Type, Quantity, and Re-Use of Residues in the Forest Products Industry in Trabzon, Turkey

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It is necessary to know the type and quantity of wastes to select the proper applications and waste management strategies. This study investigates the type, quantity, and utilisation methods of wastes generated by micro-sized enterprises that produce timber and furniture, which are two major sub-sectors of the forest products industry in Trabzon. A total of 885 enterprises of manufacturing timber and furniture in Trabzon were identified by reviewing the records from the professional chambers of commerce. The stratified sampling method was used to compare the sub-sectors, and the sample size was determined as 120. Among these, 70 furniture- and 50 timber-producing enterprises were interviewed. The chi-square test was used to determine whether the applications of timber and furniture enterprises are dependent on each other. In general, there are no differences in waste utilisation applications and education level between the sub-sectors. The percentage of the owners/managers that received any vocational training is 77.5% in two sub-sectors. In general, engineered wood wastes are used as fuel. The majority of the owners/managers in the timber industry believe that their waste has an economic value compared to those in the furniture sector. The total amount of wood waste generated by sectors was 528 tons in a month.

Keywords: Wood waste; Forest products; Timber; Furniture; Micro sized business

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INTRODUCTION

Waste is generated along with the main product during industrial activities. The generation of wood waste cannot be prevented when cutting trees to produce logs and other wood products (Eshun *et al*. 2012). When the raw materials are abundant and cheap, wastes such as wood bark are either buried in the ground or burned on site to reduce their volume. However, such practices aggravate environmental problems (Casares *et al.* 2005). Although wood wastes are valuable sources to produce other products (Lykidis and Grigoriou 2008), their value has been recognized only recently because of the increase in prices following the decreasing supply of raw wood, the enforcement of environmental regulations, and the increase in environmental awareness. As an example, wood bark, which has mostly been disposed, is now used in the construction of composite wood boards (Pedieu *et al.* 2008).

The by-products of the forest products industry (FPI) include biological wastes such as bark, chips, and sawdust. Because their disposal causes air and water pollution, it is better to use them as fuel (De Hoop *et al.* 1997). Walawender *et al.* (1997) reported that generated wastes are still buried in disposal sites, although environmental regulations are increasingly forcing companies to close their dumpsites. In some states in the United States,

medium density fibreboard (MDF) waste is buried, but this practice leads to an increase in the cost of disposal due to the limited number of regular burial sites. Therefore, these wastes are increasingly used in soil improvement with positive results (EPA 2011). Murphy *et al*. (2007) reported that the use of wastes as fuel has reduced, but their use as paper clay, fibreboard, industrial fuel, and agricultural/landscape products has recently increased.

One of the major sources of waste wood is the FPI. For many years, wastes generated by this industry have been sent to landfills. In recent years, most of these wood wastes have been used to manufacture new wood products. The main waste wood resources include (i) municipal solid wastes, (ii) construction and demolition debris, and (iii) primary and secondary wood products industry (Falk 1997).

The collection and reuse of wastes generated by primary wood manufacturing during timber harvesting and processing (NCDENR 1998) do not present any challenges to the companies because the wastes are already within the facility limits and do not need transportation (Searle and Malins 2013). Primary wood manufacturing is an important waste source because 45 to 55% of veneer logs turn into wastes or by-products (FAO 2015). Secondary manufacturers then use these by-products to build houses, cabinets, upholstery, exterior finishes, furnishings, and boats. During the secondary production, new wood waste products are generated. It is more difficult to estimate the amount of wood waste generated by the secondary manufacturing sector. The estimated waste quantity from this sector ranged between 0.7 and 4.5 million tonnes in 1997 (NCDENR 1998).

Mulch and compost are two important wood waste markets that prefer using wastes generated by primary wood manufacturing (*e.g*., bark and chips) to those generated by secondary wood production. Wood residues from secondary producers are more valuable in the fuel market because they are technically dry (NCDENR 1998).

Mulch obtained from waste wood residues is in competition with mulch obtained from raw wood chips and bark. The mulch from wood waste contains more cellulose than the mulch obtained from wood chips and bark. Cellulosic mulch breaks down and decomposes more quickly than bark mulch. Some customers prefer cellulosic mulch because it is cheaper. The price of mulch from recycled wood is below US$2.5/ton in the southeastern United States; however, the price of bark and fine cut hardwood mulch is between US$3.75/ton and US$4/ton (NCDENR 1998).

Wood waste is an alternative to using/burning fossil fuels in many parts of the United States. There were 322 wood-burning facilities in North Carolina in 1996. They used 3,673,000 tons of wood waste (approximately 31% of all generated wood waste). Most of these facilities are wood waste producers that burn their own waste for their energy needs. The average cost of wood fuel from waste is US$12/ton. Its energy value is US$1.2 per million British thermal units (MMBTU), while the energy value of natural gas is US$2.2 per MMBTU (NCDENR 1998).

Products that can be manufactured using wood residues consist of outer surface coating (hardboard), non-structural plates (chipboard, oriented strand board, fibreboard), finger-bonded wood timber, wood-plastic alloy materials, and boxes and packaging (including pallets) (NCDENR 1998). Lesar *et al.* (2016) reported that metal parts or non-wooden materials in wood residues can damage the process equipment or influence the product properties. The portion of contaminants or pollutant in waste wood can be decreased by using sophisticated sorting system but it is almost impossible to separate the pollutants out of the waste or recycled wood.

In New Mexico, a chipboard factory uses 250 tons of wood residues per day and pays US$20 per ton for them although the average price of such residues is US$18. A

fibreboard plant that uses only recycled wood has been built in California, and its production capacity is 150,000 tons MDF/yr (NCDENR 1998). It is possible to use 15% waste wood in concrete production (Thandavamoorthy 2015). Wood shavings can also successfully be used in the production of tiles in an environmentally, technically, and economically beneficial way (Novais *et al.* 2015).

There are some obstacles in the management of generated wastes such as low waste amount, waste volume, transportation costs, lack of legal regulations, a large number of small-scale enterprises, and lack of information (Top 2015). Much of waste is generated by industry. Large sized industries are more successful at managing their waste because they have sufficient financial and human resources. However, small and medium sized enterprises (SMEs) are both insufficient in waste management and less sensitive to the environment because their sources are limited and often have other problems. SMEs produce 64% of total industrial waste in the European Union (Mitchell *et al*. 2011). 92% of these SMEs in the EU are micro sized businesses (Constantinos *et al.* 2010). Casares *et al*. (2005) suggested examining the quantity, type, and components of industrial wastes for planning and developing an appropriate waste management system. Because of these reasons, the aim of this study is to compare the types, evaluation methods, quantities, average sales prices and utilisation methods of wastes generated by micro-sized wood products enterprises between the two sub-sectors, manufacture of wood (16th) and furniture (31st) (Eurostat 2015), and to provide a basis for future studies.

EXPERIMENTAL

Materials

The last Census of General Industry and Workplace was carried out in 2002 in Turkey. According to the results of this census, the number of FPI businesses except 17th subsection, manufacture of paper and paper products, was 822 (TUIK 2002). Because the data is from 2002, this number may not be accurate. More recent data were acquired from the Chamber of Commerce and Industry, Organized Industrial Zones, and the Chamber of Tradesmen and Artisans in Trabzon Province. For this survey, micro sized businesses (with 1 to 9 employees) were selected. Since the Statistical Institute of Turkey selected the enterprises with 25 or more employees in its study on waste generated by the industry (TUIK 2002), there are not sufficient data on the amount of waste produced by micro-scale enterprises.

According to the records of two Chambers of Commerce and Industry established in Trabzon, the number of FPI establishments that constitute the 16th, 17th, and 31st (Eurostat 2015) subsections of the manufacturing industry was 133 (TTSO 2015; OFTSO 2015). Data from the Chamber of Tradesmen and Artisans reported 760 micro sized businesses. In total, 893 micro sized businesses were detected when the data obtained from the registration records of all chambers were arranged according to the 16th, 17th, and 31st subsections of the manufacturing industry. The numbers of the establishments in the 16th, 17th and 31st subsection were 374, 8, and 511, respectively. The 17th subsection was excluded from the analysis, resulting in a population size of 885.

Methods

Face-to-face interviews were used as the data collection tool in this study. Monahan (1990) reported that there are three main methods to analyse the formation, type, and composition of industrial wastes and that questionnaires are one of them (Monahan 1990).

Stratified sampling, one of the probability sampling methods, was used in the implementation of the questionnaire. In this method, the main population is divided into subpopulations (the 16th and 31st subsections in this study), and the samples are selected by simple sampling from these subpopulations. In simple sampling, each element of the population has an equal chance of being selected and the weight to be given to each element in the calculations is equal (Kilic 2012). The number of samples was calculated using Eq. 1. This equation is used when the number of the main population is known and finite, but the population variance is not known (Arikan 2011).

$$n = [N \times t^2 \times p \times q] / [(N - 1) \times D^2 + t^2 \times p \times q] \quad (1)$$

where n is the sample size, t is the confidence coefficient (1.96 for $\alpha = 0.05$), and N is the main population size (885). The parameter p is the estimated proportion of an attribute that is present in the main population. It is considered as 0.9 in the present study because with stratified sampling the main population is divided within itself into subspaces with higher homogeneity (Israel 1992; Arikan 2011). q is the probability of absence of the property desired to be measured in the main population ($1 - p = 0.1$), and D is the sampling error accepted based on p (5% sampling error is assumed in this study). The sample size (n) is calculated as 120. The stratified partitioning of this sample size was calculated as 50 for subsector 16 and 70 for subsector 31 in proportion to the stratum size.

Crosstabs were used in the presentation of the data. The chi-square test was performed to investigate the relationship between categorized variables. For these tests, two hypotheses were established at the 5% significance level as follows,

Ho: There is no difference between variables ($p > 0.05$, Ho accepted).

Ha: There is a difference between variables ($p < 0.05$, Ha accepted).

RESULTS AND DISCUSSION

Demographics on Enterprises

The enterprises included in this study have been operating for 22.98 years on average. The standard deviation of this activity period was 15.54 years.

Educational background of the owners/managers is shown in Fig. 1. In both sub-sectors, the proportion of the primary school-educated owners/managers was high. The second largest group was the high school graduates. The proportion of primary school graduates was 45.7% in the furniture sector, 32% in the timber sector, and 40% in total. The university graduates made up 12.5% of the study population.

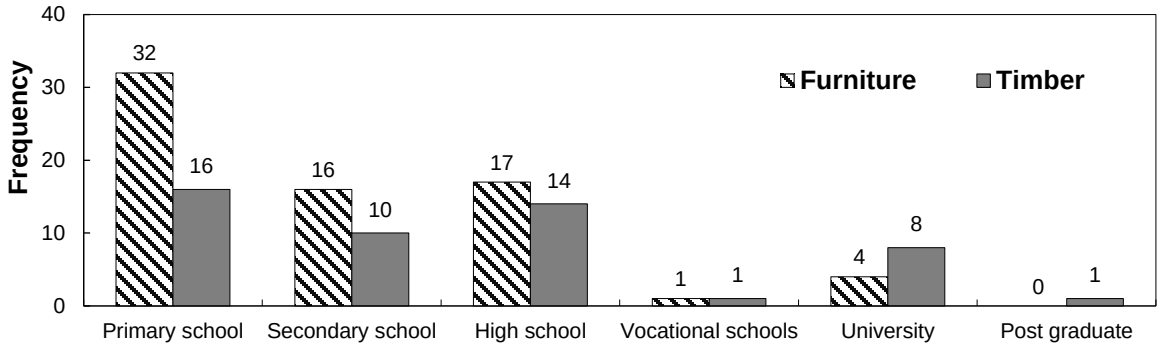

Fig. 1. Educational background of the owners/managers

The categories with less than 5% of the population were combined to determine the relationship between the educational background and the sub-sectors. According to the chi-square test results, because the p-value (0.139) was greater than 0.05, the Ho hypothesis was accepted, suggesting that the education level was independent of the sub-sector type.

The occupational education attributes of owners/managers are presented in Table 1. The percentages of the owners/managers who did not receive any vocational training in the 31st and 16th sub-sectors were 82.9% and 70.0%, respectively. In total, the ratio of owner/managers who did not receive any vocational training was 77.5%.

Table 1. Occupational Education Status of Business Owners

Vocational education of business owners	Sub-sectors					
	31st			16th		
	Frequency	Column percent	Table percent	Frequency	Column percent	Table Percent
Not for any occupation	58	82.86	48.33	35	70	29.17
Carpentry	0	0	0	1	2	0.83
Industrial vocational high school - Furniture and decoration	5	7.14	4.17	0	0	0
Industrial vocational high school	3	4.29	2.50	2	4	1.67
Commercial high school	1	1.43	0.83	2	4	1.67
Vocational school - undergraduate	1	1.43	0.83	1	2	0.83
Business administration - graduate	1	1.43	0.83	4	8	3.33
Accountancy - graduate	1	1.43	0.83	1	2	0.83
International relations - graduate	0	0	0	1	2	0.83
Engineering - graduate	0	0	0	2	4	1.67
Forest industrial engineer	0	0	0	1	2	0.83
Total	70	100	58.33	50	100	41.67

Table 2 shows the distribution of employees by educational background. The proportions of primary school and high school graduates were 32.7% and 31.6%, respectively. The ratio of the employees who have an undergraduate degree was the lowest, followed by the ratio of those with a graduate degree. The values in the frequency column in Table 2 represent the number of enterprises. For example, number 7 indicates the number of enterprises that had at least one employee who had vocational school background. Because the owners/managers also work in the companies, they were included in the values presented in Table 2.

Table 2. Number of Employees by Educational Background

Educational background	Frequency	Minimum	Maximum	Total	Mean
Graduated from primary school	72	1	4	118	1.64
Graduated from secondary school	58	1	6	104	1.79
Graduated from high school	63	1	4	114	1.81
Graduated from vocational schools	7	1	3	9	1.29
Graduated from university	14	1	2	16	1.14

The number of people employed by 120 enterprises that made up our study sample was 369, suggesting that 3.08 employees were employed by each enterprise on average. Sub-sectors 16 and 31 employed 3.50 and 2.77 workers, respectively. The employment created by the enterprises in terms of the number of employees is shown in Fig. 2. The largest employment group was formed by two-employee enterprises. The first five groups (1-5) constituted 60% of total employment.

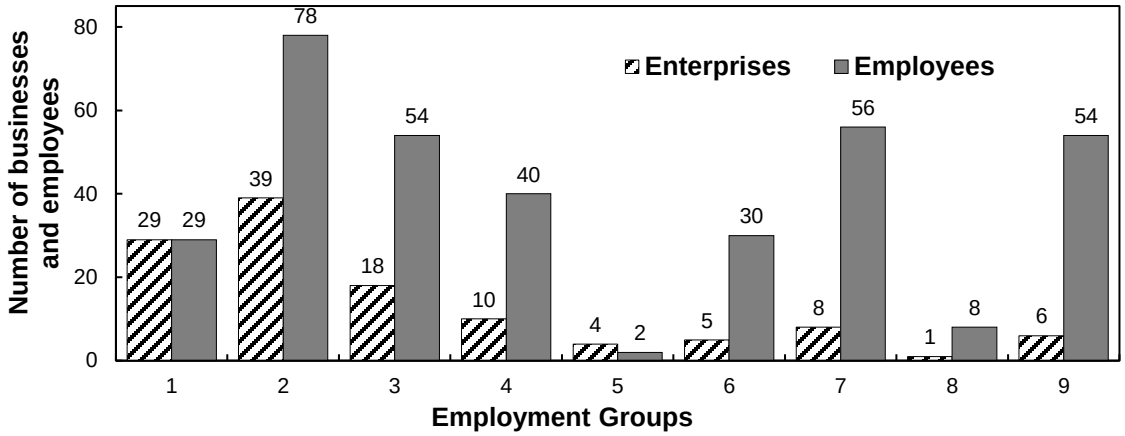

Fig. 2. Employment groups by the number of employees

Findings Related to Types and Amounts of Wood Waste Generated by the Enterprises

Figure 3 shows the types of wood waste generated in the production of furniture and timber. Some waste types were intrinsic to the sub-sectors. Composite wood sawdust was generated during the production of furniture and wood slabs by the timber-manufacturing sector. Two enterprises in the timber sector generated composite wood sawdust from MDF (Fig. 3) because companies in the carpentry and woodwork sub-classes were involved in the timber sector and both businesses used MDF in their manufacturing. In Fig. 3, the number of waste types in these two sub-sectors was 10.

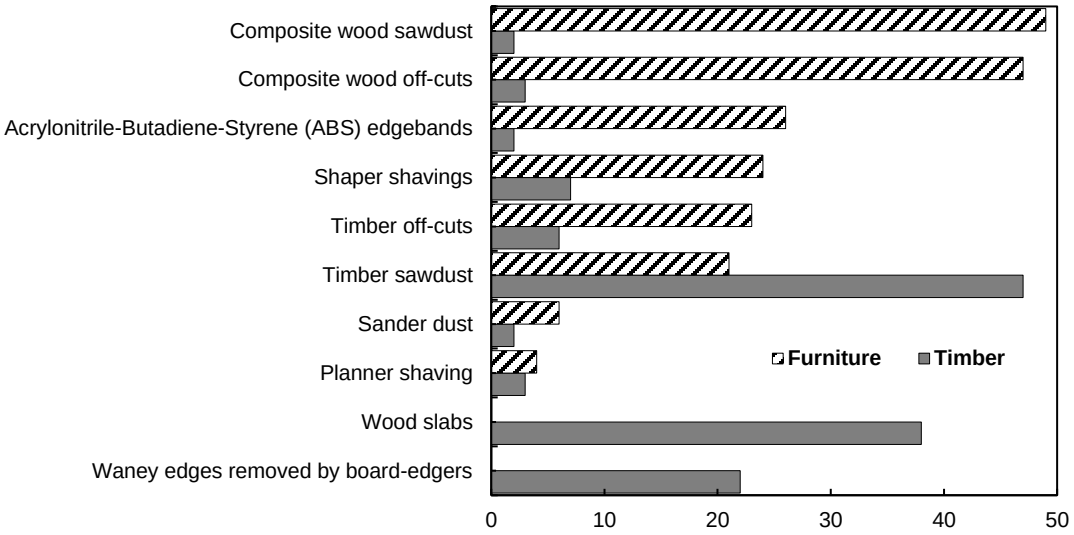

Fig. 3. Waste types and number of enterprises that produce those wastes

The quantities of wastes reported by the enterprises based on the estimates of the owners/managers is shown in Table 3. The total amount of waste was 528,307 kg/month. Wastes with the largest and smallest quantity were off-cuts and sand dust, respectively. The enterprises did not measure the amount of waste using any instruments. Instead, sawdust was filled in a sack and the amount of waste in the sack was estimated in kg. This method does not provide accurate results because the amount in a sack may vary depending on several factors such as the size of the sack, the type of sawdust, moisture, and wood type.

Table 3. Waste Amounts according to the Types of Waste (kg/month)

Types of Waste	Frequency		Amounts		Min.	Max.	Mean
	31st	16th	31st	16th			
Timber sawdust	21	46	4338	177743	20	28000	2717.6
Composite wood sawdust	49	2	17513	88	5	4000	345.1
Composite wood off-cuts	44	3	24705	400	5	4000	534.1
Wood slabs	0	37	0	218029	100	48000	5892.7
Timber off-cuts	23	5	4904	9245	9	8000	505.3
Waney edges removed by board-edgers	0	22	0	64040	50	13000	2910.9
Sand dust	6	1	67	4	1	40	10.14
Milling shaving	24	7	2882	1752	10	1000	149.5
Planner shaving	4	2	1040	1050	40	1000	348.3
ABS edge bands	24	2	505	2.5	0.1	260	19.5
Total	195	127	55954	472353.5	241	107300	13483

The responses to the question "Do businesses believe that their wastes have an economic value?" are presented in Table 4. More than half of the enterprises believed that (65 enterprises) their wastes have some economic value.

Table 4. Opinion regarding Economic Value of Wastes

		Sub-sectors		Total
		31st	16th	
Wastes have monetary value	Frequency	20	45	65
Wastes have no monetary value	Frequency	50	5	55

According to the results of the chi-square test applied to the values of Table 4, the null hypothesis was rejected because p-value (0.00) < 0.05; *i.e.*, different subsectors had different opinions about the economic value of their wastes. A larger number of businesses in the timber industry believed that their waste has an economic value compared to those in the furniture sector.

Table 5 presents the average price per ton or per piece of waste. The wood slabs were sold in two forms, by weight and by piece. The average price of wood slabs per ton was US$80.6; the average price per piece was US$0.75 (Table 5). The sales prices of the wastes from the thin sides of timber ranged from US$30/ton to US$373/ton.

Table 5. Average Selling Prices by Types of Wastes

	Frequency	Min.	Max.	Mean
Timber sawdust selling price (US$/ton)*	40	11.19	373.13	57.50
Selling price of wood slabs (US$/ton)	23	14.93	223.88	80.63
Selling price of wood slabs (US$/piece)	8	0.37	1.12	0.75
Selling price of timber or composite wood off-cuts (US$/ton)	21	22.39	373.13	148.37
Selling price of the waney edges (US$/ton)	3	29.85	242.54	111.44
*US$1=TL2.68, the exchange rate of the Turkish Central Bank at 15:30 on 01.07.2015.				

The enterprises managed their wastes in different ways (Table 6). Wood dust generated during the processing of boards in furniture manufacturing was mainly used for fuel and the off-cuts from boards were used as fuel. However, it was interesting to find out that composite wood dust was used as bedding materials by five businesses in this survey.

Table 6. Management Types of Wastes by Sub-Sectors

		Sub-sectors		Total
Types	Aim of usage	31st	16th	
Composite wood dust	Used as fuel for own need	21	1	22
	Given away as fuel	15	0	15
	Given away (usage purpose unknown)	14	0	14
	Thrown away	13	0	13
	Given as bedding	4	0	4
	Sold as fuel	2	0	2
	Bedding for own animals	1	0	1
	Sold	0	1	1
Composite wood off-cuts	Used as fuel for own need	38	3	41
	Given away as fuel	17	1	18
	Sold as fuel	3	2	5
ABS edge bands	Thrown away	12	2	14
	Combusted with fuel on site	5	0	5
Wood sawdust	Given away (usage purpose unknown)	6	16	22
	Used as fuel for own need	8	10	18
	Sold	0	14	14
	Given away as fuel	5	6	11
	Sold to enterprises which produce composite board	0	11	11

	Given as bedding	2	7	9
	Sold as bedding for animals	0	6	6
	Sold as fuel	0	4	4
	Bedding for own animals	3	0	3
	Thrown away	2	0	2
	Used for collecting the spilled waste engine oil	1	0	1
Wood slabs	Sold	0	24	24
	Sold as fuel	0	15	15
	Used as fuel for own need	0	12	12
	Given away as fuel	0	7	7
Waney edges removed by board-edgers	Sold as fuel	0	9	9
	Used as fuel for own need	0	3	3
Timber off-cuts	Used as fuel for own need	21	5	26
	Sold as fuel	6	3	9
	Given away as fuel	4	0	4
Milling or shaper shaving	Given away as fuel	19	3	22
	Used as fuel for own need	14	3	17
	Sold	1	3	4
	Given as bedding	4	0	4
	Sold as fuel	1	1	2
Total	Frequency	70	50	120
	Total %	58.3	41.7	100

Eight waste types listed in Table 6 were used by enterprises in 38 different ways. Another method of evaluation of wastes was to use their assessment rates. For example, an enterprise may sell some of the wood dust produced from the sawing process for board production, sell some as is, use some for its own fuel needs, or give it away free of charge (Table 7). In this study, 44.8% of shavings or dust produced during cutting of the boards were used by 22 enterprises as fuel for their own needs.

Table 7. Rates of Evaluation of Wastes by their Types

Types	Aim of usage	Frequency	Min. (%)	Max. (%)	Mean (%)
Composite wood dust	Used as fuel for own need	22	5	100	44.77
	Sold as fuel	2	30	80	55
	Given away as fuel	15	30	100	70
	Bedding for own animals	1	50	50	50
	Given as bedding	4	50	100	80
	Sold	1	90	90	90
	Given away (usage purpose unknown)	14	1	100	83.29
	Thrown away	13	10	100	86.85
Composite wood off-cuts	Used as fuel for own need	41	20	100	75.73
	Sold as fuel	5	50	80	71
	Given away as fuel	18	40	100	74.44
ABS edge bands	Thrown away	14	10	100	93.57
	Combusted with fuel on site	5	90	100	98
Wood sawdust	Used as fuel for own need	18	5	100	42.50
	Sold as fuel	4	10	100	63.75
	Given away as fuel	11	5	100	67.27
	Bedding for own animals	3	10	100	70
	Sold as bedding for animals	6	40	100	75.83
	Given as bedding	9	5	100	59.44

	Sold to enterprises which produce composite board	11	30	100	82.73
	Given away (usage purpose unknown)	22	20	100	80.68
	Sold	14	15	100	55.36
	Used for collecting the spilled waste engine oil	1	20	20	20
	Thrown away	2	30	40	35
Wood slabs	Used as fuel for own need	12	1	80	26.33
	Sold as fuel	15	10	100	64.60
	Given away as fuel	7	25	100	62.14
	Sold	24	10	100	82.92
Waney edges removed by board-edgers	Used as fuel for own need	3	10	40	20
	Sold as fuel	9	60	100	93.33
Timber off-cuts	Used as fuel for own need	26	5	100	77.69
	Sold as fuel	9	15	100	67.22
	Given away as fuel	4	40	95	68.75
Milling or shaper shaving	Used as fuel for own need	17	10	100	42.65
	Sold as fuel	2	90	100	95
	Given away as fuel	22	10	100	66.59
	Sold	4	80	100	95
	Given as bedding	4	50	100	85

Demographic Structure of Enterprises

The average life span of the enterprises in Trabzon was approximately 23 yr. This means that micro-scale family enterprises were generally short-lived and most of them could not be handed down to the next generation. Karayilmazlar and Cabuk (2006) reported that the average life span of the forest products enterprises in Bartin Province was 16 years. According to the World Bank, the average age of Turkish enterprises including all sectors is 34, and 80% and 96% of the enterprises in Turkey are closed before reaching their 5^{th} and 10^{th} year, respectively (Firat 2007).

There was no difference in the educational background of owners/managers between the sub-sectors. Forty-percent of the owners/managers were primary school graduates while only 12.5% were university graduates. In an empirical study on the environmental awareness and practices in small- and medium-sized enterprises, 35.9% of owners-managers were secondary school graduates that belonged to the most dominant group in that study, and 25.6% received a university degree (Gadenne *et al.* 2009). The comparison of the results from that empirical study with the results showed that the educational background of the owners/managers in Trabzon was much lower.

Educational background of the owners/managers was also investigated in terms of whether the education they received was related to any occupation or not. The majority (77.5%) of the owners/managers received education not directed towards a vocation, while 22.5% received a vocational education and only 5.8% of them had an education related to the forest products (Table 1). In other words, 94.2% of the owners/managers of the micro-scale furniture and timber production enterprises in Trabzon province did not receive any training related to their current work.

The educational background of the employees was similar to that of the owners/managers; primary school graduates were the largest group, followed by high school and secondary school graduates. In both groups, the university graduates belonged to the smallest group.

The enterprises employed an average of 3.08 people in total. Timber and furniture sectors provided 3.50 and 2.77 jobs on average, respectively. The enterprises with two employees were in majority (39 enterprises in total with 78 employees), constituting 21.13% of total employment (Fig. 2). Top *et al*. (2013) reported that the average employment was 2.55 in Gumushane, a neighbouring city, and the enterprises with two employees constituted the largest group. According to the 2002 General Census of Industries and Businesses, the average number of employees in micro-scaled FPIs in Turkey and Trabzon was 2.05 and 1.85, respectively (TUIK, 2002). In Trabzon and Gumushane, the number of enterprises employing 0–4 or 0–5 workers were usually the highest. In this study, the number of enterprises employing 0–4 workers accounted for 80% of the total number of enterprises and the number of employees who worked in these businesses constituted 54% of the total number of employees (Fig. 2). Gadenne *et al*. (2009) reported that in the Queensland Province of Australia, small- and medium-sized enterprises with 0–4 employees accounted for 53.4% of 166 enterprises. Gadenne *et al*. (2009) studied the enterprises with 200 or fewer employees operating in different sectors, but this study included only the micro-sized establishments in the forest products industry.

Types and Amounts of Waste Generated by the Enterprises

The results showed a relationship between most waste types, except sand dust and planner shavings, and the sub-sectors. Both sand dust and planner shavings were generated by both sub-sectors in similar amounts. The most common type of waste was sawdust, generated during the processing of boards and wooden materials. Yang and Jenkins (2008) have categorized wastes generated in timber production as coarse wastes, fine wastes, and bark. Wood bark was not considered as waste in this study because the logs harvested in the forest had to be debarked by law; thus, the logs had no bark when they arrived at the enterprise location.

For proper waste management, the amount of waste generated by manufacturing activities should be known. Each manufacturing sector should provide information on their activities so that the amount of waste can be determined accurately, which is also important for processing of hazardous wastes and planning of disposal facilities (Karahan *et al.* 2011).

The enterprises in this study did not have any systematic efforts or practices to measure the amount of waste they generated during production. The amounts declared by the enterprises were estimated values (528,307 kg waste per month). The most generated waste in terms of weight was wood slabs and the least generated one was sand dust. Redmond *et al*. (2008) reported that 120 small-scale enterprises (number of employees < 20) in different sectors producing pallets, MDF, timber, and particleboards generated 12 m^3 of waste per week. According to the waste statistics from the Turkish Statistical Institute in 2004, the forest products sector, including wood furniture production, generated 479,000 tons of waste. The amount of waste produced by these sectors corresponds to 2% of the total waste generated by different manufacturing sectors in relation to production in Turkey (Karahan *et al.* 2011). The waste generated by 120 enterprises in our study corresponded to 1.3% of the waste produced by the Turkish FPI in 2004.

The opinions of the enterprises on the value of the wastes differed between the sub-sectors. Ten percent of timber producers and 71.4% of furniture producers believed that their waste is not economically valuable. Mitchell *et al*. (2011) reported that 22% of small- and medium-sized manufacturing enterprises in Europe believed that waste is not a major resource, while 66% believed that it is.

The average price of wastes per ton sold for use in various forms was US$ 57.5 (the cheapest) for sawdust and US$148.4 (the highest) for board or woodcuts. The variations in sales prices of wastes were quite large (Table 5) because there was no free market for wastes. Đerčan *et al*. (2012) indicated that pellet producers do not pay more than €25/ton if they buy the waste generated by nearby forestry activities. If waste must be transported up to 50 km, there is a transportation cost of €0.7-1.4 per km affecting the waste sales price. The tonnage of unpacked and packed briquettes or pellets made of wood waste is sold for €100 and €200 in large packages, respectively (Đerčan *et al.* 2012). Therefore, more income could be earned when waste is processed. However, this study showed no evidence that enterprises had sold their wastes after processing.

The utilisation of wastes depended on the type of the wood waste. For example, the usage patterns of dust from composite boards and solid wood-cutting were different. The number of companies that sold dust from the composite wood boards was three, while the number of companies that sold solid wood dust was 35. Transportation costs of waste wood restricted the recycling option. That is why most primary and secondary manufacturers reused waste wood where it was generated. In addition, demand for painted and treated waste wood is low (NCDENR 1998).

The results of this study showed that waste wood was mainly used as fuel. Some enterprises used part of their wastes for their own fuel needs and sold or gave away some of the wastes to nearby facilities to be used as fuel. Waste woods were also sold to customers as bedding material for animals or as raw material for particleboard and pellet production. The wastes that could not be utilized were disposed of in landfills. Murphy *et al.* (2007) reported the use of wood wastes for energy and non-energy purposes. Approximately 75% of wood processing enterprises and about half of the paper industry meet their energy needs utilising their waste products (Virginia Forestry Association, 2003 cited in Murphy *et al.* 2007). Non-energy usage areas are (i) the production of composite boards such as chipboard and medium density fibreboard, engineered wood products such as OSB, (ii) the agricultural applications as fertilizer by mixing them with other organic wastes, and (iii) the bedding material for animals (Murphy *et al.* 2007). Walawender *et al*. (1997) reported that 80% of wood waste is sold or given free of charge in Northeast Kansas and 20% is burned, transported to landfills, or stacked on-site and that the cost of waste disposal at regular landfill sites is US$10 to 12/ton. This study did not detect any applications such as burying wastes that cannot be reused in regular storage areas and stacking on-site in Trabzon Province.

One of the factors that limited the usage of waste wood is the ordinance for waste woods. Lesar *et al*. (2009) reported that many recycling enterprises follow the German ordinance for management of recycled wood (Altholzverordnung), since there is no common European ordinance on waste or recycled wood. Daian and Ozarska (2009) mentioned the quality requirements for the use of wood residues, *e. g*., the sawdust must not include any MDF particles, glue, etc. to use them for the animal products. But, in our study it was found that composite wood dust are used as animal bedding material.

CONCLUSIONS

1. The long life span of an enterprise was an indicator of its profitability and management quality. The operation periods of the enterprises that manufacture forest products in Trabzon were shorter than the average life spans of the companies in Turkey. Among

the owners/managers of these companies, primary school graduates were the largest group and the university graduates made up the smallest group. In addition, the training that the majority of the owners/managers received was not related to any vocation. The proportion of the owners/managers trained in the furniture and timber production field was rarely encountered. The educational status of employees was also similar to the educational status of owner/managers. The average number of employees in furniture- and timber-producing enterprises in Trabzon was higher than the average number working in FPI enterprises in Turkey.

2. The type of waste generated in the furniture and timber production sector varied depending on the sub-sector. Wastes such as particles and sawdust of MDF and chipboards and ABS edge bands were produced during furniture production, while wastes such as waney edges removed by board-edger and wood slabs were formed during timber production. However, the formation of wastes such as sand dust and planner shavings were independent of the sub-sector. The most common type of the waste was sawdust formed during the cutting of boards and timbers. It is important to note that there were no wood bark wastes in timber production because timber logs were prohibited from being removed from the forests without peeling the bark.
3. The amount of waste generated should be accurately known when determining proper waste management policies. The enterprises in the forest products sector in Trabzon were not interested in measuring the amount of waste they generate. The waste amount reported by the enterprises only in this study corresponds to 1.3% of the waste produced by the Turkish FPI, including the enterprises with more than 25 employees, according to 2004 waste statistics of the Turkish Statistical Institute. Thus, it could be concluded that micro sized businesses are a significant waste producer.
4. The approach of the businesses to waste differs between the timber and furniture sectors. The vast majority of timber producers believed that their waste is economically valuable. However, only one-fourth of furniture-producing enterprises believed that their waste is of an economic value. The sales price of wastes was highly variable because there was no waste market where sales prices were determined by supply and demand.
5. The physical properties of wastes had a remarkable effect on the evaluation methods. The number of enterprises selling their sawdust from boards was smaller than the number of enterprises selling their sawdust from timber. Enterprises used their wastes directly to generate energy/heat by burning them under incomplete combustion conditions, which was the most common way to utilize the waste. Some types of the wastes such as composite sawdust were used incorrectly. If the wastes could not be used within the business boundary, enterprises either sold them, gave them free of charge, or disposed of them.

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