The effect of harvesting system on forest residue production in Fiji

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Abstract

Pacific Island Countries including Fiji have large tract of forest areas and plantation forestry mainly for log production. With the current increases in world oil prices and Fiji's dependence on oil for its transport and energy sector, Fiji is looking at renewable energy sources from forest biomass to minimise reliance on oil for energy production and also to utilise forest residues arising from annual harvesting operations.

Fiji's current harvesting system is mainly semi-mechanised with manual felling, delimbing and conversion. Rubber tiered skidders are mainly used for tree hauling from the cut-over areas to the landings although in native forest logging tracked bulldozers are used. Current log supply volume form the forest totals to 300,000 tonnes per annum and is expected to increase to 500,000 tonnes from 2010. Fiji Pine Limited, the owners of the plantations, also see forest biomass sale as a source of revenue especially with the planned increase in log supply volume.

Independent power producers will soon be demanding biomass for their renewable energy production. This research will compare conventional with integrated harvesting on *Pinus caribaea* plantations, establishing production estimates and costs for biomass supply. This research is to be undertaken for a PhD degree at the University of Canterbury in Christchurch, New Zealand. The forest residue production research based on commercial harvesting operations will be the first to be conducted for Pacific Island Countries and hence it is hoped the research findings can be widely applied.

Introduction

Pacific Island Countries and States (PICS) face a number of unique challenges to their pursuit of sustainable development, foremost among these challenges is the high dependence upon imported energy sources. Ironically, these countries like Fiji have considerable water and forest resources for renewable energy sources. Fiji, like many other small developing countries, used to depend almost totally on imported oil (95% in 1981) to satisfy its commercial energy requirements. With the completion of a hydro dam in 1982 and Independent Power Producers (IPPs) starting to produce power, Fiji's reliance on fossil fuel has decreased (34% in 2008). Even though electricity from diesel generation has decreased in 2008, the fuel price has increased by five and seven percent in 2007 and 2008 from the 2006 figures when 42% of electricity was generated from diesel generation. With droughts occurring frequently in Fiji, industrial diesel generators still play an important role in the production of power in the country hence Fiji's dependence on fossil fuel remains despite increase in world oil prices (Figure 1).

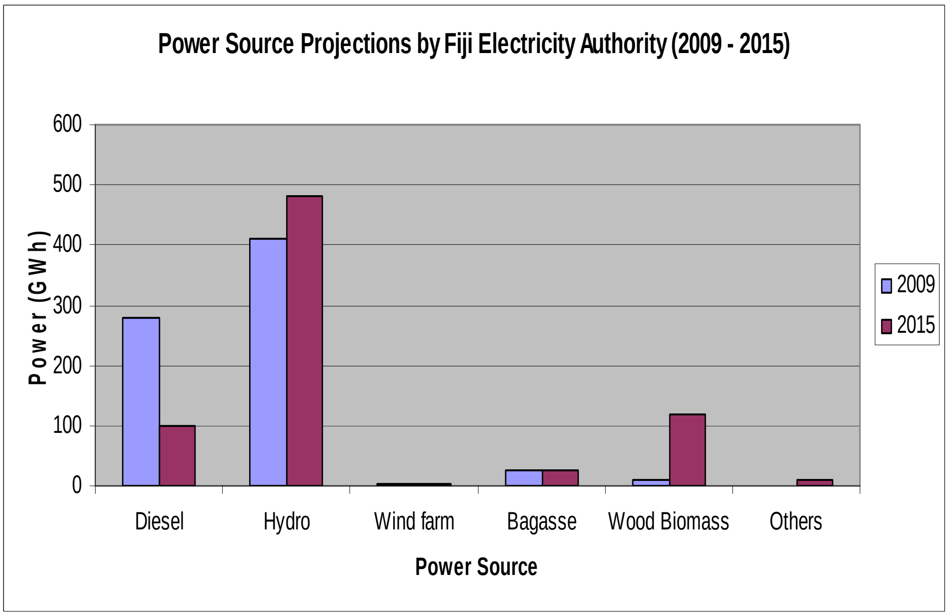

Figure 1: Fiji's energy: comparing current supply with projected for 2015. Note the intended increase in energy coming from biomass.

The Fiji Department of Energy (DOE) is promoting renewable energy sources as a viable commercial electric generation option (DOE, 2006). The biomass power industry has a promising future, especially with recent and proposed regulatory changes in the development of Fiji's National Energy Policy and Fiji government's budget incentives announced in 2009 and 2010 that will look at renewable energy sources for the electricity market. (MFNP, 2009). There is a need to take advantage of these regulatory changes, as IPPs can play a major role to produce electricity through the use of an alternative energy source such as woody biomass.

Fiji Electricity Authority (FEA) forecasts an annual growth in power consumption of 5-6% per annum thereby an annual production capacity of 1,200 MW by 2025. FEA has also indicated in its mission statement of producing 90% of power from renewable energy sources by 2015 and expects power production from wood biomass to increase from the current 1% to 16% of the total power production by 2020 (FEA, 2009). This has implications to forestry companies and other wood growers that there will be an increased demand for wood biomass in the future.

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New Zealand estimates that to meet its bio-energy demands by 2050, it would need to establish 2.5 to 2.8 million hectares of energy forest plantations (Hall et al, 2008). Calle and Woods (2003) undertook individual biomass resource assessment profiles for the Pacific Island Countries including Fiji and highlighted the fact that considerable fieldwork is required to determine the biomass levels because of the non-availability of data. Calle et al. (2003) also noted that forestry residues were poorly utilised and there was a potential for forestry biomass in Fiji to be a source of bio-energy production.

Forest biomass from forest management is a renewable, carbon feedstock that can substitute for fossil fuels in the production of energy and other products (Caputo, 2009). In forest industries, biomass is a product of forest management practices applied during the growth of a stand such as pruning and thinning, are normally termed as silvicultural residues (Puttock,1995; Malinen et, al. 2001; Richardson et al, 2002). In commercial harvesting operations, low quality stems, branches, treetops, stumps and root systems are referred to as logging residues (Puttock, 1995, Richardson et al 2002). Silvicultural and logging residues are called forest residues. Wood residue is produced from the processing or breakdown of logs and/or round wood into sawn timber or other wood products (Figure 2). Common wood residues produced from primary processing include: bark, slabs, sawdust, chips, coarse residues, planer shavings, peeler log cores, and end trimmings. Secondary manufacturers typically produce the following types of wood residues: chips, sawdust, sander dust, end trims, used or scrapped pallets, coarse residues and planer shavings. Coarse residues, for both manufacturing groups, include slabs, edgings, trims and cores.

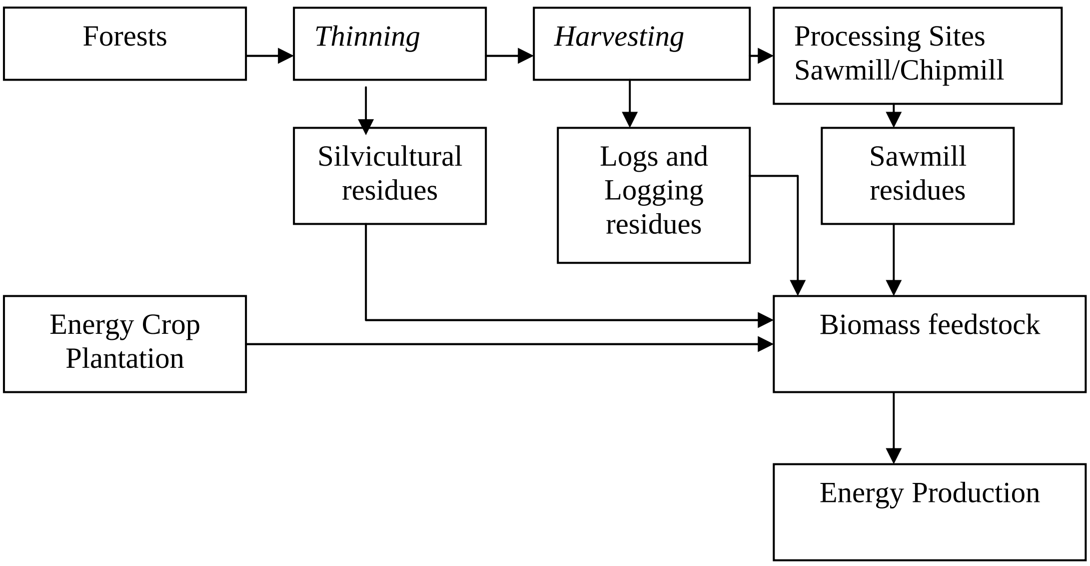

***Figure 2**: Sources of biomass in forestry*

Economic factors affecting the supply of forest biomass include production costs, prices of biomass and its substitutes, competing uses of forest resources, and policy, among others (Hamelinck et.al, 2005). First, technologies for forest production, biomass harvest and transport, and energy conversion will dictate the production costs of forest biomass and bio-energy. Thus, research and development will have an important role to play in forest biomass and bio-energy development. The costs will also vary with scale of operation, biomass spatial density, terrain conditions, average stem diameter, and transport distance, among other things. The most cost-effective production of biomass for energy occurs when it is produced simultaneously with other higher valued forest products (saw logs, pulp logs).

Capital investment in biomass production is quite intensive and in the case of Fiji, current investments on logging machines are mostly restricted to purchase of second hand machines from New Zealand and Australia. The volume and quantum of biomass operations will also dictate the capital investment in the PICs. Current interest rates in Fiji on business loans are between 13 – 15% (RBF, 2009) compared to 6-9% in New Zealand (ANZ, 2009) hence costs of biomass production are affected.

Harvesting of Biomass

The biomass supply chain is made up of a range of different parties including forest owners (individual/companies), contractors, transport and distribution companies and customers. Poor decisions relating to the choice of harvesting, transport and processing equipment, or poor matching of the various components of the fuel supply chain, can lead to unacceptably high costs and unacceptable fuel quality (Sims, 2005).

The current method of log harvesting in the study area involves partial trimming of logs and topping off at the cut-over area with final trimming and log conversion in the landings (Figure 3).

Figure 3: Four photos showing typical harvesting operations in Fiji

There are different methods of harvesting logging residues. Puttock (1995), Hudson (1995), IEA (2007) suggest the integrated harvesting approach where energy and conventional forestry products are harvested simultaneously in a one pass harvesting operation mainly because the method offers potential for reducing harvesting costs. Hudson (1995) identifies the cost reduction from the method because forest residues are by-products of the production of conventional forest products thus it is assumed that the forest residue production is available at zero cost.

In developed countries, integrated harvesting has gone through improvements to minimise costs. Scandinavian countries have modified systems to handle cut-length harvesting residues using chippers, bundling (Baker et al, 2010). Some USA states have modified system by adding chipper (Green et al., 2007). While Visser et al (2009) suggest options to process residues and transport as chips or bundle and transport to stationary chipper for processing in New Zealand.

Baker et, al. (2010), Stuart et, al. (1981) and Desroches et al. (1994) view that the production cost should be shared between the conventional forest products and forest residue based on some appropriate percentage. Other benefits from residue recovery includes the reduction in detrimental environmental effects arising from accumulation of forest residue materials, as whole tree processing ensures minimum accumulation of residues and ease of silvicultural operations for next rotation (Puttock, 1995). Integrated harvesting systems also reduce forest fuel level at harvesting sites (Han and Johnson, 2004).

This study will investigate the potential use of wood biomass energy resources arising from harvesting operations and energy wood plantations. The future generation of commercial electricity from wood biomass would increase the utilization of wood and forest residues from FPL resources. A model will be developed to determine the forest residue levels arising from different harvesting systems and the economics benefit of wood biomass sale to forest growers.

The objectives of the study are:

1. To understand how different harvesting systems impact on residue (cutover and landing) volumes and the costs related in collection and transportation of residues.
2. To develop a robust model that will predict biomass volumes and delivered costs from harvesting residues and energy wood plantations.
3. To use these results in an estate level case study to evaluate the economic benefits to the forest grower of biomass supply options.

Methods

The methodology developed for this study estimates the theoretical and available biomass potential. The model that will be used in the estimation of the forest residue, log volume and energy wood component of the study is illustrated in Figure 3. The model is a mathematical model using MARVL and EXCEL software for the forest residue component, LIRO software for the harvesting system. The model will ensure the validation of potential biomass volume by undertaking field data collection on cut-over and landing residues.

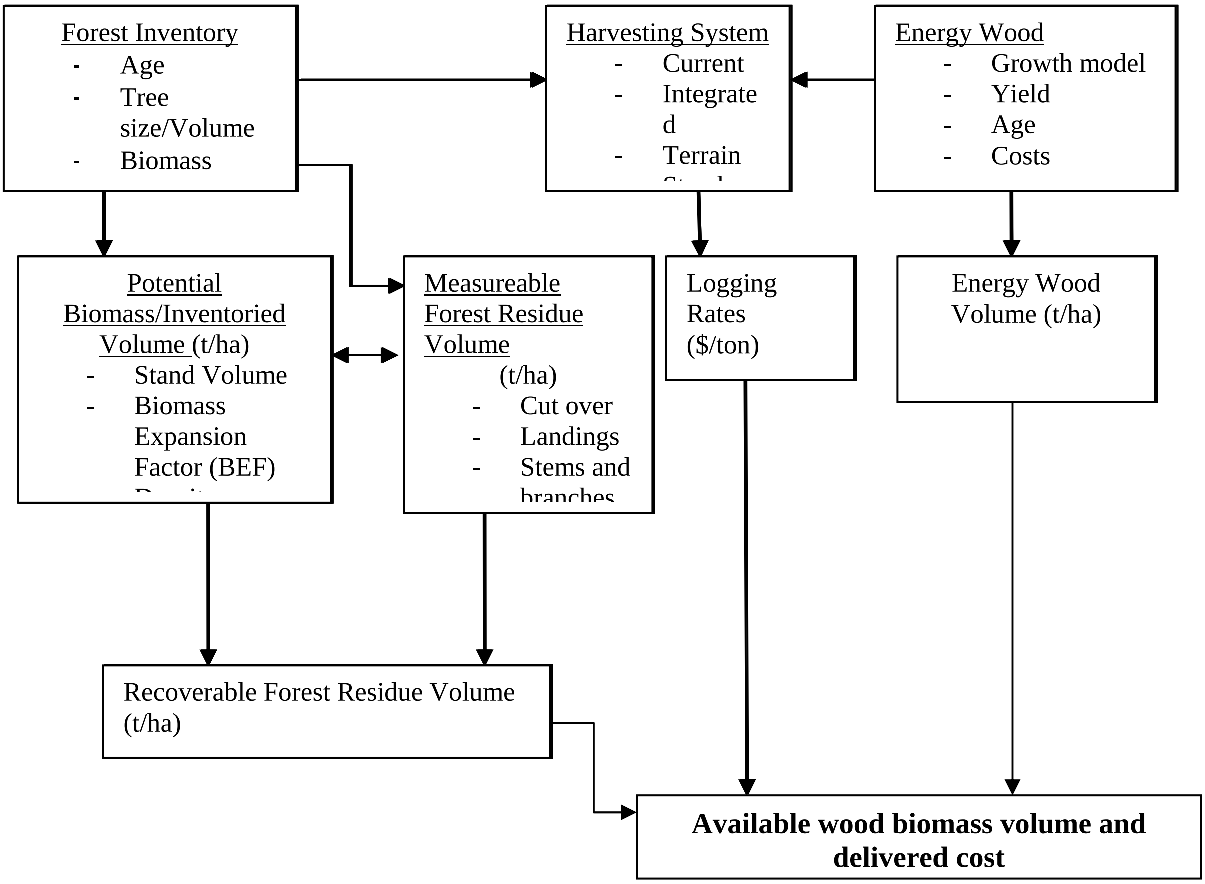

Figure 4: *Illustration of forest biomass model*

Summary

The key question of the research is will focus on how much biomass can be mobilized in a sustainable and cost-effective way from harvesting residues and energy wood plantations. The research will assess the technical and economical aspects of wood biomass production and supply of wood biomass for bio-energy production. The model will be tested on a Fiji case study.

The research will be expected the following on new information for wood biomass:

i. Forest residue production of two different semi mechanised harvesting system common in the Pacific islands compared to mechanised systems in developed countries.

ii. Development of biomass allometric equations and growth model for Acacia *mangium* in Fiji.

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