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Economic Loss Caused by Hollow and Shake Defects in Log, Nepal

Bikash BUDHA, Manoj PANTA, Ram Asheshwar MANDAL*

Kathmandu Forestry College, Koteshwar Kathmandu
**corresponding author, email: ram.mandal@gmail.com*

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ABSTRACT

The management of old growth forest is challenging issues. Thus, the scientific forest management system has been initiating to produce the quality timber to meet the demand of local people and generate the revenue. Especially *Shorea robusta* is the most valuable timber species but due to hollow and shake defect, timbers are very poor quality. At the same time, old and over mature trees hinders the growth of regeneration and intermediate storey plants. Therefore, this study was objectively carried out to list out the type of hollow and shakes defects in log, assess timber and economic loss due to these defects. The 1A and 2A felling series of block A of Devdah collaborative forest, Ruandehi Nepal was selected as study site. Altogether 215 defected trees measured in both felling series. Next, diameter of two ends and mid-point of log including defected sections and their lengths measured. Formal and informal interview organized with local people including district forest technicians to know causes and types of defects. Volume of defected timber was calculated subtracting net volume from whole volume of log. The economic loss was estimated multiplying defected section of timber with its price. The result showed that shake, canker and hollow are major defects of loss of timber. There two types hollows in logs particularly partial and whole. Meanwhile, the shakes are cup, ring, heart, star and radial. The highest volume loss was 354.34 and 433.7 cubic feet (cft) in *Shorea robusta* at felling series 1A and 2A respectively. The highest economic loss was US$ 1557.93 in *Shorea robusta* caused by degradation to class B from A. Total monetary loss US$ 5804.27 in felling series 1A in *Shorea robusta* while it was US$ 8365.11 in felling series 2A in same species. This research will be useful for evaluation of forest stand.

1. Introduction

Initially, the scientific forest management was focusing on sustainable timber production from the forest to meet the demand of local people (Mann, 2012; Rawat, 2008). It means sustainable harvest of the timber from the forest annually (Berkes and Davidson-Hunt, 2006). The forest management approach has been changing according to time, environment and people’s demand. Thus, these days scientific practice has been extending to manage the forest for social benefit, cultural promotion and environmental benign (Genin and Simenel, 2011; FAO, 2016). The terms ‘scientific forest management’ and ‘sustainable forest management’ are interchangeably using for forest management (Genina et al., 2018). This management approach has been well practicing in India and China (Mann, 2012). Nepal has also learned this practice from neighboring countries and started to practice in some block forests.

It is believed that, the scientific forest management practices is very good option to manage the forest sustainably. The forest quality will be improved and productivity will be increased. Obviously, harvestable annual timber in next rotation will be truly quality (MSFP, 2015). The scientific forest management practice can ensure the balance in supply of fuel and forest products. This also helps to create the employment opportunity of local tenant and national revenue generation. These days, scientific forest management practices have been implemented in blocks of collaborative forests in Nepal (Subedi et al., 2014; DFRS, 2015).

The old growth forests have been facing the rapid decrease in production especially (Angelstam 2003; Cyr et al., 2009). The consequence is degradation in quality and structure of the forest (Axelsson et al., 2002; Kuuluvainen 2009). On the other hand, the old growth forest is natures' gift in the world. The old growth, natural and unevenaged forests have their own social, aesthetic and cultural significane. Indeed, there is needed to keep the balance between science and society. The biodiversity cannot maintain and restore while reshaping the forest through application of sustainable management (Lindenmayera, 2006) since its principle aim is production (Blowers et al., 2012). The old growth forest cannot meet the demand of forest products to the local people. Thus, it is very important to understand the process, structure and function of old growth natural uevenaged forest before applying the management options (O’Hara, 2002).

The forests especially in Terai, Nepal are almost natural and old, hence the growth of such trees is quiet nil or negative (MSFP, 2015; Kafley, 2017). The consequence is lowering the quality of timber and forest. The resultant effect is huge economic loss. The forestry sector contributes nearly 15% in total Gross Domestic Product (MoFSC and FAO, 2009; Khatri et al., 2015). This is because of application of sustainable forest management practice in Nepal. Most of the trees in Tarai are hollow, diseased and defected. The affected trees have less volume and mean annual increment (Amatya, 2013; Szabolcs et al., 2013). Ultimate effect is loss of monetary value of the timber and whole forest. Defects like hollow and shake have clearly observed while converting the felled tree into sections. However, there is gap in such types of research in Nepal. Moreover, the reason behind such defects have not so far explored yet. Therefore, this study was objectively carried out to list out types of hollow defects and shakes in log, assesses the timber loss due to hollow defects and shakes in log and estimates the economic loss due to hollow and shake defects in log.

2. Materials and Methods

2.1. Study area

Devdaha collaborative forest, which is located in Rupandehi District of Nepal having latitude and longitude was 27.6874° N, 83.4323° E was selected as the study site (figure 1). The major plant species in this collaborative forest are *Shorea robusta, Terminalia tomentosa, Syzygium cumini, Tectona grandis, Delbergia sissoo, Adina cardifolia, Albizia spp., Bombax ceiba* and *Acacia catechu* (L.f.) Willd.

The measurements were carried out in 1A and 2 A felling series of A block during the felling season April, 15 to May 11, 2018. The defected plants were observed and listed after the felling (Fig.1).

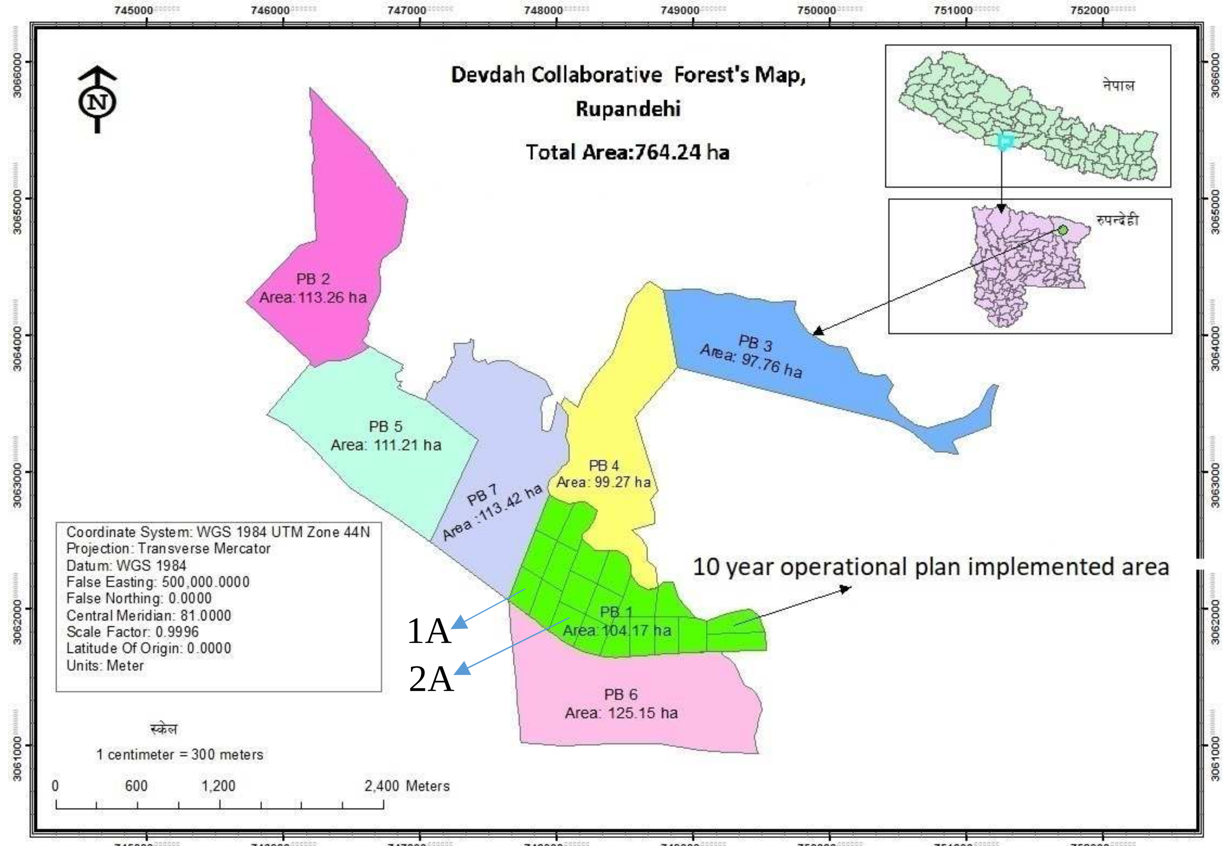

Figure 1- Geographic location of the study area

2.2. Data collection

Total enumeration was carried out to meet the research objectives. GPS coordinates of defected trees were noted. Total defected trees were 116 in felling series 1A. Out of this, there were 101 *Shorea robusta*, 11 *Terminlia tomentosa* and 4 *Syzygium cumuni*. Similarly, total 99 defected trees were enumerated in felling series 2A. Among this, there were 93 *Shorea robusta*, 2 *Terminlia tomentosa*, 3 *Syzygium cumuni* and 1 *Adina cardifolia*. These trees were debarked after felling. Next, diameters of two ends and mid-point, length of log, defected diameter and length of logs were measured and recorded.

Formal and informal interview was set with local people, district forest office staff and forest technicians to find the causes and types of defects. At the same time, the field observation was carried out to find the causes of defects. Meanwhile secondary data were collected from related offices and various published and unpublished articles, books and journals.

2.3. Data Analysis

The logs were categorized according to the timber grading norms. According to forest regulation 1993 (MoFSC, 1993), the price of the categorized logs was used to estimate the total price of the loss of timber (table 1).

Table 1- Grading norms and price of the logs

Species	*Grading class*	*Grading Criteria*	*Local price (per cft) US $*
Shorea robusta	A	Length > 7ft, Girth > 6ft and swan timber production> 65 %	13.64151
	B	Length> 4ft, girth> 4-6 ft defected, crack hollow insect attacked timber and timber production = 40% to 65 %	8.990566
	C	Length > 2.5ft, Girth > 2.5ft and swan timber production < 40 % (defects: insect attack, defected, crack)	5.886792
Terminalia tomentosa/syzygium cumini/adina cardifolia	A	Length>7ft, Girth> 6ft and swan timber production> 65 %	5.886792
	B	Length>2.5ft, Girth > 2.5ft -7ft and swan timber production < 65% (insect attack, defected, crack)	13.64151

Source: Forest regulation 1993, Nepal

Evaluated volume was calculated based on the first observation at scheme preparation time. In addition, the estimated volume was calculated before felling based on the measurement.

Total volume of the whole and defected parts of log was calculated using

For the estimation of economic loss due to defects in logs:

Whole volume = $[\pi \times d^2/4] \times L$ Where, d = diameter, L = length of log.

Defected volume = $[\pi \times (d_f)^2/4]L_d$, whereas d_f = defected diameter, L_d = defected length of log

Net Wood Volume = Whole volume of stem-defected volume

Monetary loss due to defect = price of timber × defected volume

(Note: Here the market price refers to the local market price)

Moreover, the descriptive and inferential statistics were applied to analyze the collected data.

3. Result

3.1. Types of hollow defects and shake in logs

There were many types of hollow defects in log at both felling series. These were complete hollow, partial hollow and cancer formation in *Shorea robusta, Terminalia tomentosa, Syzygium cumini* and *Adina cardifolia*. The causes of these defects were due to leakage of rain water into wounded part of stem or branch. The generally wounds are caused by heavy wind, hurricane, termites or insect attack. There were two types of shake in the logs viz. ring and cup (table 2). Moreover, the shakes were heart and star, ring and cup as well as radial shake. These shakes are due to light, wind and frost.

Table 2- Types of hollow defects and shake in timber

Affected Species	*Hollow defect*		*Shake*	
	Type	*Cause*	*Type*	*Cause*
Shorea robusta	1. Complete hollow	Due to heavy wind and rainfall	1. Heart and star shake	Light
Terminalia tomentosa	2. Partial hollow	Termite attack	2. Ring and cup shake	Wind
Adina cardifolia,	3. Cancer formation	Degraded site quality	3. Radial shake	Frost
Syzygium cumuni		Water logging area		

3.2. Differences in volume due to degradation at felling series 1A and 2A

The result showed that in *Shorea robusta*, the evaluated class A in management scheme was found to be in grade B and C because of quality degradation and vice versa from grade B to grade C. Obviously the defects affect the gross and net volume of timber. The volume differences were not same in all plant speies. The highest volume differences in *Shorea robusta* was found to be 94.19 cft (13.17%) while this was the least about 31.81 cft (4.6%) (Table 3). However, there was very less volume difference in *Syzygium cumuni* with 1.63-2.22 cft.

Table 3- Differences in volume at felling series 1A

Evaluated grade (in scheme)	*Evaluated Volume cft*	*Existing grade*	*Estimated volume cft*	*Volume Difference cft*	*Volume Difference %*
			Shorea robusta		
A	690.72	A	658.91	31.81	4.60
A	258.87	B	218.98	39.89	15.40
A	142.88	C	93.69	49.19	34.42
B	936.89	B	854.37	82.72	8.82
B	258.72	C	195.99	62.53	24.16
C	715.04	C	620.84	94.19	13.17
			Termanilia tomentosa		
B	97.16	B	85.74	11.42	11.75
			Syzygium cumuni		
A	14.06	A	12.44	1.63	11.59
B	17.31	B	15.09	2.22	12.82

3.3. Differences in volume due to degradation at felling series 2A

Similar finding was reported at this felling series too. In case of *Shorea robusta*, the highest record found to be 110.56 cft (54.49 %) due to change from grade B to C (Table 4) at this felling series. The differences were very less in *Terminalia tomentosa* with 0.93-5.03 cft.

Table 4- Differences in volume at felling series 2A

Evaluated grade (in scheme)	*Evaluated volume cft*	*Existing grade*	*Estimated field volume cft*	*Volume difference cft*	*Volume difference %*
			Shorea robusta		
A	437.32	A	400.74	36.58	8.36
A	542.83	B	441.06	101.77	18.75
A	223	C	138.37	84.63	37.95
B	601.86	B	529.9	71.96	11.95
B	202.87	C	92.28	110.56	54.49
C	304.88	C	256.65	48.23	15.81
			Terminalia tomentosa		
A	42.54	A	37.51	5.03	11.82
B	14.83	B	13.9	0.93	6.27
			Syzygium cumuni		
B	59.6	B	53.78	5.82	9.76
			Adina cardifolia		
B	20.32	B	5.22	15.1	74.31

3.4. Volume loss due to defects at felling series 1A

The volume was varied according to quality degradation in different species. It was found that, there was 145.25 cft (12.14%) loss in grade B in *Shorea robusta*. It was found to be 11.42 cft (11.75 %) in *Terminalia tomentosa* at felling series 1A (Table 5). The volume loss in *Syzygium cumini* was 1.63 cft in grde A and 2.22 cft in grade B.

Table 5- Volume loss in *Shorea robusta* due to defects at series1A

Grade	*Gross volume*	*Defected volume*	*Differentiated volume*	*Defect (%)*
		Volume loss in *Shorea robusta*		
A	1092.47	114.87	977.6	10.51
B	1195.61	145.25	1050.36	12.14
C	715.04	94.19	620.85	13.17
		Volume loss in *Terminalia tomentosa*		
B	97.16	11.42	85.74	11.75
		Volume loss in *Syzygium cumini*		
A	14.06	1.63	12.44	11.59
B	17.31	2.22	15.09	12.82

3.5. Volume loss due to defects at felling series 2A

Similar results were found in this felling series too. It was found that, 222.98 cft (18.53%) loss in grade A in *Shorea robusta* that was 5.03 cft (11.82%) in same grade in *Terminalia tomentosa* (Table 6).

Table 6- Volume loss in *Shorea robusta* due to defectives at felling series 2A

Grade	*Gross volume*	*Defected volume*	*Differentiated volume*	*Defected %*
		Volume loss in Shorea robusta		
A	1203.15	222.98	980.17	18.53
B	804.73	162.55	685.18	20.19
C	304.82	48.17	256.65	15.80
		Volume loss in Terminalia tomentosa		
A	42.54	5.03	37.51	11.82
B	14.83	0.93	13.9	6.27
		Loss in Syzygium cumini		
B	59.6	5.82	53.78	9.76

3.6. Economic loss due to defect in *Shorea robusta, Terminalia tomentosa, Syzygium cumini* and *Adina cardifolia at felling series 1 A and 2A*

Total economic loss was about US $ 5948.65 in felling series due to timber quality loss particularly from higher grade to lower grade. Specifically, there was highest loss US $ 1557.93 in change in grade A to B but it was the lowest only US $ 454.69 even change in A to A (table 7).

Table 7- Total loss amount due to defect at felling series 1A

Spp	***Loss value due to quality (grade conversion) US$***						***Total loss US$***
	Grade A to A	***Grade A to B***	***Grade A to C***	***Grade B to B***	***Grade B to C***	***Grade C to C***	
Shorea robusta	432.56	1557.93	1331.29	739.63	1190.03	552.83	5804.27
Terminalia tomentosa	-	-	-	102.36	-	-	102.36
Sizygium cumini	22.13	-	-	19.89	-	-	42.02
Total	454.69	1557.93	1331.29	861.88	1190.03	552.83	5948.65

(Remarks: US$ 1 = NRs 106.32 in 1st May, 2018)

Total estimated loss was US $ 8490.69. In fact, there was the highest loss US $ 3429.25 due to quality degradation from A to B. This was only about US $ 527.00 in grade change within A grade. This indicates there was huge loss due to different types of defects in Nepal (Table 8).

Table 8- Economic loss due to quality degradation at felling series 2A**.**

Spp.	***Loss value due to quality (grade conversion) US$***						***Total loss US$***
	Grade A to A	***Grade A to B***	***Grade A to C***	***Grade B to B***	***Grade B to C***	***Grade C to C***	
Shorea robusta	497.47	3429.25	2220.78	645.04	1289.89	282.68	8365.11
Terminalia tomentosa	29.53	-	-	4.03	-	-	33.56
Sizygium cumini	-	-	-	26.85	-	-	26.85
Adina cardifolia	-	-	-	65.17	-	-	65.17
Total	527	3429.25	2220.78	741.09	1289.89	282.68	8490.69

4. Discussion

The Quality loss in timber is main problem in Terai Nepal due to several types of defects. Some major defects are complete hollow, partial hollow, cancer formation, ring shake, cup shake etc. These all kinds of defects were found in *Shorea robusta*, *Terminalia tomentosa*, *Syzygium cumini* and *Adina cardifolia*. These defects were because of leakage of rainwater through wounds. Generally, the wounds were formed because of termite attack, infection and insect attack (Lycken, 2006). On the other hand, the old growth natural forests have less emunity capacity to cope aganinst such calamities. These forests are highly prone to fires, disease and insects and resultant effect is quality degradation of timber (Siitonena et al., 2003).

There was huge loss in the felling series due to these defects. The results were the most of the timber was low grade. Generally it was conversion to low grade from high grades (from A to B, B to C and A to C) and ultimate loss was economic value. The timber quality degradation means may be useful only for firewood or low quality timber (SSMA, 1982, Gillian, Menzies, 2013).

The grading of timber helps to standard the timber quality. The size specially length, diameter, different types of defects are considered to grade the log and sawn timber (Lycken, 2006). The defects are the most important characteristics to categorize the log into different grade. The defects are the major problem in grading of timber logs. *Shorea robusta* is the most important tree species in Nepal especially in Terai but of most of the old tree are defected. Similar problems have been observed in other associate species particularly *Terminalia tomentosa*, *Syzygium cumini* and *Adina cardifolia*.

There is chain effect of the defects in wood (Donovan, Nicholls, 2003). The length, width and thickness of the wood were affected because of defects. The chain effect is linked with the consumers' interest. The consumers like to purchase the high quality wood rather than defected timber. The consumers' interest may decline because of defects. Therefore, they search for other reliable options (Donovan and Nicholls, 2003, Nyrud et al., 2008).

Sometimes there was more than 50% loss due to the hollow and shake defects. Generally, 10-40% loss was recorded due to wood defects (Vanderberg, 2002). Obviously, the monetary loss is the ultimate result (Lowell, 2010). Our research is quite reliable evidence of defects and timber loss.

Several types of defective cause the degradation in wood (Henman G S, 1991)**.** The ultimate results of defect in wood are the monetary loss (Nordmark, 2005). The price of wood depends mainly on the quality products. The higher the quality the higher is the price in the market and vice versa (Lewis, Hartley, 2005). The defects also consequence to wood materials used in the house. The economic loss also linked with the durability of the wood (Lindenmayer, Noss, 2006).

5. Conclusion

Many types of defects were found in the tree like whole and partial hollow; heart and star shake, ring and cup shake, radial shake and cancer formation was found in log. The highest volume loss was found in grade B in both felling series. The loss was the highest in *Shorea robusta*. The consequence was the high economic loss due to wood defects. Thus, management operations are essential to enhance the regeneration and remove the defected old trees.

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