was also found in the survey, that elections disrupt coffee production. Elections take place between April and June every five years. These are months were coffee season is at its peak. During elections, people move around from place to place to show support for candidates. This is the time when people are no longer interested in working in their coffee gardens, because their immediate wants like food, beer and other items are taken cared for by their candidates. The producers are not 'serious' in producing coffee. They could still produce casually but it will not be the same amount they normally produce in non-election years. This greatly affects the overall level of production of coffee during the election year.

[5] CIC commented that coffee production increased as a result of drought. The coffee shrubs were put to extended period of stress during the drought, and while some stress is necessary to induce strong recovery and flowering when rain falls, the extended period of stress appeared to have had a better effect. However, the unusual weather conditions in 2006 had resulted in a drastic decline in production as most coffee farms in the Highlands were waterlogged.

3.2.14 Assistance

In order for the producers to increase and maintain the production at a high level, they need help from certain key stakeholders. Some of these stakeholders are already starting to chip in their help while others have fallen short of helping. The key stakeholders are; the government through its various bodies like Department of Agriculture and livestock (DAL), Works Department, Telikom, CIC, Trade and Industry; donor agencies and others.

3.2.15 Government

The support given by the Government directly and indirectly through its various agencies to the smallholder coffee growers and block-holders, including plantations, has been minimal and to some areas, non-existent. All the producers interviewed expressed openly that transport infrastructure like roads and bridges are in very bad conditions, and there are no subsidies on freight and inputs' costs.

Most of the out-growers expressed dissatisfaction that it takes them days to transport coffee bags to the nearest buying point. The roads are so bad that it forces coffee producers to hire four wheel drive trucks or other people to carry their coffee bags at very high costs. When the producers see that the roads are in terrible conditions or the price of coffee is very low, coffee bags are stored away, which results in the coffee losing the quality and can be treated as bad coffee. For example, the roads in and out of Okapa, Aiyura and Baiyer River are so bad that it requires continuous maintenance program, for coffee and other agriculture produce to be taken to the nearest market, which is normally the provincial capital. While in places like Karamui, Ombura/ Waninara, Kaintiba and Jimmy, roads are non-existent and the only mode of freight is air transport and it is very expensive for the coffee growers to take their coffee bags to the buying points. Currently, there are no government sponsored freight subsidy schemes available to assist farmers, apart from the CIC Freight Surety Scheme.

The prices of inputs increased over time. For example, the prices of a bag of fertilizer, a spade or a bush knife in 1990s is not the same in 2011. Coffee producers expressed during the survey that these tools are vital and for everyday use in their coffee gardens. With the increase in the price of these tools, combined with transport costs and others, the producers are discouraged to work in coffee blocks. Therefore, a subsidy on these inputs will assist farmers to increase production.

Government taxation also impacts on supply and demand of goods. Government taxes on inputs of coffee production are also another burden left with the producers by the Government. The tax raises the prices of inputs into the production and supply of coffee and makes them become very expensive. This becomes a disincentive and has the potential of limiting the quantity of coffee a producer is willing and able to produce at the given price at that time. The emphasis on the ability of producers to produce indicates that it is the effective supply of coffee that is important. This will affect the individual supply of coffee, which will lead to a fall in overall market supply, the market

supply being the sum of the supply of individual producers at any time.

3.2.16 Donors

CIC is currently implementing a help from National Agriculture Development Plan (NADP) to rehabilitate existing coffee blocks, distribute coffee seedlings, tools like wheel barrows, bush knives, spades, scissors, pruners, knapsack etc. as part of its growers assistance. The overall aim is to assist the producers to improve their engagement with their coffee blocks and increase production level. The coffee industry is also being assisted by other donor agencies like the World Bank through the 'Productive Partnerships in Agriculture Projects (PPAP)' to assist smallholder producers to access markets and improve performance at all levels of production process. European Union, AusAid and Australia Center for International Agriculture Development (ACIAR) are also funding the industry in various areas, including technical assistance and capacity building, crop protection and post harvest and market chain analysis on various marketing systems (CIC various publications).

All of these projects are being implemented by CIC. The CIC has built up its capacity to develop projects and access Government and donor projects funding to assist the coffee industry, but a lot is yet to be done. To be able to help the majority of the smallholders, rundown plantations and block-holders, it is necessary for the Government to play a vital role in funding the CIC and its activities, improve the roads and bridges, introduce freight subsidy schemes, and other incentives to boost the morale of the producers to increase coffee production. Almost 80 percent of the producers interviewed mentioned that the CIC is the only source of help, while the remaining 20 percent have not received any help from anyone else. Department of Agriculture and Livestock (DAL) has also assisted the coffee industry through the Smallholder Support Services Pilot Project. There are some far lying coffee producing areas and producers, CIC has not reached. If all these areas are reached and all producers are included and assisted, production of coffee will be boosted significantly.

3.2.17 Communication

The deregulation of the communication industry, especially the mobile phone segment has resulted in the entry of Digicel in 2007 and the introduction of cheaper mobile phone handsets, introduction of competitive call rates helped the producers in a more beneficial way. The 99 percent of the surveyed households interviewed mentioned that improved communication enhanced the mobility of the coffee buyers and sellers. Sellers were able to easily identify the location of the nearest buying points and/or buyers were able to identify, which areas have coffee stock. The leaders in each coffee producing area organize and advice each producer through mobile phones to bring their coffee bags to the nearest buying points. They are also able to get the latest coffee prices information from different buying points on their mobile phones. These improvement in communication helps the coffee producer to make informed decisions on where and when to sell their coffee bags to appropriate buyers. This also helps the

flow of coffee bags from the farm-gate to the exporters smoothly.

3.2.18 Weather/Natural factors

The weather condition and natural factors like floods, storms and droughts negatively affect the market supply of coffee. However, good drainage and coffee growing facilities and other supports to the coffee sector can positively affect the market supply of coffee. For instance, the El Nina that caused a severe drought in 1997 negatively affected most marketable agricultural cash commodities, including coffee. As a result, production of every agricultural commodity was very low. Global warming will impact climatic conditions to change and will result in frequent landslides, unusual long period of rain or sun, or floods. This will have its toll on the existing conditions of infrastructure like roads and bridges, and will certainly affect the production and supply of coffee, including other agricultural commodities, from the farm gate to the market.

4.0 Plantation and Blocks holdings production

The PNG managed sector (Blocks and Plantation sector) has put PNG coffee on the world market during the early days and is recognized globally as the producer of sufficient volumes of the top-of-the-top quality coffee with assured consistency in supply and quality.

However, production from the blocks and plantation sectors declined steadily to less than 20% of total production in recent times. This was due to several factors such as land ownership issues, plantations being taken over by local land owners, lack of management skills for the plantations, deteriorating road and bridges, and coffee cherry theft. As a result of this, the production by the managed sector dropped to such a level where production by the smallholders can not make up for that loss. With drop in production by the managed sector, the level of coffee production in PNG will remain low, until aggressive intervention is done to assist the smallholder producers to meet the shortfall created by the running down of plantations.

5.0 Constraints

Coffee producers, while trying to maximize production face numerous challenges. Some of the challenges are common while others vary across the different coffee producing provinces. For example, some of the coffee hub like Karamui is so isolated that only light planes transport the coffee bags at a very high cost, compared to a producer in Western Highlands, where a producer can stand on the side of the road and sell their coffee. Some of the major problems highlighted during the survey are listed below.

5.1 Infrastructures: Roads and Bridges

The most notable impediments to the movement of coffee from the production sites to the markets are the dilapidating roads and bridges. All the coffee growing regions face a general decline in the conditions of all existing roads and bridges. Most of the roads and bridges and to some extent air strips are poorly maintained to the extent that it makes the transporting of coffee harder and an expensive exercise. The bad conditions of the infrastructure results in inadequate security for traders and producers, who are vulnerable to robbery and assaults. Some of the coffee growers have to cross big rivers and mountains to sell their coffee. Also the roads leading to some of the plantations are in a very deteriorating condition, so much so that the plantations have to use their own machines and equipment to upgrade the roads leading to their coffee plantations and the roads to some of the outlying coffee growing places. Most of the interviewees expressed that government assistance in the form of providing good roads, bridges and other assistance in the production of coffee has been non-existent for a very long time. In order to participate in coffee or any other commodity production, access to markets is vital; therefore, not accessing markets due to bad road conditions or the closure of buying points will influence production. For example, consider the headline *"Biaru coffee rots away"* as reported in the Sunday Chronicle of 27 November 2011, where the road conditions are so bad that it affected the production and supply of coffee in that area. The deteriorating conditions of the road have deprived the producers to have access to buyers and markets. This is the same story for all the producers in remote areas.

Roads like these are not for the faint hearted but the coffee producers can endure such treacherous roads to bring the coffee bags to nearest buying point. Photos: Irau and Aba (2011)

5.2 Lack of awareness and transmission of information on good farming techniques

Most of the out-growers lack vital information on how to plant, take care and harvest coffee. For example, a producer in a remote village in Karamui does not have information on the spacing of coffee seedlings, how much fertilizer to apply, what tools to use etc. This will eventually have a bearing on the level of production. Therefore, lack of dissemination of information and planting materials has been a contributing factor in producers not adhering to good coffee farming techniques and producing poor quality coffee for export, thus not meeting market requirements.

5.3 Access to financial and capital assistance

There is still limited access to credit and working capital by the producers, because as indicated by the producers, the banks and financial institutions have stringent lending guidelines, which most of the coffee producers do not qualify. The process involved in securing loans and financial assistance is obscured and not readily available to most of the producers. In terms of financial inclusion, the producers are not linked to any financial institutions and even if they tried, it is a futile exercise.

5.4 High Cost of Inputs

The costs of inputs have been increasing above 100 percent. All producers of coffee are faced with increasing production costs. For example, the price of a spade or knife purchased by a producer in 2000 is not the same as in 2011, or wages paid to employees by a plantation increases annually. With deteriorating conditions of machines and equipment, combined with high fuel prices the cost of running them are high.

5.5 Shortage of Land and Manpower

Shortage of land associated with the rise in population and migration of people from arid land to good fertile lands, result in the limited availability of good land for further extension and improvement for high productivity, especially for large-scale production of coffee. Also associated with the increase in population and movement of people, cherry thievery becomes a major problem during peak season of coffee, and it costs a lot of money to provide security.

Smallholders are family-based and when kids are in schools there is always a shortage of labor and those with big blocks find it hard to harvest and some of the coffee cherries are let to rot. Therefore, with the limited manpower and inadequate capital and machinery, the production by smallholders can not match the production used to be produced by plantations. Also smallholders produce for specific reasons, and if

those reasons are satisfied, they do not bother producing more.

5.6 Other challenges

A real threat that is facing the industry now is the emergence of CBB at Jaya Pura, the border of PNG and Indonesia. Lack of knowledge about good management of coffee blocks can provide a route where the CBB can enter PNG and affect the industry, as the shady and moist areas are vulnerable to the disease. The disease can destroy the entire coffee plots, resulting in low production, diminished income level of producers, and low sale prices. The income earned from coffee is sometimes mismanaged, especially among the youth and young. They need to be taught good financial management skills so that the income from their hard work can be properly managed and used in more meaningful ways than to spend recklessly on beer and gambling. With constant price distortions, it discourages the producers to work in their coffee blocks. Whenever, there is price shocks, people respond to it directly by not producing coffee. Therefore, removing price distortion is one way; people can be encouraged to improve their production.

6.0 Modeling Supply Response of Coffee in PNG

The survey highlighted a lot of variables that are responsible for the production and supply of coffee in PNG. Most of these variables that affect production and supply of coffee do not have time series data. These are all qualitative information and it is difficult to guestimate based on proxies, consequently the model will use variables that have a long time series data and estimate the effect of these variables on the production and supply of coffee in PNG. Based on these a priori expectations is that, less than 50 percent of variations in the production and supply of coffee will be explained by the model.

6.1 Methodology

Most supply response studies use Nerlove models to study the impact of price on supply of agricultural commodities. One of the major weaknesses of Nerlove models is that these are static models and are unable to capture short-run dynamics. In this study cointegration techniques will be used to study the impact of international price and non-price factors in determining the supply of coffee exports in Papua New Guinea. The cointegration properties of the variables will be established first and then using error correction model, the long-run equilibrium model and the short-run dynamic model will be estimated.

Due to data limitations, selected variables with extended time series data were used to model the supply response function of the coffee industry.

6.2 The model

Using a similar model as that of Nkang, Abang, Akpan and Offem (2006), to model the supply response of cocoa in Nigeria to changes in international prices of cocoa and non-price variables, the supply response of coffee to international price changes and non-price variables will be modeled for Papua New Guinea. The model assumes imperfect substitution and is founded on traditional supply response theory with the exclusion of export subsidies and inclusion of non-price variables as in Tambi (1999) and Gbetnkon and Khan (2002) thus:

$$LnQE_t = \lambda_0 + \lambda_1 LnREP_t + \lambda_2 LnTWY_t + \lambda_3 Trend_t + \lambda_4 SOI_t + \lambda_5 Dummy\ Elec_t + \mu_t \quad \textbf{(1.0)}$$

Where,

QE_t	=	export supply of coffee measured in tonnes
REP_t	=	(REP_t / DP_t) the ratio of export price to the domestic price index.
TWY_t	=	trade-weighted income of Papua New Guinea's major coffee trading partner countries.
$Trend_t$	=	trend variable to capture major technological changes in production and export processes.
SOI_t	=	Southern Oscillation Index[6] capturing weather patterns in Papua New Guinea.
$DummyElec_t$	=	Dummy variable to capture the impact of elections[7] on production and export of coffee in Papua New Guinea.
μ_t	=	stochastic error term assumed to be independently and normally distributed with zero mean and constant variance.

A priori, $\lambda_1 \ldots \lambda_4 > 0$, $\lambda_5 < 0$

Most time series data are non-stationary and ordinary least squares (OLS) estimates of non-stationary data are known to produce spurious results; that is, high R^2 and low Durbin Watson statistics. Spurious regression problems can be eradicated using cointegration techniques, which can provide interpretable estimates for both the short-run dynamics and long-run equilibrium model. This paper adopts Engle and Granger (1987) two-step procedure to establish co-integration. According to "Granger Representation Theorem", establishment of co-integration implies error correction representation of the model.

[6] The Southern Oscillation Index (SOI) refers to the air pressure differential between Darwin and Tahiti, which drives trade winds. When this index is particularly low, this is called an SO event, and trade winds will be low. Periods of high water-surface temperatures and low air pressure differentials are called ENSO events which typically are associated with droughts in western Pacific countries, including Papua New Guinea. Rainfall in Papua New Guinea is determined by the long run EL Nino-Southern Oscillation (ENSO) system.

[7] Elections have been blamed for lower coffee production.

As a first step, the stationarity of variables used in the model are tested using the Augmented Dickey-Fuller (ADF) test. The following equation specification is applied for the ADF test;

$$\Delta Y_t = \alpha_o + \delta Y_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta Y_{t-i} + \mu_t \qquad (2.0)$$

Results of the ADF test are presented in table 2.

Table 2. Results of Augmented Dickey Fuller (ADF) unit root tests with trend for individual series.

Variable Level	ADF statistics	Variable First Difference	ADF statistics
$LnQE_t$	-2.298	$\Delta LnQE_t$	-6.556***
$LnREP_t$	-3.202	$\Delta LnREP_t$	-6.176***
$LnTWY_t$	-1.256	$\Delta LnTWY_t$	-3.745**
Test Critical values			
	1% level	*-4.273*	
	5% level	*-3.558*	
	10% level	*-3.212*	

Note
*** represents 1 percent significance level
** represents 5 percent significance level
* represents 10 percent significance level

Sources: Author's Calculations

The ADF test results indicate that export quantity of coffee (QE), the ratio of export price to domestic price index (REP) and the trade weighted income of Papua New Guinea's major coffee trading partners (TWY) are stationary at the first difference I(1).

Table 3. Results of ADF tests on residuals of cointegrating regressions.

Variables	**Long-run coefficients (t-statistics)**	**Residual Level ADF statistics**
$LnQE_t$ on $LnREP_t$	-0.212 (-3.086)	-4.460***
$LnQE_t$ on $LnTWY_t$	0.227 (4.359)	-5.773***
$LnQE_t$ on both variables	see table III	-5.645***
Test Critical values		

	1% level	*-2.642*
	5% level	*-1.952*
	10% level	*-1.610*

Note

***	*represents 1 percent significance level*
**	*represents 5 percent significance level*
*	*represents 10 percent significance level*

Source: Author's Calculations

Co-integration test were done on the bi-variant variables on each of the two independent variables on the dependent variable using Engel and Granger (1987) two step procedure. First by establishing the long-run relationship of the variables, then testing the residuals of the variables using ADF for co-integration. ADF results run on the residual of bi-variant models in Table 3 shows co-integration. Testing for co-integration of the 2 independent variable against the dependent variable also establishes co-integration.

Table 4. Estimates of long-run cointegrating regression and diagnostics, sample: 1977 – 2009, Dependent variable: $LnQE_t$

Variable	Coefficient	Std.error	t-statistics	Probability
$LnREP_t$	-0.031	0.092	-0.338	0.738
$LnTWY_t$	0.207	0.077	2.676	0.012
Constant	7.970	1.307	6.097	0.000

R^2 = 0.382 adjusted R^2 = 0.341 DW = 1.972
F (3, 31) = 9.286[0.000]
Akaike Information Criteria (AIC) = -0.634; Schwarz Criteria (SIC) = -0.499

Source: Author's Calculations

Co-integration of variables surpasses spurious nature of time series regression. The long-run co-integrating regression is presented in Table 4. In the long-run, international export price does not have any impact on the supply of coffee exports, while income levels of Papua New Guinea's major coffee importing countries play a significant role in determination of supply of coffee exports. A 10 percent increase in trade weighted income of PNG's trading partners results in an increase in coffee exports volumes by 2.1 percent, i.e. supply response is inelastic.

Establishment of co-integrating properties of the variables in the model qualifies error correction specification of the model, according to Granger Representation Theorem. Accordingly the error correction mechanism (ECM) of the model can be specified as:

$$\Delta Y_t = \partial_0 + \partial_1 \Delta \bar{A} - \partial_2 (Y_t - Z_t)_{t-1} + \varepsilon_t \qquad \textbf{(3.0)}$$

Where

$\bar{A}$	=	the vector of explanatory variables
Y_t and Z_t	=	the co-integrating variables
∂_2	=	the error correction mechanism (ECM)
∂_1	=	the vector of parameters.

Using equation 3.0 results of the over-parameterised error correction model is presented in Table 5. A 3 year lag period has been used in the over-parameterised model as harvesting of crop commences after 3 years from initial planting.

Table 5. Estimates of over-parameterised error correction model (ecm), sample: 1977 – 2009, Dependent variable: $LnQE_t$

Variable	Coefficient	Std.error	t-statistics	Probability
$LnQE_{t-1}$	5.156	2.514	2.051	0.067
$LnQE_{t-2}$	-0.376	0.268	-1.405	0.190
$LnQE_{t-3}$	-0.644	0.402	-1.601	0.141
$\Delta LnREP_t$	-0.743	0.269	-2.760	0.020
$\Delta LnREP_{t-1}$	-0.027	0.195	-0.137	0.894
$\Delta LnREP_{t-2}$	-0.076	0.189	-0.402	0.696
$\Delta LnREP_{t-3}$	0.250	0.175	1.427	0.184
$\Delta LnTWY_t$	2.486	1.208	2.058	0.067
$\Delta LnTWY_{t-1}$	-4.154	1.832	-2.267	0.047
$\Delta LnTWY_{t-2}$	-0.135	1.160	-0.116	0.910
$\Delta LnTWY_{t-3}$	-0.180	1.041	-0.173	0.866
ECM_{t-1}	-5.294	2.638	-2.007	0.073
SOI_t	-0.021	0.097	-0.218	0.832
SOI_{t-1}	0.039	0.071	0.542	0.600
SOI_{t-2}	-0.076	0.076	-1.011	0.336
SOI_{t-3}	-0.015	0.080	-0.188	0.855
$DummyElec_t$	-0.102	0.146	-0.700	0.500
Trend	-0.040	0.031	-1.320	0.216
Constant	-33.537	23.162	-1.448	0.178

R^2 = 0.734 adjusted R^2 = 0.256 σ = 0.171 DW = 2.406
F (3, 31) = 1.534 [0.248]
Akaike Information Criteria (AIC) = -0.449; Schwarz Criteria (SIC) = 0.447
Source: Author's Calculations

From the general over-parameterised model, an economically interpretable model was generated. Lags were reduced and variables were omitted to achieve a parsimonious ECM model. The reduction process was carried out using intuition and statistical significance and not based on any economic nor scientific production theories. The parsimonious reduction process made use of stepwise regression, subjecting

each stage of the reduction process to several diagnostic tests before arriving at an interpretable model, which is presented in Table 6.

Table 6. Estimates of parsimonious error correction mechanism (ecm) model, sample: 1977 – 2009, Dependent variable: $LnQE_t$

Variable	Coefficient	Std.error	t-statistics	Probability
$LnQE_{t-1}$	0.855	0.235	3.639	0.001
ECM_{t-1}	-0.926	0.303	-3.059	0.005
$DummyElec_t$	-0.136	0.076	-1.773	0.087
Constant	1.628	2.569	0.634	0.531

Diagnostic tests

Jarque–Bera F-statistics	2.027[0.363]
B-G LM test F-statistics	0.020[0.980]
ARCH test F-statistics	0.270[0.607]

R^2 = 0.357 adjusted R^2 = 0.288 σ = 0.166 DW = 2.000
F (3, 31) = 5.178 [0.006]
Akaike Information Criteria (AIC) = -0.642; Schwarz Criteria (SIC) = -0.459
Source: Author's Calculations

The parsimonious model has a better fit compared with the over-parameterised model as indicated by a high value of the F-statistics (5.178), which is significant at the 1% level of significance, compared with the F-statistics (1.534) of the over-parameterised model, which is insignificant.

The structural variables of the reduced model explain export supply of coffee better than the over-parameterised model as indicated by the values of their adjusted coefficients of multiple determinations. Specifically, the adjusted R^2 for the reduced model (0.288) is higher than the adjusted R^2 of the over-parameterised model (0.256). Similar evidence is given by the value of the standard error of the regression (σ), Durbin-Watson (DW) statistics for first-order serial correlation and the two model criteria (that is Akaike & Schwarz information criteria).

Diagnostics test were applied to the model in order to test the validity of its estimates. Apart from the DW test for first order serial correlation three tests were applied on the residuals of the parsimonious model.

The Jarque-Bera Normality test on the residuals, with F-statistics of 2.027, could not reject the null hypothesis of normality in the residuals, as indicated by the level of significance shown in table 6.

Bruesch-Godfrey serial correlation Lagrange Multiplier (LM) test for higher order

serial correlation with a calculated F-statistics of 0.020 could also not reject the null hypothesis of absence of serial correlation in the residuals.

Finally, the Autoregressive Conditional Heteroskedasticity (ARCH) tests were done to test for heteroskedasticity in the error process in the model. The results of the calculated F-statistics of 0.270 indicated absence of heteroskedasticity in the model.

From the array of diagnostics tests, the model is proved to be well estimated and the observed data fits the model specification adequately, thus we expect that the residuals to be distributed as white noise and the coefficients valid for policy discussions.

6.3 Discussions of the results.

The coefficient of the error correction term ECM_{t-1}, as expected has a negative sign and is significant at the 1% significance level. The significance of the error correction term supports cointegration and suggests the existence of long-run steady-state equilibrium between coffee export supply and real export price. The results indicate that 92.6 percent of previous year's disequilibrium from the long-run elasticity of coffee export supply is corrected in the current period. It takes over 9 years for coffee export supply to adjust to long run equilibrium volume of coffee exports. The speed of adjustment is sluggish.

In the long-run, weighted income of PNG's coffee trading partners is significant in determining supply of coffee, while real export price of coffee is insignificant. Price of coffee exports does not have any influence on the supply of coffee. Real export price and the weighted income of coffee trading partner countries explain 38 percent of the variation in supply of coffee exports in the long run. 62 percent of the variation in coffee export supply is therefore determined by other factors. During the survey of farmers, there were other factors that were highlighted. These factors include, bad road conditions, customary obligations that take farmers away from actively looking after their coffee gardens, and ad-hoc farming techniques, i.e. as and when they need money they work in their coffee gardens etc.

In the short-run, previous periods coffee export supply and the general election influence coffee supply. About 86 percent of current periods coffee export supply is from previous period's coffee production. Coffee production from previous period is stock piled and dried for current period exports. General election periods have a major impact on short-run supply of coffee exports, with coffee supply declining by 13.6 percent. Similar to long-run supply trends, in the short-run only 29 percent of the variations in coffee export supply is explained by previous periods export supply of coffee and general elections, while 71 percent of the variations are explained by other factors. The survey results highlighted in the literature section of this paper shows that there are other factors that influence the export supply of coffee in Papua New Guinea.

Coffee export price developments are insignificant in determining export supply of

coffee both in the short and the long-run. Coffee growers are insensitive to coffee price developments; however the income level of Papua New Guinea's major coffee trading partner countries plays a significant role in determining the supply of coffee exports. When Papua New Guinea's coffee trading partner countries experience negative shocks in their economy, demand for Papua New Guinea coffee export supply shrinks by about 21 percent in the long-run.

7.0 Conclusion

Policy challenges for the Coffee Industry Corporation (CIC) should be to look at ways to mitigate short-term shocks during election period by educating coffee growers to tend to their coffee gardens maybe by enticing growers with some reward structure in association with coffee export companies and processors.

Another way forward would be for the CIC to diversify coffee production to other provinces in the country. Coffee production is concentrated in the Highlands provinces of Papua New Guinea and these parts of the country are known to be more volatile during general elections. Diversification of production to other provinces, which are not volatile during general elections, should see coffee supply remain steady during election periods.

For the long-run volatilities driven by partner country income level, CIC and relevant authorities should encourage downstream processing of coffee in large scale rather than exporting raw coffee cherries. Raw material price and supply tend to be influenced by external forces and are more volatile than processed products, which tend to fetch better price and are more market driven.

With data limitations on acreage, age of trees, usage of fertilizers, productivity, use of labor etc were omitted in the model. This paper confined its discussions on a defined number of variables that has readily available time series data. There are other areas of possible research that can be done using a gravitational model to study the accessibility issues relating to transportation of coffee beans by small holder growers. Modeling the effect of public investment on small holder coffee supply is another important area as most coffee growers are in the remote areas and need support from the government in terms of infrastructure.

Appendix 1. Survey Results

Supply Response Field Trip Data for Coffee - Eastern Highlands, Western Highlands & Jiwaka Provinces

	Likalika Farmers Corporation - EHP	Haukapehuvo Comm. Dev. Association - EHP	Okapa Station-Pusarasa Farmers Ass. - EHP	Okapa District-Keta Village-Lafone Kopi Group - EHP	Okapa District-Tarabo-Fesmaka Hausman - EHP	Goroka District-Gahuku Farmer Cooperative - EHP	Nobel Tai project Farmers (Jiwaka)	Anego Company Ltd-Processing and Export (EHP)	Ungai Bena Korofegu Corp Beae-fecs	Ruklie WHP	Kafuku	TOTAL	Labor Composition
1. Houseold Data													
No of Head	15	11	16	32	11	3	11	1	11	14	8	133	15%
Spouse	18	12	17	28	8	1		1	11	16	5	117	13%
Children >15	18	18	32	45	17	4		4	20	22	14	194	21%
Children 10-14	22	4	6	23	8				19	13	3	98	11%
Children <10	38	22	53	42	12	2				20	5	194	21%
Relatives > 15		4	24		3							31	3%
Relatives 10-14		2										2	0%
Relatives < 10		6	7	9				10				32	4%
Employees (Others)				6	6			100				112	12%
Total manpower	111	79	155	185	65	10	11	116	61	85	35	913	100%
2. Crops Cultivated													
Coffee Trees	59290	27600.00	28650	45673	33849	6400	46000	163300	33460	72808	47400	564430	
Other Perennial	0		0		1-timber				Orange				
Annual Crops	Banana, yam, sugar cane	Banana, yam, sugar cane	Banana, yam, sugar cane	kaukau, Taro, Banana, Yam, potatoes	kaukau,	kaukau, carrot, cabbages, sugar cane		yes	kaukau,banana,taro,peanuts,tapiok, corn,				
Total Area (ha)	25.8	12.0	15.9	28.2	14.0	2.3	20.0	70.6	18.4	32.6	15.8	256	
3. Age of Coffee Tree (Current)													Coffee Trees Composition
<1				480	1000							1480	0.3%
1-2				1388	3900	400						5688	1.0%
3-4	900	400		4788	2679				160			8927	1.6%
5-6	3500		4000	12983	3070				4000	2300		29853	5.3%
7-8	21760	500		3660	8000				6800			40720	7.2%
>8	33130	26700	24650	23074	15200	6000	46000	163300	22500	70508	47400	478462	84.7%
Total Trees	59290	27600	28650	46373	33849	6400	46000	163300	33460	72808	47400	565130	100.0%
4. Yield in bags (1 bag = 75kg)	146	68	90	160	80	13	113	400	104	184	90	1448	132

	Likalika Farmers Corporation - EHP	Haukapehuvo Comm. Dev. Association - EHP	Okapa Station-Pusarasa Farmers Ass. - EHP	Okapa District-Keta Village-Lafone Kopi Group - EHP	Okapa District-Tarabo-Fesmaka Hausman - EHP	Goroka District-Gahuku Farmer Cooperative - EHP	Nobel Tai project Farmers (Jiwaka)	Anego Company Ltd-Processing and Export (EHP)	Ungai Bena Korofegu Corp Beae-fecs	Ruklie WHP	Kafuku	TOTAL	Labor Composition
5. Removal, Replanting & New Palm Tree													
Trees Uprooted (average 5% of total number of trees)	2964.50	1380.00	1432.50	2318.65	1692.45	320.00	2300.00	8165.00	1673.00	3640.40	2370.00	28257	39.5%
Trees replanted (almost 100% of trees uprooted are replanted)	2964.50	1380.00	1432.50	2318.65	1692.45	320.00	2300.00	8165.00	1673.00	3640.40	2370.00	28257	39.5%
New tree (acreage)	16100	4600	16100	16100	16100	16100	16100	16100	16100	16100	16100	15055	21.0%
6. Other perennial and annuals													
Kaukau	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Yam	yes	yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Vegetables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Others	Yes	Yes	fresh Veg-etables	Yes	Yes	carrots, cabbage	Yes	Yes	Yes	Yes	Yes		
7. Inputs & Labor													
Fertilizer	nil	nil	nil		nil	nil	Yes	Yes	Yes	Yes	Yes		
Insecticide	nil	nil	nil		nil	nil	yes	yes	yes	yes	yes		
Herbicide	On demand	On demand	1-Sprays when needed /gramoxone		9-Glyphosate /herbicids /weedicide	Glyphosate	Yes	Yes	Yes	Yes	Yes		
Tractor (rent)	nil		Once in awhile					Yes					
Other tools (sharip, bush knife, spade, wheel barrow, etc.	sharip, bush knife, spade, wheel barrow	sharip, bush knife, spade, wheel barrow	Saws, scissors, bush knife, spade, axe										
No. of workers	111	79	155	185	65	10	11	116	61	85	35	913	
8. Wealth Owership													
Cattle	2		7	0				yes	yes	yes	yes		
Pigs	9			33	8			yes	yes	yes	yes		
Sheep and Goat	26	21	19	24				yes	yes	yes	yes		
HMCD	0							nil	nil	nil	nil		
Other (specific)	12	x2 poultry, fish pond	5					nil	nil	nil	nil		

	Likalika Farmers Corporation - EHP	Haukapehuvo Comm. Dev. Association - EHP	Okapa Station-Pusarasa Farmers Ass. - EHP	Okapa District-Keta Village-Lafone Kopi Group - EHP	Okapa District-Tarabo-Fesmaka Hausman - EHP	Goroka District-Gahuku Farmer Cooperative - EHP	Nobel Tai project Farmers (Jiwaka)	Anego Company Ltd-Processing and Export (EHP)	Ungai Bena Korofegu Corp Beae-fecs	Ruklie WHP	Kafuku	TOTAL	Labor Composition
Other sources of income	100% interview-ers produce garden food/ vegetables and sell them at the markets. 1 has a PMV and 3 have poultries.	Vegetables and chicken	5-poultry Almost all pro-duce garden food to be sold at local Markets, such as Pinnapple, kaukau,etc whiles 1 sells cows & 1 has a trade store and an other a pcc club	2-Fish Farming 1-Blind weeving 3-trade store 9-poultry 3-buys coffee 1-informal market 5 don't have gardens, the rest have.	1-Honey bees, a dump truck, and a hardware store. 1-sales agent proma 2-buys coffee 2-garden produce 1-trade store 2-poultry 2-betelnut selling	1-road side market 1- bakes scones	Garden produce	Gardening	Gardening	Garden-ing	Garden-ing		
9. General Comments - Most of the income earned is spent on: 1. school fees, 2. reinvested into the coffee blocks like buying fertilizers & tools etc. 3. invest in other ares like buying PMV, planting other crops like cabbage, 4. food and clothes, 5. traditional obligations like bride price, head pay, compensation, 6. Savings and servicing of loan, 7. PMV fares, 8. church offering, 8. Servicing of loans, 9. buying material for permanent house, and 10. payment of casuals.													

Coffee = 2300 trees per hectare
1 Hectare produces 425 kgs per year

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Notes

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