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Productivity Analysis of Chute System integrated with Portable Winch and Synthetic Rope for Uphill Logging Operation

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Abstract

Timber extraction activities are generally conducted by using traditional logging methods that involve little or no mechanization. In recent decade, plastic chute systems have been employed as alternative method during timber extraction. There is an increasing interest in implementing chute system because this alternative method reduces the value and volume loss of timber and minimize the total time of logging operation. Even though chute system had been used to extract small size timber in the early times, it has been employed to transport large size logs in recent years. In previous studies, chute system was analyzed during downhill transportation of wood products by gravity force. In this study, chute system integrated with portable winch was developed to haul large logs uphill direction. Besides, synthetic rope was used instead of steel rope in order to reduce weight of the system. The chute system was tested in a harvesting operation take place in Çınarpınar Forest Enterprise Chief in the border of Kahramanmaraş Forest Regional Directorate in Turkey. Productivity of the uphill logging operation was examined for three chute distances (36 m, 48 m, 60 m) at three ground slope classes (30%, 50%, 70%). The results indicated that the highest productivity (7.00m^3/hr) was reached at the shortest chute system with 30% slope. The main factors that affect productivity was total time of winching logs uphill within chute system. It was found that chute system integrated with portable winch was more economic, practical, and efficient method comparing with traditional logging methods.

Keywords: Logging, chute system, portable winch, synthetic rope, productivity

1. Introduction

The extraction of timber involves hauling of wood products from stump to landing areas by using various logging techniques including man and animal powered traditional methods and mechanized methods (Eker and Acar, 2006; Erdaş et al., 2014). In Turkey, the most costly and time consuming stage of timber harvesting is logging operations. The cost of timber extraction can dramatically increase in mountainous regions where terrain conditions are unfavorable and road network is not sufficient (Gülci et al., 2016).

Timber extraction activities using traditional logging methods are not productive and they require heavy labor force. On the other hand, highly productive mechanized logging methods can be economically infeasible in the stands with low timber value. In such cases, plastic chute systems become effective logging method that provides economic and functional alternative (Göker, 1986). Chute system is established by attaching half-circle pipes made of polyethylene or fiberglass material. This system has been used to transport various wood products such as fire woods, industrial wood, small-diameter logs, and large-diameter logs (Acar and Ünver, 2009; Akay et al., 2014a; Zarifoğlu, G. 2014).

During chute applications in Turkey, wood products are generally moved downhill within the chute system by gravity. However, when the landing areas are located uphill and wood products are located in lower elevations at the bottom of a valley, they are to be pulled uphill by winching. The obstacles or dense vegetation covers on the ground cause difficulties during operation which increases cycle time and reduces productivity. To overcome this problem, wood products can be pulled uphill by winch system within the chute system. In such cases, portable winches integrated with synthetic ropes can be practical and cost efficient logging method with labor efficiency. In this study, it was aimed to analyze productivity of chute

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system integrated with portable winch. The system was implemented during a sample logging operation where large-diameter logs were pulled uphill by using portable winch and synthetic rope within chute system.

2. Material and Methods

2.1. Study Area

The study was conducted in Çınarpınar Forest Enterprise Chief (FEC) located in the border of Kahramanmaraş Forest Regional Directorate (Figure 1). The total area of the FEC is about 30592 ha in which 59.19% is covered with forest. The geographical location of the area was between 37º44'47"-37º32'38" north latitude and 36º31'50"-36º52'21" east longitude. The study was implemented during a harvesting operation taken place in compartments 302 and 303 in Çınarpınar FEC. The areas of the compartments were 46.5 ha ve 52.33 ha, respectively. The dominant tree species were Brutian pine (*Pinus brutia* Ten.). The average ground slope and elevation were 39.20% and 672.85 m, respectively.

2.2. Chute System

In logging operation, chute system consisted with polyethylene pipes (Korige Pipe SN8) which is produced with low density material and highly resistant to external influences such as crushing, tearing and bumping. Table 1 indicates the features of pipes used in chute system. In order to strengthen connection points between consecutive pipes, they were fixed with special attachments which prevent chute system to be scattered during logging operation (Figure 2).

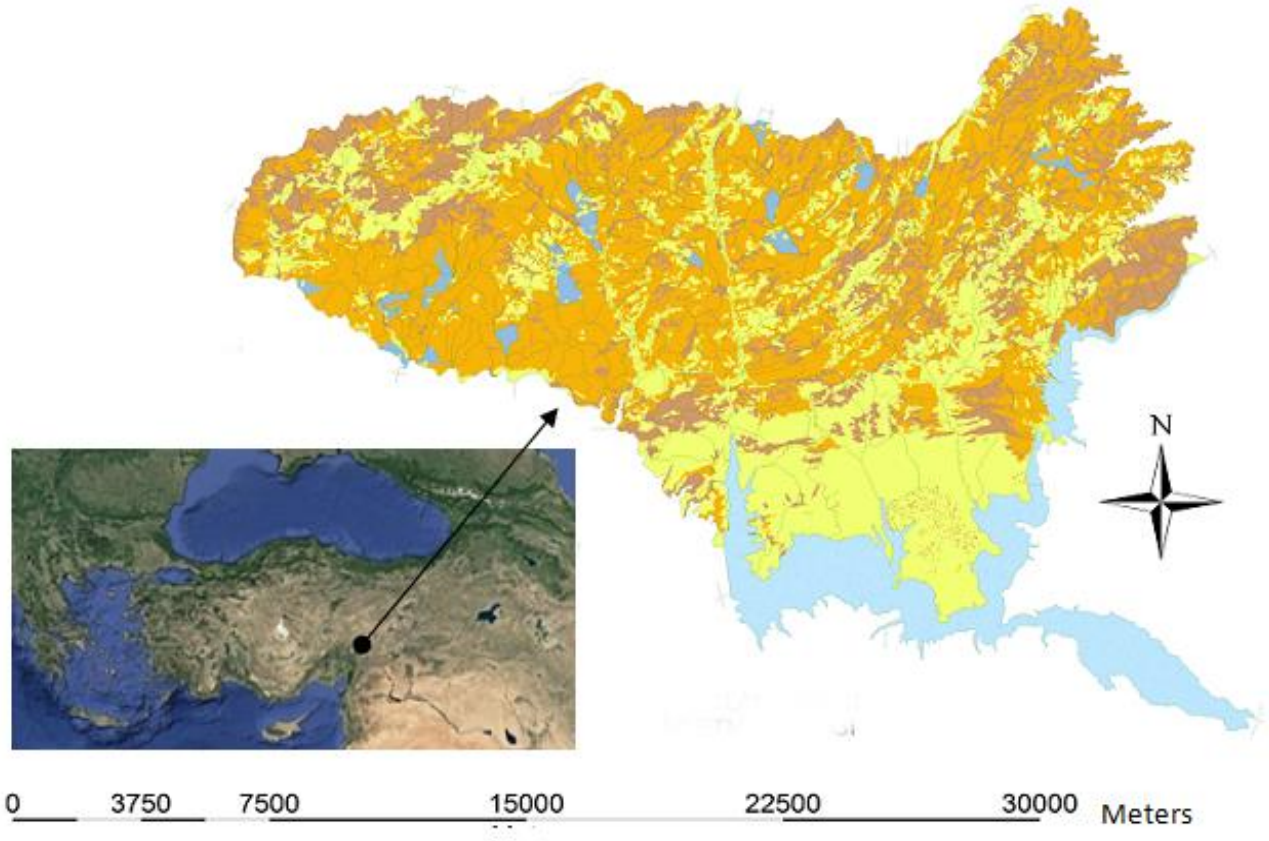

Figure 1. The study area (Gülci et al., 2016)

Table 1. Some of the specifications of pipes used in chute system

Material	Shape	Small diameter (mm)	Thickness (mm)	Length (m)	Weight (Kg)
Polyethylene	Half-circle	500	6	6	25

Figure 2. Special attachments used to connect pipes

During winching stage, the logs were pulled by PCW5000 model portable winch that is capable of pulling one-tone load with single line from up to 100 m distance. Table 2 indicates the technical features of the portable winch. The winch system was equipped with a synthetic rope (100 m long and 12 mm thick), a polyester choker (2 m), two metal locks, and a metal hook. The portable winch was tightened to a tree or a stump with a polyester choker and logs were attached to synthetic rope using the hooks.

Table 2. Technical specifications of portable winch

Specifications	
Engine	Honda GXH-50cc
Weight	16 kg
Maximum strength (single line)	1000 kg
(double line)	2000 kg
Minimum rope diameter	10 mm
Maximum rope diameter	20 mm

The logging applications were implemented for three slope classes (30%, 50%, and 70%) at three distance classes (36 m, 48 m, and 60 m). In the study, total of 270 trips were monitored by running 30 trips for each slope and distance class. The productivity of the operation was analyzed by using time motion study where time was measured by a chronometer.

The work stages involved chute logging were carrying choker to the logs, choker setting, locating log into the chute system, uphill winching, and releasing the logs from the chokers at landing (Figure 3). The productivity of the chute system was calculated by using following formula (Gülci et al., 2017):

$$P = 60x(V/t) \quad (1)$$

P = productivity (m^3/hr)
V = log volume for each trip (m^3)
t = cycle time (minutes)

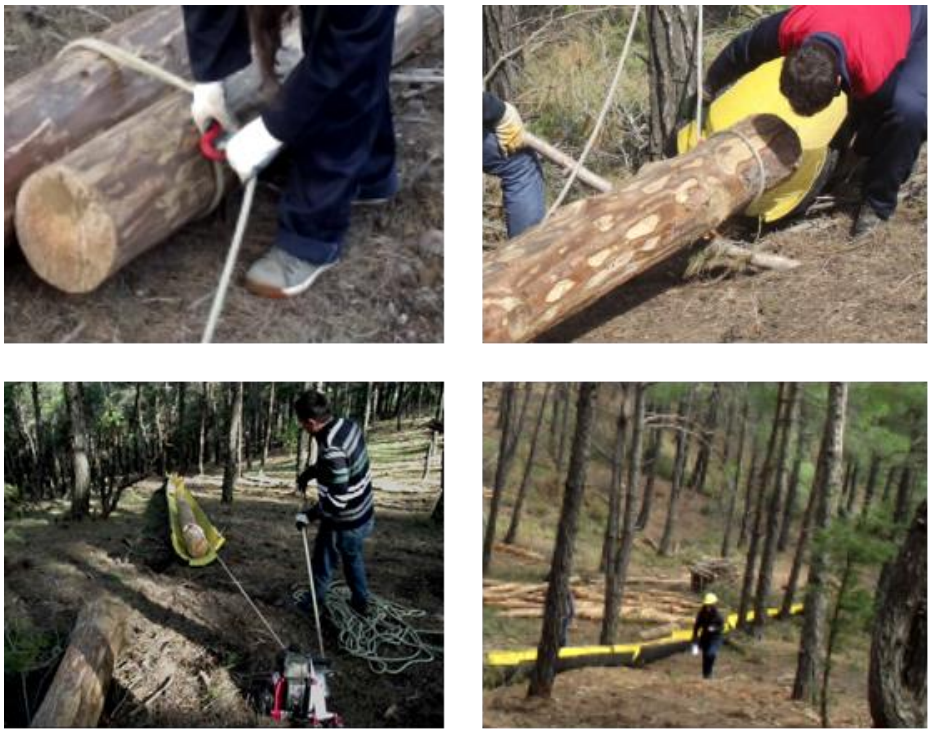

Figure 3. Chute logging operation

3. Results and Discussion

The results indicated that the average log length, diameter, and volume were found to be 3.10 cm, 31.21 cm, and 0.24 m^3, respectively. During logging operation, total cycle time was averaged at 163.49 seconds with average productivity of 5.41 m^3/hr. The average uphill winching time was found to be 1.47 km/hr. The average slope of the chute system was about 50%.

The information about alternative chute systems was listed on Table 3. The highest productivity (7.00 m^3/hr) was reached at the Chute System (CS) 1 with 36 m length at 30% slope. The CS 9 with 60 m length at 70% slope provided the lowest productivity (4.17 m^3/hr). Total cycle time was relatively low at CS 1, 4, and 7 since the length of the system was shorter than that of other systems.

While searching the effects of specified factors (i.e. distance and slope) on productivity, log volume was kept constant during the field study in order to eliminate potential effect log volumes on productivity. In a case where system length is constant, productivity was the highest at the chute system with lower ground slope. Ground slope is one of the factors that closely effects productivity in chute systems since the time spent on uphill winching tends to increase with increasing ground slope (Acar et al., 2015). On the other hand, productivity of the chute system decreased with the increased length of the system when ground slope was kept constant (Figure 4). Previous studies also indicated that winching distance adversely effects the productivity (Akay et al., 2014b).

Tablo 3. The average values for the parameters of chute systems

Chute System	Log Length (m)	Log Diameter (cm)	Log Volume (m^3)	Chute Length (m)	Chute Slope (%)	Productivity (m^3/hr)
1	3.10	31.23	0.24	36.00	30.00	7.00
2	3.10	31.27	0.24	48.00	30.00	5.70
3	3.11	31.35	0.24	60.00	30.00	4.55
4	3.10	31.27	0.24	36.00	50.00	6.49
5	3.10	31.20	0.24	48.00	50.00	5.28
6	3.11	31.17	0.24	60.00	50.00	4.26
7	3.10	31.13	0.24	36.00	70.00	6.10
8	3.11	31.03	0.24	48.00	70.00	5.11
9	3.10	31.20	0.24	60.00	70.00	4.17

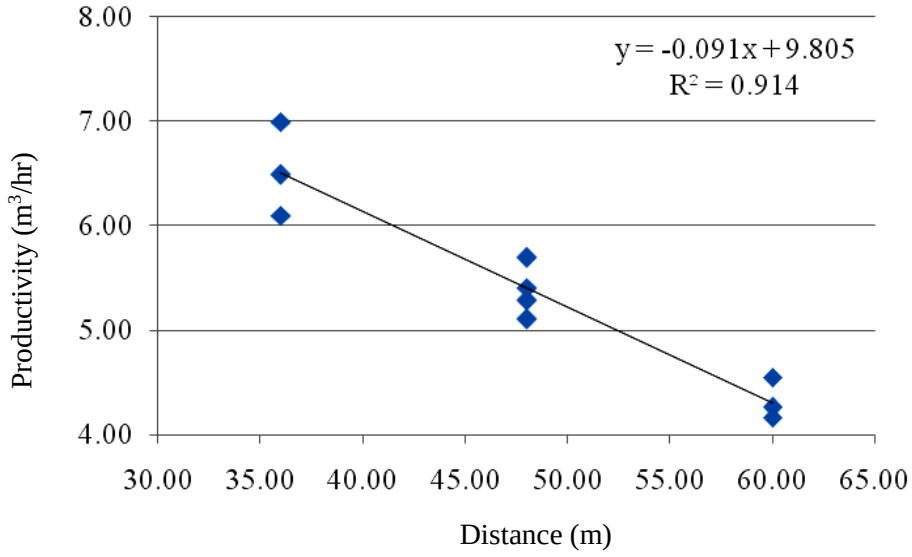

Figure 4. The relation between productivity and length of the chute system

The summary of time motion study conducted on work stages of chute system is shown in Table 4. In all of the chute systems implemented in the study, the most time consuming work stage was uphill winching, followed by carrying choker to the logs. These two stages took the highest time at the CS 9 with 159.78 seconds and 28.52 seconds, respectively. When comparing other stages, the most time consuming stages were locating log into the chute system, choker setting, and releasing the logs from the chokers.

Table 4. The time spent on each work stage as a percentage of total cycle time

Chute System	Carrying choker to the logs	Choker setting	Locating log into the chute system	Uphill winching	Releasing the logs from the chokers
1	21.08	3.95	7.34	65.03	2.60
2	17.85	3.22	6.00	70.81	2.13
3	14.29	2.55	4.75	76.73	1.69
4	20.27	3.67	6.77	66.88	2.41
5	17.23	3.02	5.54	72.23	1.98
6	13.99	2.42	4.46	77.54	1.59
7	19.36	3.52	6.49	68.29	2.33
8	16.94	2.96	5.46	72.67	1.97
9	13.87	2.41	4.44	77.68	1.61

4. Conclusions

The chute systems have been commonly used to transport wood products downhill direction with gravity. However, wood product can be effectively hauled uphill direction by using chute system integrated with portable winch, especially in forested areas where available road network is not efficient. In this study, it was aimed to implement chute system integrated with portable winch as an alternative method for uphill hauling of wood products. In order to lower down the total weight of the system, synthetic rope was used instead of steel rope.

The performance of the system was monitored during timber extraction activity taken place in Çınarpınar FEC located in Kahramanmaraş Forest Regional Directorate. The field measurements were conducted during uphill logging for three slope classes (30%, 50%, and 70%) at three chute distances (36 m, 48 m, and 60 m).

The productivity of uphill winching by chute system was maximized (7.00 m^3/hr) at CS 1 in which slope and distance was 36 m and 30%, respectively. Based on the time study data, the productivity of the chute system was mostly affected by the uphill winching stage. The uphill winching time is closely related with ground slope and system distance. The productivity of the chute system increased as ground slope and system distance decreased.

It is highly anticipated that using chute system integrated with portable winch will be economic, ecological, and ergonomic alternative in logging activities in Turkey. The future studies on chute system may involve searching the effects of using double line on load capacity of the system. Besides, the capabilities of the system should be tested for hauling large diameter logs by installing wider pipes into the system.

Acknowledgements

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