Developing the fuelwood economy of Papua New Guinea

Ian K. Nuberg *

School of Agriculture, Food and Wine, Waite Campus, University of Adelaide, PMB 1 Glen Osmond, South Australia 5064, Australia

A R T I C L E   I N F O

Article history:
Received 4 June 2014
Revised 30 October 2014
Accepted 31 October 2014
Available online xxxx

Keywords:
Fuelwood
Survey
Papua New Guinea
Small business

A B S T R A C T

This paper describes the fuelwood economy of Papua New Guinea (PNG) based on a survey of domestic users (n = 3994), commercial and industrial users (n = 66) and fuelwood vendors (n = 157). The survey period (2009) covered urban and rural, coastal and highland districts of known fuelwood-stress. The survey region represents 11% of the national population. It reveals that the fuelwood economy has a relatively flat structure with a very short and direct supply chain. Fuelwood is regularly or occasionally used by 85% of the population for domestic and commercial cooking, even in urban areas where there is good access to electricity and other energy sources. Proportions of the population selling fuelwood at some time in the survey period were 3% and 10% of urban and rural populations respectively. Those generating an income using fuelwood were 26% and 58% respectively. Fuelwood consumption is estimated to be 1.8 m³/person/year which is 6 times greater than the average of south and south-east Asian countries. It is estimated that 2.08 million m³/y of fuelwood is freely collected for domestic use in the survey region, while the amount traded was USD$7.14 million. The survey provides details of regional variations in fuelwood consumption, gender relations, income generation, and conflict associated with fuelwood, tree planting activity and attitudes to the need for woodlots. It describes and quantifies fuelwood flows from various sources to users and argues the point that the impact of fuelwood collection on forests is only localised. The fuelwood economy is largely informal with no public engagement in supply, marketing, distribution, pricing, and taxation. This paper argues the case for a national fuelwood policy which will encourage the private sector to invest in fuelwood trade and create economies of scale while still protecting smaller informal actors.

© 2014 International Energy Initiative. Published by Elsevier Inc. All rights reserved.

Introduction

Papua New Guinea (PNG) is a country with great potential for economic and social development based on its natural resources. Its export income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014). Yet the average annual income of approximately USD 4.8 billion/y is largely generated from mineral wealth (75%) followed by agriculture (19%), forest extraction (4%) and marine products (2%) (PNG, 2014).

...
Port Moresby and Lae, and the 40% of the population in the highland provinces are largely clustered in the cleared valleys. The fact that fuelwood vendors are a common feature of urban and rural market places indicate that many people do not have access to these trees for fuel. Even that fuelwood that is collected for “free” is a diminishing and highly contested resource (Murphy, 2006).

PNG has the problem of many resource-rich developing countries; a two-tiered economy where a small proportion of the population benefits from the extractive industries (mining and forestry), plantation industries and the public sector that is supported by them, while the majority have few opportunities at income generation beyond cash cropping and opportunistic service sector (e.g. market place hot food vending). Hanson et al. (2001) estimated that about 10% of the population also engage in selling fuelwood at some time and that it is a relatively easy market to move into. Apart from sawmill-offcuts there is no fuelwood available from forest logging or plantations. The market appears to be entirely informal and based on collected wood; i.e. not specifically purpose-grown. It is proposed that the fuelwood sector can be developed with more efficient, value-adding supply chains that provide livelihoods for small entrepreneurs. Much more knowledge about this sector is required to test this proposition.

Therefore, the aim of this paper is to present a quantified description of the fuelwood economy of PNG, with a view to understanding the potential for developing a sustainable domestic energy market that provides livelihood opportunities for a broad section of the population. This description is based on analysis of results of a large survey of domestic and commercial fuelwood users, fuelwood vendors and other stakeholders in the fuelwood sector.

The survey was undertaken in 2009 and focussed on regions that were known to be fuelwood-stressed; i.e. where there are strong fuelwood markets and where it is known to be conflict arising from competition for gathered wood. While fuelwood is used across the whole nation, in both urban and rural settings, the main rural districts where it is recognised as a significant part of the local economy are found in the highland provinces of Chimbu, Enga and the Eastern, Western and Southern Highlands. Many of these districts have been assessed to be under significant agricultural pressure and overall relative social disadvantage (Hanson et al., 2001).

The survey had 3 components: a large questionnaire survey of domestic users and vendors, a case-study monitoring activity; and semi-structured interviews of industrial and commercial operations using fuelwood and other fuelwood stakeholders. The complete results of the survey can be found in Nuberg (2013b).

### Method

A set of three questionnaire surveys were undertaken over two periods October–December 2008 and March–May 2009 of 2673 domestic urban users of fuelwood, 1321 domestic rural users and 157 fuelwood vendors. In addition the fuelwood use of 36 urban and rural case study households was monitored over a 2-week period and semi-structured interviews undertaken with 66 commercial and industrial users of fuelwood.

The survey was designed in a facilitated participative process at the PNG Forest Research Institute (FRI) in Lae. The survey design focused on areas where there is known fuelwood stress in PNG. These areas were determined to be the National Capital District (NCD) around Port Moresby, the city of Lae and its rural hinterland, the city of Mt Hagen and the rural areas of Mt Hagen District of the Western Highlands Province, Chimbu District in Chimbu and Henganofi District in the Eastern Highlands (Fig. 1). In terms of populations, the provinces from which these districts are selected represent 36% of the national population of 5,190,000 (NSO 2000). The actual districts represent about 10.6% of the national population.

### Questionnaire sampling strategy

The stratification of the survey population was based on information from the most recent national census (NSO, 2000). Within each of the survey districts the appropriate sample size for each Local Level Government unit (LLG) or ward was determined on the basis of relative population. The census unit is the finest level in the census hierarchy and represents entities such as roads, hamlets, villages, compounds, barracks etc. Each of these wards had different numbers of census units. It was not feasible to survey all census units in a district so a further level of sample discrimination was necessary. For each district the key indicator used to segregate census units was “Proportion aged 10 years and over economically active”. This indicator includes both males and females. The distribution of this indicator was separated into three equal thirds. An equal number of census units were randomly selected from each third of this distribution. The selected census units were allocated a sample size and identified on maps to be surveyed. In all, there were 55 sampling strata. Some of these were at the level of LLG/ward some were at the level of census unit.

### Survey data collection and collation

The questionnaire surveys and case-study monitoring were administered by the Foundation for People and Community Development (FPCD), a national NGO with experience in survey work. Six professional FPCD staff were involved and they trained a further 35 interviewers to assist with the questionnaire surveys. The surveys were undertaken in the lingua franca Tok Pisin but recorded on survey forms in English. The interviewers worked in pairs for security reasons. They worked on either side of a road and called upon every third dwelling along the road. If no-one was home or declined the survey, the interviewer moved to the next house until a willing interviewee was found. The interviewers continued through the sample stratum like this until the requisite number of interviews were made for that sample stratum.

The Fuelwood Vendors survey was undertaken opportunistically during the second round. Vendors were generally approached as they were encountered on the street in the progress of the user surveys. The interviewers also visited all the known fuelwood markets in each sample stratum.

On completion of each round, the questionnaires were shipped to Adelaide and entered into a database in MicroSoft Access 7.

### Questions asked in the survey

The nature of the questions asked are summarised in Table 1. Question 7 in the domestic user’s surveys was critical for aggregated estimates of fuelwood consumption. Interviewees were asked to estimate how much fuelwood they had used in the week prior to being interviewed, and the week before that. They were shown a 5 or 10 kg bundle of firewood (or photograph equivalent) and asked how many of these they would have used.

Such re-called information provides ‘guestimates’ at best, so a sub-sample of 36 urban and rural households interviewed in the questionnaire survey was invited to participate in the case-study monitoring exercise. This exercise involved two 1-week periods of direct weighing, and recording of species, of all fuelwood consumed on a daily basis. This survey was undertaken by FPCD staff in April 2009.

The diversity of small commercial and industrial users of fuelwood, and stakeholders in the fuelwood economy, was such that semi-structured interviews were a more appropriate survey tool. The interviews were directed to gather: quantitative information about fuelwood use, in which case physical measurements were sometimes taken; qualitative information about problems and opportunities associated with fuelwood. These interviews were undertaken by FRI staff and included 42 hot-food vendors and bakeries along the Highlands Highway, 11
lime burner communities along the Morobe coast, 12 oil palm, cocoa and copra factories in West and East New Britain Provinces and 1 tea factory in the Western Highlands. These interviewees were not necessarily in the fuel-stressed districts covered in the questionnaire survey.

Analysis

Estimates of aggregate fuelwood use and expenditure

The analysis of data included aggregate estimates of fuelwood expenditure and volume of freely wood collected. The estimate of annual expenditure on fuelwood across the fuelwood-stressed districts was determined using Eq. (1) (Table 2 explains terms used in equations).

\[ E_A = \sum_{d=1}^{5} \left( \left( \frac{H_{d}}{H_s} \right) \times 26 + \left( \frac{H_{d}}{H_s} \right) \right)_d \]  

The survey quantified the amount of fuelwood collected in terms of mass (see Q7 in Table 1). The annual tonnage of fuelwood collected across the 5 survey districts is the sum of the district totals, \( M_A \), which was calculated in Eq. (2).

\[ M_A = \sum_{d=1}^{5} \left( \frac{H \times m_h \times 52}{1000} \right)_d \]  

Weight to volume conversions were based on assumed basic density of 0.725 gm/cm\(^3\) (FAO, 1993). This approximation was validated using the water-displacement method on the more common species found in the market, Casuarina oligodon (in highlands) and Eucalyptus alba (around NCD). The annual volume of fuelwood consumed by person in each survey district was estimated using Eq. (3).

\[ V_d = \frac{m_d}{0.725 \times H_d \times H_u} \]  

Gender equity index

The interviewees were asked who collects and who buys fuelwood in their household, and this was analysed by a simple gender equity index. This was calculated as the ratio of the relative proportion of instances of female activity to instances of male activity, or

\[ \text{Gender Equity Index} = \frac{\text{sum of reports of female activity in district}}{\text{sum of reports of male activity in district}} \]  

Within a survey district, if men and women share the load equally in collecting and buying fuelwood, i.e. a 1:1 ratio, then the index = 1.0. In the gender index used here, if there are more instances of men's activity then index < 1, if women more active > 1. A change in 0.1 units of the index reflects a change in 10% of the sample population.

Results and discussion

In this section, the core quantitative survey data is presented in Tables 3, 4 and 5 with supplementary data and information from the interviews in the text. The subheadings cover the main messages that emerge from the data and the significance of these is discussed. This is then followed by an integrated description of the fuelwood economy including a picture of woodflows in the survey region (Fig. 2). This figure
Not all questions are dealt within the presentation of results in this publication.

Energy were also used by 88% of fuelwood users. The most common re-
nial and celebratory use, in small business or just in the event of power
outages.

Fuelwood affects most of the population

Overall 85% of the surveyed population used fuelwood in the 12 months preceding the survey. Table 3 provides the regional breakdown. Virtually the whole rural and highland populations use fuelwood. In the NCD there is a moderate correlation ($R^2 = 0.6$) between the proportion of dwellings with access to power lines with the proportion of non-fuelwood users in each of the 9 NCD wards. However, even in wards with almost 100% access to electricity, 47% of inhabitants still used fuelwood in the survey year; this could be for regular cooking, for ceremo-
nial and celebratory use, in small business or just in the event of power
outages.

While domestic cooking is the most important use of fuelwood, 17% of the interviewed population cooks their food by other means. Only 4% of rural people use other energy for cooking. Alternative sources of energy were also used by 88% of fuelwood users. The most common re-
sponse was to use kerosene for lighting, then the hierarchy went from gas for cooking, generators for appliances, then mains access. About 15% of the sample population had access to mains power and 30% access to generators, which may be communally owned in rural areas.

Considerable time and expense are involved in fuelwood procurement. In all the urban areas a many of the interviewees travelled between 1 and 3 km into the surrounding hills to gather fuelwood. The proportions were 27% in NCD, 32% in Lae and 32% in Mt Hagen. A further 11%, 25% and 2% respectively travelled more than 3 km into the sur-
rounding hills and beyond. The average estimated distance travelled be-
yond 3 km was 10 km (range 4–30 km, $n = 175$). In rural areas 11% of interviewees travelled more than 3 km, mainly into the natural forest, their current gardens and bush fallows.

The most common form of transporting wood that was collected was on foot which accounted for 68% of respondents. Of the 32% of re-
spondents who used vehicles to transport collected fuelwood, most of these used public transport (31%), their own car (29%), or had it deliv-
ered (22%).

The average expenditure per household on fuelwood for regular dom-
estic use over a 2 week period was on average about US$10 with slightly higher amounts for rural buyers (Table 3 row 6). These estimate exclude purchases that were deemed for ceremonial and com-
mercial uses. Table 3 highlights the strong regional differences in the purchasing population. In particular 53% of Mt Hagen urban residents, many of whom are settlers from other districts, do not have access to local trees through clan relationships. In comparison, the Lae and NCD urban samples include wards which are peri-urban and better treed than Mt Hagen. The proportions of fuelwood buyers in rural areas are much lower because these residents are largely on their own land (Table 3 row5).

Daily household fuelwood use was determined in two ways (Table 3 rows 18 and 19). The re-called information generated by the domestic surveys is compared with the daily measurement of fuelwood used by case-study households. The two data sets are within reasonable agree-
ment, although it is clear that interviewees providing re-called informa-
tion tend to underestimate their fuelwood use. The average daily fuelwood use across the monitored households was 24.8 kg/d. However, there was a considerable range in measurements from 2.2 to 97.4 kg/d, so the median value of 16.0 kg/d may provide a more conservative estimate.

Gender relations of fuelwood collection and purchase are traditional

When considering gender data from an interview survey it is impor-
tant to describe the gender balance of the sample and the interview
team. The male:female ratio in the urban sample was 56:44 while the rural sample was 82:18. The interview team though largely male did include female interviewers; however, in rural areas the teams were usually pairs of males for security reasons. Even if there was a female in the pair, it was usually a male who represented the interviewed household. This was unavoidable in the context of PNG rural culture.

Table 3
Core quantitative dimensions of fuelwood economy as determined by questionnaire surveys of domestic users, vendors and case study monitoring.

<table>
<thead>
<tr>
<th>Regions of fuelwood stress surveyed</th>
<th>Urban</th>
<th>Rural</th>
<th>Highland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NCD</td>
<td>Lae</td>
<td>Mt Hagen</td>
</tr>
<tr>
<td>Populationa</td>
<td>254,158</td>
<td>78,692</td>
<td>27,877</td>
</tr>
<tr>
<td>Row Sample size</td>
<td>1868</td>
<td>558</td>
<td>247</td>
</tr>
<tr>
<td>1 % sample using fuelwood (FW) over past 12 months</td>
<td>73</td>
<td>90</td>
<td>88</td>
</tr>
<tr>
<td>2 Average frequency of FW gathering per week (Median?)</td>
<td>1.4</td>
<td>2.0</td>
<td>2.9</td>
</tr>
<tr>
<td>3 Average frequency of FW purchase per week</td>
<td>2.4</td>
<td>1.9</td>
<td>2.6</td>
</tr>
<tr>
<td>4 % user population buying over last 2 week</td>
<td>24</td>
<td>27</td>
<td>47</td>
</tr>
<tr>
<td>5 Number of buyers for every 100 users</td>
<td>33</td>
<td>27</td>
<td>53</td>
</tr>
<tr>
<td>6 Average spent over 2 weeks in PNG Kina$</td>
<td>20.65</td>
<td>21.60</td>
<td>20.39</td>
</tr>
<tr>
<td>(USD)</td>
<td>(9.06)</td>
<td>(10.04)</td>
<td>(9.48)</td>
</tr>
<tr>
<td>7 % FW users experienced conflict over access to FW</td>
<td>48</td>
<td>40</td>
<td>58</td>
</tr>
<tr>
<td>8 % FW users who have planted trees in past 2 years</td>
<td>44</td>
<td>25</td>
<td>54</td>
</tr>
<tr>
<td>9 % FW users expressing need for local woodlots</td>
<td>92</td>
<td>62</td>
<td>94</td>
</tr>
<tr>
<td>10 Gender equity index for fuelwood collection</td>
<td>1.0</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>11 Gender equity index for fuelwood purchase</td>
<td>1.0</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>12 % planted trees in the last 10 y</td>
<td>78</td>
<td>48</td>
<td>73</td>
</tr>
<tr>
<td>13 % FW vendors with access to land to grow trees</td>
<td>86</td>
<td>39</td>
<td>88</td>
</tr>
<tr>
<td>14 % sample travelling &lt;3 km to gather FW$</td>
<td>6</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>15 % domestic FW users also using fuelwood commercially</td>
<td>26</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>16 % domestic FW users also selling fuelwood</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>17 % for whom FW more difficult to access over past 2 y</td>
<td>65</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

Daily household fuelwood use

<table>
<thead>
<tr>
<th>In PGK</th>
<th>Entertainments using fuelwood to generate incomeb</th>
<th>Fuelwood vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>Urban (n = 2916)</td>
<td>Rural (n = 1028)</td>
</tr>
<tr>
<td>100–499</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>500–999</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>1000–4999</td>
<td>22</td>
<td>32</td>
</tr>
<tr>
<td>5–10,000</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>&gt;10,000</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Average PGK (USD)</td>
<td>3503 (1629)</td>
<td>1557 (724)</td>
</tr>
<tr>
<td>Minimum</td>
<td>20 (9)</td>
<td>30 (14)</td>
</tr>
<tr>
<td>Maximum</td>
<td>73,000 (33,945)</td>
<td>33,600 (15,624)</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8802 (4092)</td>
<td>2923 (1359)</td>
</tr>
</tbody>
</table>

Table 4
Frequency of income categories in enterprises using or selling fuelwood.
This should be kept in mind when interpreting the gender equity indices in Table 3 rows 10–11. It is possible that the rural data reflects unbalanced, positive self-reporting from male respondents.

The gender equity index showed that while males and females across all age classes share the responsibility of fuelwood collection and purchase equally in NCD, this is not so in other regions. For example, while males collect fuelwood more than women in Mt Hagen Urban (which may well be due to security reasons), the relationship is opposite in Lae Rural. In particular, in rural households men are twice as likely to buy fuelwood as women.

The gender relations of fuelwood collection and purchase in PNG do not appear to be as unbalanced as they are in other developing countries where it is a largely a woman’s task (e.g. Anon, 1995; Raghupathi and Venkaiah, 2007; Larinde and Olasupo, 2011; Nizami, 2013). In some cases it is gender independent, such as rural Argentina (Cardoso et al., 2012).

The validity of this survey’s results on gender equity can be tested against the only other study of gender relations in fuelwood collection in PNG (Murphy, 2006). This was a smaller, focussed survey ($n = 401$) with both urban (town settlement) and village sub-samples to the southeast of Goroka, Eastern Highlands. The sample had a slight female majority because the interviewers were local. Even in this survey 45% of the collection of fuelwood was done by males in the household (i.e. gender equity index = 1.2).
Fuelwood use is unsophisticated and inefficient

The most common form of fireplace is a simple open fire outside the house (51%) or similarly open fire inside the house (34%), the preferences for these arrangements much higher in rural areas (69%) and 68% respectively. Many respondents had more than one type of arrangement associated with their dwelling. The type of fuel-saving stoves being promoted in Africa and other developing regions (GACG, 2013; Manibog, 1984); East Africa (Clough, 2012); India (Kishore and Ramana, 2002), (Venkataraman, Sagar, Habib, Lam, and Smith, 2010); China (Smith, Kennedy, Shah, and Schreier, 1993) were not observed at all either in domestic or small commercial operations.

The ceremonial and celebratory use of fuelwood is most commonly in the form of traditional mu-mu; where rocks are heated in a pit oven and the food (e.g. pig, sweet potato, yams etc) are cooked on the radiant heat once the fire is removed. Table 3 row 23 presents the estimated purchases of fuelwood for these purposes for the survey year. The survey could not detect how much charcoal was freely gathered for this specific purpose.

Charcoal is considered an improved energy source because it generates much less smoke and it is lighter and cheaper to transport (Antal and Gronli, 2003). The charcoal market in PNG is very small and barely obvious. Charcoal imported from Australia is sold in urban centres at an average price of USD 4.70/kg primarily for use in barbeques. Small amounts are produced locally and sold USD 0.70/kg Lae for Asian consumers who are familiar with its use. It is not commonly used by Papua New Guinean nationals.

There was an effort in the mid-1970s and early 1980s to establish charcoal as a relatively clean and affordable energy source in the NCD (Gamser, 1980; Gamser and Harwood, 1982; Harris, 1979). Research into the most appropriate charcoal kilns produced the TPI kiln (Tropical Products Institute) and the simpler Tongan Drum kiln. Equally simple and cheap charcoal stoves were also developed (Nakau) and promoted (Kamila, 1998). These stoves were even distributed among public servants at cost to prime the charcoal economy. However, the attempt stalled because of lack of charcoal supply and poor extension (Gamser and Harwood, 1983).

The knowledge of using charcoal for cooking is not widespread. During the survey it appeared that most highland respondents were not aware that charcoal is a commercial product. ’Sakol’ to them was just the coals left in the fireplace from the previous night.

Many people use fuelwood as a livelihood strategy

Use of fuelwood for income generation is high among both urban and rural domestic respondents (Table 3 row 15). This included activities such as baking, hot food vending and smoking fish. The proportions of interviewees in the urban and rural domestic surveys earning some income from selling fuelwood were 3% and 10% respectively. Much of this business activity is part-time to meet occasional expenses such as school fees and medical expenses. Table 4 indicates the range and distribution of incomes of people either using fuelwood to generate income or selling fuelwood. Accordingly, the average annual incomes generated using fuelwood were USD1629/y in urban areas and USD720/y in rural areas. The proportion of respondents earning >K5000/y (USD 2325) were 14% in urban and 5% in rural areas. Hot food vendors were interviewed along the Highlands Highway from Markham Bridge (Morobe Province) to Wailu Water fall (Enga Province). Estimated incomes ranged from USD32 to K418/week and daily fuelwood consumption ranging from 10 to 30 kg/day.

Lime burning is a major source of income for many villages along the Morobe coast with access to dead coral and sea shells. This lime is used in the consumption of buai, or betel nut, and is widely traded throughout PNG. Incomes among lime burning groups ranged from USD395–22,320/y. Estimated annual fuelwood use of these groups ranged from 1920 to 60,000 kg/y. The net (i.e. income after costs) efficiency of burning wood to make lime is USD1.38/kg for bamboo but only USD0.15/kg for mixed hardwood species. Access to fuelwood through collection or purchase did not seem to be a problem in this region; mangroves are observably protected from wood collection and reefs from live coral collection.

Table 5 presents the core results from the special survey of fuelwood vendors. 36% of vendors identified fuelwood sales as their sole source of income. 92% of vendors earned K5000 or less in the previous 12 months. (The official minimum wage for PNG is K5240.) So, only 8% of vendors earned >K5000. The maximum income was recorded as K70,000 of a large vendor (family group) in Mt Hagen.

Perhaps the most important finding in Table 5 is the range of values for fuelwood per kilogramme. The high prices in Mt Hagen reflect the dependence on and scarcity of fuelwood in the WHP. Throughout PNG fuelwood is sold in bundles at standard prices: PGK 2, 5, 10 etc. The lower value/kg in NCD reflects larger bundles for a given price point, presumably for quicker sales.

Fuelwood economy is largely informal

The RWEDP surveys mentioned in the introduction identified three parallel sectors in the fuelwood economies of the 16 Asian countries surveyed: 1] A formal sector supplied by the government forest organisation subject to regulation. The wood is sold either directly to the public or through wholesalers and retailers; 2] An informal sector of suppliers operating outside of the formal regulations who directly gather and sell locally, or sell to truck drivers transporting the fuelwood to a distant market. This sector also includes that fuelwood that is directly gathered by the consumer; 3] A private sector where the agents will buy the wood as whole trees, engage in the processing and transport of product to distant wholesale and retail markets. The private sector is generally thought to have the largest impact on overall fuelwood supply (RWEDP, 1996).

In PNG there is no formal sector in the fuelwood market. The PNG Forest Authority does not have an explicit fuelwood policy, nor does it have the capacity to undertake specific fuelwood plantings. There are no regulations on the harvest, transport or trade of fuelwood as there are in all the RWEDP countries. The only regulations affecting fuelwood are those imposed by local government or landlords who forbid the use of fuelwood within certain precincts. In the NCD, 25% of interviewees could not use fuelwood at home for this reason; the value was 9% in both the Lae and Mt Hagen urban samples.

The informal sector predominates with most fuelwood being gathered directly by users. Of the fuelwood vendors interviewed 84% were classed as informal, and this was following a sampling procedure that was likely to preference larger vendors who operate on a permanent basis. In addition, 3% of urban and 10% of rural interviewees in the domestic user surveys indicated that they sold fuelwood on a part-time basis; they will all fall into the informal sector. These proportions scale up to indicate that there were about 13,000 urban and 32,000 highland rural people were involved in the informal sector in the survey year. About 35% of the interviewed vendors fell into the USD1-2000/y category, while the rest earned below this.

A numerically small but highly visible private sector also exists. These enterprises are in two forms: selling retail fuelwood from a permanent site; or trucks which pick up fuelwood from roadside suppliers and deliver to large customers (e.g. factories, hospitals, schools, barracks etc). The partnerships and purchasing patterns of the sedentary enterprises are characteristically kept within extended family and clan boundaries, and the level of investment may include a chainsaw and/or a truck. The truck-delivery enterprises will purchase fuelwood wherever it is on offer. Indeed, 17% of the informal vendors sell to the
truck traders. These two types of private enterprise are relatively lucrative with an income range from USD 23–44,000/y.

**Conflict over collected fuelwood is serious**

Access to fuelwood had become more difficult for 65% of urban and 41% of rural respondents over the 2 year period previous to the survey (Table 3 row 7 for district values). Problems with accessing fuelwood are particularly severe in the coastal wards of NCD such as Napa Napa (84%) and Kila Kila (82%); populations closest to the mangroves around Port Moresby. A decade earlier the problem was nowhere near severe, but one can safely assume a trend of increasing conflict over access to fuelwood into the future.

The experience of conflict related to fuelwood collection is very high across all survey districts; this is particularly so considering the proportion of users who buy their fuelwood in urban areas. It is relatively low around Lae because the hinterland is well-treed. (Lae’s average annual rainfall is 4636 mm compared with Port Moresby’s 1012 mm). Conflict over fuelwood in the highlands is very common because: everyone uses but very few people purchase fuelwood; the population density is very high (e.g. 3 highland provinces 38–59 persons/km² cf Morobe and national average of 15 person/km²); the region is culturally very diverse (there are 42 traditional languages over the three highland provinces in the survey); and inter-tribal conflict is common over all aspects of rural life, not just fuelwood collection (Reilly, 2008).

The nature of the conflict reported ranged from quarrels and demands for compensation to serious fights leading to injury and death. An associated problem is the real threat of harassment and rape of women while in the process of collecting fuelwood.

As a consequence there was strong agreement (62–95%) with the need to plant more fuelwood trees (Table 3 row 9), but this was by no means universal for reasons ranging from lack of good sites (e.g. around NCD) to abundant natural supply (e.g. around Lae).

**A strong tree-planting culture**

Trees feature prominently in the traditional farming systems of PNG. The high proportions of interviewees who plant trees (Table 3 line 12) indicate a strong culture of tree planting. This is an important consideration if smallholders are to be encouraged to plant trees specifically for fuelwood production. From the re-called data offered it is estimated that about 3.6 million trees were planted by the population in the survey regions in the 2 years previous to the survey. It is likely that most of the trees planted by urban respondents were not actually planted within the survey region, but on family land in rural areas.

Across the highlands Yar (C. oligodon) is by far the most preferred species for fuelwood (>85%). It is commonly planted in highland villages and a dominant shade species in coffee agroforestry systems (Bourke, 1985). In Mt Hagen there is also a preference for the introduced eucalypts (87%, mainly Eucalyptus grandis and Eucalyptus robusta), while in Henganofi and Chuave the indigenous PNG Oak (Castanopsis acuminatissima) is highly favoured (85 and 91%). Naturalised Leucaena spp is also an important fuelwood used in these areas (22 and 29% respectively).

Most of the vendors interviewed (78%) had access to land to grow trees for fuelwood with many of the NCD vendors have family land either in the NCD hinterland or Central Province (Table 3 row 13). Similarly most highland fuelwood vendors are selling close to their home village. The low values for Lae indicate that these vendors originate from areas other than Lae.

**Impact of fuelwood gathering on forests is local not general**

In PNG there was common perception before the survey that fuelwood collection is a cause of deforestation. This is probably influenced by the ‘fuelwood gap’ theory that was current in the 1970s (Eckholm, 1975). This cannot be directly supported from the survey, and it is probably too simplistic a claim to make. The relationship between fuelwood collection, per se, and deforestation may be very location specific and not a general problem. This has been found to be the case in other developing countries where most fuelwood is collected from sources other than natural forests (Arnold and Persson, 2003).

In PNG urban areas 66% of non-traded fuelwood is collected from the sources such as: around the house, own land, garden clearings. The sources and proportion of respondents accessing these and other sources in both urban and rural populations are illustrated in Fig. 2. The proportion of fuelwood collected from mangroves around NCD was only 3% but this is having a significant impact and is of concern. Assuming these residents collected all their wood from this source, this could amount to about 6860 m³/y around those population centres collectively. This may only be a localised problem as the lime burning communities on the Salamaua Coast south of Lae in Morobe Province were observed to respect the local restrictions and do not use mangrove wood for their business activity.

Rural residents can gather fuelwood more widely over the range of sources available. However it is possible that the 12% from garden clearings and 9% from natural forests could be impacting on forest integrity. The garden clearings have evolved from the traditional swidden cycle which left the land to recover for decades before re-clearing. With population growth the recovery periods have grown much shorter as a response to land pressure. The survey did not determine whether the garden clearings were new from natural forests, or from bush fallows, grassland or just garden falls. So it is difficult to assess their direct impact on standing forest. However, it is estimated that 56% of land used for cultivation across all PNG is covered in secondary forest before it is cleared for planting (Allen et al., 2001).

It is likely that much of the wood collected from garden clearings and even under the ‘natural forest’ category was re-growth and could have been included under ‘bush falls’. Bush falls are essentially a long-cycle agroforestry system and should not be considered as forest degradation. Nevertheless, the fuelwood collected from ‘garden clearings’ is equivalent to 43,708 m³/y. The 9% collected from ‘natural forests’ is equivalent to 8552 m³/y in the fuelwood-stressed districts. Is this a significant and unsustainable harvest? This is difficult to answer and won’t be attempted here. The only comparison available is the total raw log export volume for PNG in 2006 which was about 2.7 million m³ (Shearman et al., 2008).

A survey of PNG forests using remote sensing imagery showed that over the period 1972–2002 15% of PNG’s rainforest was cleared and 9% degraded to secondary forest. The expansion of subsistence agriculture contributed to 46% of the net forest change over this period. A further 4.4% of forest was lost due to fire associated with subsistence agriculture (Shearman et al., 2008).

The PNG population grew from 2.7 to 5.6 million in this period and the highest population densities exist in highlands between 1200 and 2500 m. There is a strong relationship between population density and forest loss in lowland and island regions, and this relationship is also apparent in the highlands. About 30–40% of the population lives in the highlands, growing at 3.2% /y and showing no signs of slowing. The average population density is 22 persons/km² with patches of 200 person/km² (Allen et al., 2001). The next densely populated region is the islands (10 persons/km²).

Given the high population in the highlands one could be struck by how relatively little deforestation and degradation of rainforests has occurred in the highland provinces. Earlier studies analysing forest change between 1975 and 1996 claimed that population increase in the highlands was accommodated by intensification of garden systems rather than clearing for more gardens (McAlpine et al., 2001). The Shearman et al. (2008) study, which is over a longer time span and finer resolution, disputes this and squarely points the finger at garden clearing being the main cause of deforestation. Filer et al. (2005) contest this claim with the view that much of what is called deforestation is actually part of
the traditional cycle of farming, fallow and regrowth; i.e. what is called “bush fallow” in the current paper.

None of these studies adequately quantify the relationship between clearing for gardens, tree planting in gardens, collecting fuelwood, fires caused by clearing and the processes of regeneration. Elsewhere in the world (e.g. Nepal: [Bajracharya, 1983]) deforestation is understood to be primarily a response to clear forest for food cultivation, not so much for fuelwood. So it is the food-fuel system that needs to be understood, particularly in a region like the Waghi Valley in WHP.

Overview of the fuelwood economy

In a broad view, the fuelwood economy in PNG, compared to other developing countries where similar studies have been done, has a relatively flat structure with a very short and direct supply chain. Fuelwood is regularly used by most of the population for domestic and commercial cooking, even in urban areas where there is good access to electricity and other energy sources. In the domestic market, most fuelwood vendors are collectors although larger vendors may buy from landholders and sell on to smaller vendors as well as selling directly themselves. In the industrial market it is largely supplied by local traders who pick up wood from roadside collection points. Selling fuelwood is an easy market to enter with many people entering it on a part-time basis. It is an informal economy in that there is no public engagement in supply, marketing, distribution, pricing, taxation, and use (except for instances of the prohibition of firewood use in some urban areas). Tree planting is widely practiced and many of these trees would be used for fuelwood. Value-adding of fuelwood into charcoal exists but it is on a very small scale, fragmented and infrequent.

Fuelwood consumption is estimated to be 1.8 m$^3$/person/year which is 6 times greater than the average consumption of 16 south and south-east Asian countries in the FAO Regional Wood Energy Development Program (and only exceeded by Bhutan). The absence of fuel-efficient stoves must surely contribute to this high value. In PNG there will be at most (and rarely) 2 intermediaries between landholder and fuelwood consumer; this compares with other countries which can have up to 7–8 intermediaries (Hadikusumah et al., 1991; Cruz et al., 1991; Hyman, 1983). PNG also contrasts with these countries in the absences of government involvement in either trade or regulation of the fuelwood market, a significant organised private sector, and a charcoal market.

Fig. 2 illustrates the flow of wood from various sources to urban and rural users through free collection and the market. The percentage values on the flow lines indicate the proportion of collectors who access their wood from these sources. While it would be useful to be able to quantify the volume of fuelwood from each of these sources, the data from this survey can’t make that estimate. However, estimates are made of the volume of fuelwood that flowed into each of the districts the year of the survey using Eq. (2).

General discussion and conclusion

Fuelwood surveys reveal the dimensions and significance of fuelwood in the domestic economy and its regional variations. As such they can better inform public policy and private business decisions that can have wide-reaching impacts on industrial and small-business development, public health, and forest management.

In summary the survey shows the following: most people continue to use fuelwood even in the presence of other energy sources; its use in the home and market place is unsophisticated and inefficient because there has been scant interest in improving it; many people use fuelwood as a livelihood strategy, with some earning good incomes; conflict over fuelwood collection is serious and growing; there is a strong tree planting culture; and the environmental impact of fuelwood collection is local but not general; the economy is largely informal.

This survey shows that firewood will remain a key component of PNG’s domestic energy economy for long into the foreseeable future, especially in rural areas. The way this fuelwood is accessed must change in response to population growth and increasing intensification of land use. Its socio-economic value needs to be formally recognised and integrated into the domestic energy economy along with modern, imported fuels.

The first step for this would be a National Fuelwood Policy. Clearly, this policy would not be just a forestry issue, but embraces the sectors of: energy, agriculture, education, community development and regional economic development. Without pre-empting this policy, it seems that the government intervention should not be of the sort to tax or regulate the flow of this trade, as people will easily find ways around these regulations. However, the Government of PNG could create conditions to encourage the organised private sector to invest in fuelwood trade and create economies of scale. The Government’s regulatory role would then be to ensure that this firewood is sustainably harvested or grown, and that actors in the informal market are still protected. Local and provincial governments could encourage the use of clean burning charcoal in public places (some local jurisdictions, eg Goroka, already prohibit firewood in the market place).

Such a policy would need further research to inform its development. Modelling of local woodflows in communities would help understand the role of regeneration of wood harvest from village gardens, bush falls, forests, plantations, public areas. Such models would help pinpoint areas where fuelwood gathering is, or will be, causing deforestation and areas where fuelwood collection is buffered by natural regeneration.

Consumers’ choice about energy sources is very complicated and likely to concern much more than relative prices. Both econometric and social studies of the domestic energy market could explain the very large difference price (per kg) of fuelwood around the country, as well as help design market instruments to encourage the organised private sector to invest in the fuelwood market.

Acknowledgements

This study was sponsored by the Australian Centre for International Agricultural Research as part of the project Promoting Diverse Fuelwood Production Systems in PNG Project FST/2006/088 (Nuberg, 2013a). The author is very grateful to the following people: from Foundation for People and Community Development who implemented the questionnaire survey and case-study monitoring activity Yati Bun (director), Israel Bewang (coordinator), Bazakie Baput, Bonti Krais, Fletcher Onise, Kafuri Yaro, and Linzon Zamangi; from the PNG Forest Research Institute, Lae, who undertook the semi-structured interviews John Paul, Agnes Sumareke and Maman Tavune; and Dessy Kusbandi for data entry.

References


