

# Comparison Of Time Consumption And Productivity During Beech Forest Felling And Processing In Two Different Working Conditions

Ylli Kortoci <sup>1</sup> , Mirvjena Kortoci (Kellezi)\*<sup>1</sup> 

**Abstract:** This study was carried out in two countries, Italy and Albania. The aim of this research was to compare time consumption during felling and sorting works between two countries, considering the working conditions. The study was conducted in two utilization sites, one in each country, Monte Amiata site in Italy and Dardhe Xhyre in Albania. Field observation was used to determine the working conditions for each site. In Monte Amiata site it was noticed a delay working time of 40.13%, which is lower in comparison to Dardhe Xhyre, which was about 57.6%. Most of this time in both countries is an unavoidable delay time, respectively of 21.35% in Monte Amiata site and 36.93% in Dardhe Xhyre. Average productivity per gross hour in Monte Amiata is 3,480 m<sup>3</sup> /h /team while in Dardhe Xhyre it is 3,610 m<sup>3</sup> /h /team. Working conditions in Albania are worst compared with Italy, especially about accessibility and transport to the working place.

**Keywords:** Tree felling and sorting, working times, avoidable delay, unavoidable delay, productivity, working conditions.

**<sup>1</sup>Address:** Faculty of Life and Environmental Sciences, Universiy “Ukshin Hoti” Prizren, Rruga e shkronjave Nr.1 20000, Kosovo.

**\*Corresponding author:** mirvjena.kortoci@uni-prizren.com

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## 1. INTRODUCTION

The distribution of forest species in Albania can be described as follows: beech accounts for about 21.6% of the surface; conifers, 19.6%; oaks 36.6% and 22.3% for other species. High forests represent approximately 45.5% of the total forest cover; coppice forests about 29.5%; shrubs, 25% (Kortoci and Kellezi, 2014). About 47% of the total timber volume comes from the use of beech forests, which is the main species in the Country. In terms of governance of beech forests, 90% of them are governed as high forest and only 10% as coppice. In Albania beech forests are generally located in marginal terrain where 70% of them belongs to the category of very rugged terrains (Kotro et.al. 1996).

Beech forests in Italy extend over 550,000 hectares; they can be governed as high forest or coppice. In Italy, the beech coppice (around 330,000 hectares), dominating the Alpine arc and the northern Apennines, has been widespread in relation to the growing demand for firewood and coal that has practically occurred up to half of the last century (Hofmann, 1991).

Time consumption of forest harvesting is studied for various reasons. The most typical task is to investigate the main factors affecting work productivity (Mousavi R., Naghdi R.).

The main factors which have influences on working times are the volume of logged trees, sorting type, the availability of suitable tools, the ability of workers and the efficiency of the organization and direction of the work. The working times increase while tree volume increases. Considerable reductions of working times can be achieved by sorting only the main assortments (Hippoliti and Piegai, 2000).

The objective of comparative studies is to compare two or several machines, working methods, etc, (Bergstrand, 1991).

The higher productivity suggest that forest workers are well motivated, properly trained and adequately remunerated (Ole-Meiludie & Fue).

Working without any breaks results in fatigue. This increases accidents, illness, discomfort and this reduce the productivity (Axelsson, 1998).

The aims of this study were to compare working times and productivity in felling and wood processing between two different working conditions, one in developed countries and the other one in developing countries.

## 2. MATERIALS AND METHODS

### 2.1. Study site

Monte Amiata has an elevation of 1680 meters above sea level. The climate of this area can be associated, within the temperate zone, with Mediterranean climates. Rainfall is on average more widespread around the reliefs. From a geomorphologic point of view, the territory of Tuscany region is generally very rough, hills and mountains represent 90% of the total area.

Beech is the dominant species of "Monte Amiata", and in this case it was managed as high forest. A few fir seedlings can be found sporadically distributed on the surface examined.

The apparent age of the forest was around 60-80 years old. The trees cut in this forest were old standards with a density of about 200 - 250 plants per hectare, a diameter greater than 60 cm, and average height of the trees varied between 20 - 25 m. This terrain is considered of the third class of slope (40-60%).

The maximum height above sea level in Dardhe Xhyre is 2253 meters, within continental climate conditions, which can be noticed in the fairly cold period of winter. In addition to cold temperatures, winter in this area is very humid, but summer is short, hot and very dry.

Beech is the dominant species also in Dardhe Xhyre, covering about 95% of the surface. The forest was about 100 years old, and clear cut of an area of 20 hectares was performed in this case. The diameter of plants was greater than 50 cm, and the height reached 20 - 25 m. The terrain was rough, with many holes and stones and it is considered of the third class of slope (40-60%).

This study examines forest logging and sorting by analyzing working phases, productivity, operators and machines safety in two different sites of beech forest.

The harvesting method applied in "Monte Amiata" is mixed by "cut to length" and "short wood system", this last for firewood production. The same harvesting method is used in Dardhe Xhyre.

### 2.2. Measurements and statistical analysis

In both the examined utilization sites, productivity data were collected, calculated and analyzed toward the applied methodologies. The equipments used for field data acquisition were an analogue chronometric table "Minerva", equipped with three chronometers with subdivisions per hundredth of a minute, a 40 cm "Haglof" caliper used for diameters measurement and a 25 m long self-rolling metric cord for distances. The distribution of times during the day has been estimated concerning each working phase and volume of harvested trees. "Working time" generally

includes a whole series of items, but in the specific case only the following units have been taken into consideration: productive times, during which the workers and equipments are present in the workplace, accessory times subdivided into "service" and "preparation", during which the workers and vehicles are present on the work area but do not perform functions directly finalized to the specific operation, operating times obtained by the sum of those mentioned before, non-operating times divided into various sub-items representing moments in which workers and equipments are physically stopped and not busy in any kind of jobs .

Hourly productivity was calculated on the basis of the working times and volume of material harvested, respectively average net hourly productivity based on the operating times, and average gross hourly productivity based on the total times. From these data, the respective daily productivity was then deduced referring to 8 gross hours.

For the determination of fresh density, three samples for each single plant positioned one at the base, one at mid-height and one at the top were taken on 10 plants. For each sample it was measured the fresh weight with bark, the two orthogonal diameters of each circle of wood and the thickness at the four external points. These values were used to calculate the volume.

The felling and bucking operation in Monte Amiata was performed by a single team of two workers. The division of work was as follows: the first operator, through the help of one "STIHL MS 660" chainsaw, cut down and bucked the trees, while the second one delimited the felled stems and piled up the brushwood by using a "STIHL MS 362" chainsaw. While in Dardhe Xhyre the team was composed by two workers, the first one using a "STIHL MS 660" chainsaw performed the trees cutting down, bucking and delimiting of large branches, and the second operator helped by an ax, carried out the limbing of the small branches and piled up the brushwood.

During the felling and bucking phases, the following data were collected: approach time or the time for the team to approach the plant to be felled, notch time or the time needed by the chainsaw to make the directional notch on the plant to be cut, cutting time or the time it takes for the chainsaw to perform the felling cut, fall time or the time from the moment the plant starts to tilt until it reaches the ground, knockdown time that is the time it takes for the team to knock the plant down when it hungs up on the standing plants, unavoidable delay (dead) time, which are non-operational times used for breakfast, accidents or physiological needs, avoidable delay (dead) time, or non-operating times, when workers chatted, or had to lower the height of the stump, number of plants cut down, diameter of the felled plants, diameter in the middle and total length of a sample of plants, delimiting and bucking time of the plant.

Correlation and regression analysis have been performed to determine the dependence of working times from the breast height diameter of tree.

### 3. RESULTS

Wood density has been used to determine the weight after calculating volume of trees cut down.

Table 1. Fresh wood density in both study sites.

Harvest sites	Fresh wood density ( g / cm <sup>3</sup> )
Monte Amiata (fustaia)	1,007
Librazhdi	1,392

From the analysis of working times, a high percentage of delay times is present in both sites. This percentage in Monte Amiata is 40.13% while in Dardhe Xhyre it is almost 57.6% mainly due to the very scarce road accessibility in Albania. Most of these times are unavoidable delay time, 21.35% in Monte Amiata and 36.93% in Dardhe Xhyre, while about the time spent in total work phases, the biggest part belongs to

tree bucking, 45% in Monte Amiata because of the diameter of trees, and 33% in Albania.

Table 2. Total values of the working times of felling, bucking and delimiting phases in both study sites.

Working times	Monte Amiata	Dardhe Xhyre
Gross Total Time (min)	1225,92	223,13
Net Total Time (min)	995,68	176,99
Total delay (dead) times	492,01	128,54
Avoidable delay times	230,24	46,14
Unavoidable delay times	261,77	82,4

For each sub-phase of work, the average net time and its standard deviation were determined, trying to highlight how much the bucking time affects the average cutting time per plant.

Table 3. Average felling and sorting (bucking and delimiting) times and standard deviation for tree divided into phases in both study sites.

Average times	Monte Amiata		Dardhe Xhyre	
	Per tree (min)	Standard deviation	Per tree (min)	Standard deviation
Passage time	1,54	0,78	2,46	0,32
Notch time	2,15	0,70	0,70	0,21
Cutting time	1,47	0,79	2,01	0,99
Bucking and delimiting	13,86	7,08	13,05	4,52
Avoidable delay time	5,48	6,90	7,69	4,52
Unavoidable delay time	6,23	6,10	13,73	14,56
Total net time	28,25		31,95	
Total gross time	30,73		39,64	

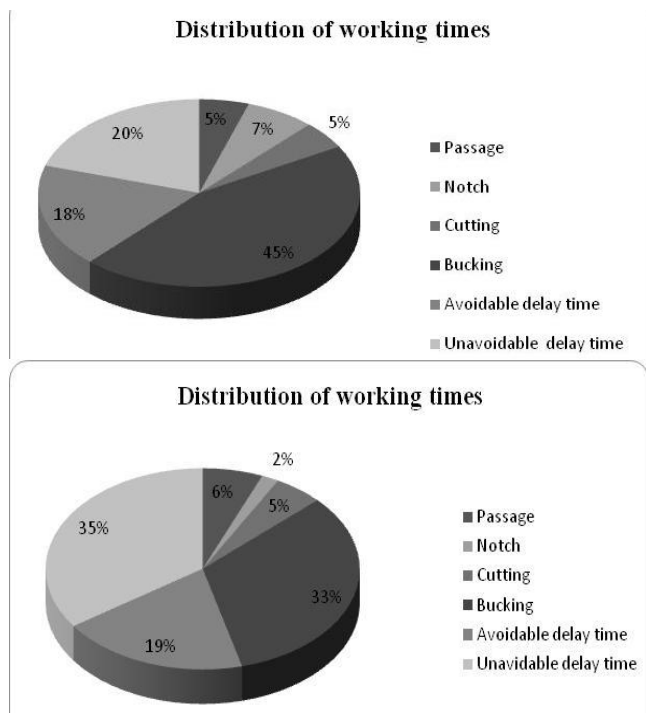


Figure 1. Percentage distribution of total working times respectively in Monte Amiata and Dardhe Xhyre.

It is obvious in both situations that bucking time has the biggest percentage (respectively 45% and 33%) of the total working time spent.

During the felling, tree diameters were measured and then the correlation with the respective felling times was made, as shown in the following graph.

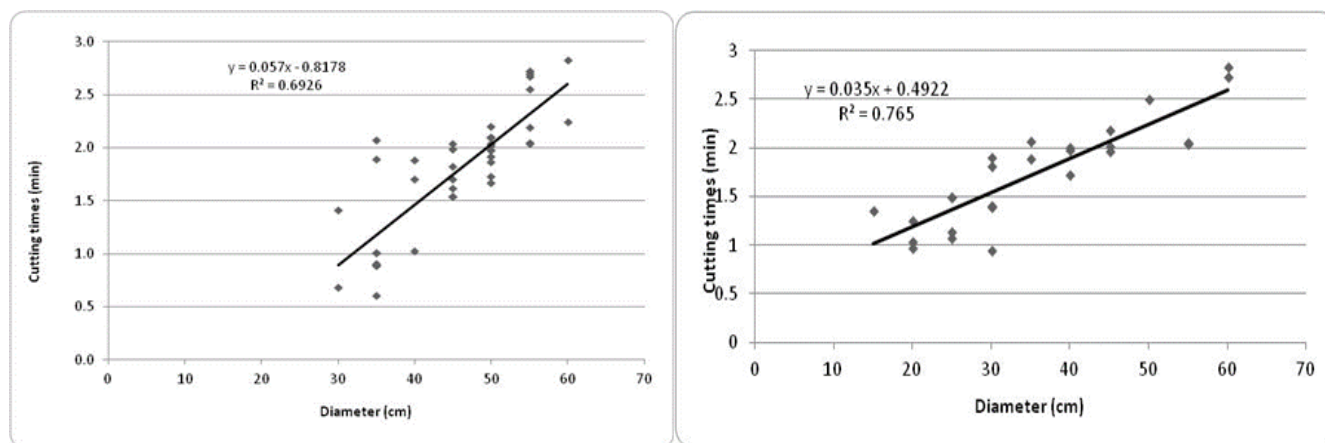


Figure 2. Correlation between diameter of cut trees and felling times respectively in Monte Amiata and Dardhe Xhyre.

There is a significant positive linear correlation between the diameter and working times in both cases.

Productivity was calculated both per team and per worker, considering the working day made up of 8 gross hours. The volume cut down in Monte Amiata was 73.477 m<sup>3</sup>, corresponding to a weight of 73.9 t. The volume cut down in

Dardhe Xhyre was 13.42 m<sup>3</sup>, corresponding to a weight of 17.83 t.

It has to be stressed that a working day in Albania lasts only 4 hours because the workers need 3-4 hours to reach the working place. The real productivity is nearly the half of the potential productivity.

Table 4. Real gross and net productivity calculated per hour and per team in meter cube and in tons for both study sites.

Productivity	Monte Amiata	Dardhe Xhyre
Gross hourly average productivity (m <sup>3</sup> /h/team)	3,480	3,610
Hourly average production net of ADT (m <sup>3</sup> /h/team)	4,430	4,550
Gross hourly average productivity (t/ h/team)	3,50	4,79
Hourly average production net of ADT (t/ h/team)	4,46	6,04
Gross daily average productivity (m <sup>3</sup> /day/team)	27,840	14,440
Gross daily average productivity (t/day/team)	28,00	19,16
Daily average productivity net of ADT (m <sup>3</sup> /day/team)	35,440	18,200
Daily average productivity net of ADT (t/day/team)	35,68	24,16

In Albanian case potential productivity is calculated for both team and workers, taking into account a composite workday of 8 gross hours.

Table 5. Potential gross and net productivity calculated per hour and per team in meter cube and in tons for Dardhe Xhyre considering the day work of 8 hours.

Productivity	Dardhe Xhyre
Gross hourly average productivity (m <sup>3</sup> /h/team)	3,610
Hourly average production net of ADT (m <sup>3</sup> /h/team)	4,550
Gross hourly average productivity (t/ h/team)	4,79
Hourly average production net of ADT (t/ h/team)	6,04
Gross daily average productivity (m <sup>3</sup> /day/team)	28,880
Gross daily average productivity (t/day/team)	38,32
Daily average productivity net of ADT (m <sup>3</sup> /day/team)	36,400
Daily average productivity net of ADT (t/day/team)	48,32

A very important aspect to be stressed is that in both cases the security during work performance is almost inexistent, even though it is very important to be respected.

#### 4. DISCUSSION AND CONCLUSIONS

The main purpose of this study was to compare beech forest harvesting, felling and processing, between Italy and Albania.

In Albania the road infrastructure is very scarce and not very present. The time needed for workers to reach the workplace was excessive (3-4 hours).

The productivity was almost the same in both areas because workers in Albania, taking into account the time spent to reach the working place, worked harder and with very limited breaks to compensate the time lost. According to this, the avoidable delay times are lower in Albania than in Italy. The unavoidable delay times were mostly due to the poor preparation of the workers and the lack of organization both in Italy and in Albania.

In Albania the beech is the most important forest species and, given the quality of its wood, it represents a great economic potential for the forest sector and for the whole Country. To ensure that the supply chains related to this species (timber and firewood) can develop, creating then new job opportunities, it is a first priority to ensure that operators,

often inexperienced, are informed about the principles of beech forestry. In fact, it is necessary that silvicultural treatments are carried out in the correct way and through the right working times to ensure the development of the stands and their safeguard.

Studies about these problems in Albania are almost inexistent.

To reduce the non-productive times due to the movement of workers, temporary shelters in the forest with beds and kitchen could be built, so that they can stay there from Monday to Friday without having to move for 3 - 4 hours.

(Halilovic et. al. 2017) reports unavoidable delay time is 30.79%, and avoidable delay time is 2.09% in his research about felling and processing work times. Tree cutting as a work operation participates with 8.46% in total time, that is a little bit higher comparing to our study, where cutting operation takes 5% of total work time.

(Halilovic et. al. 2017) reports that "Moving from tree to tree" operation takes a share of 7.58% of total time comparing to our study results where "Passage" occupied 5-6% of total work time.

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