Safety Science 79 (2015) 369–378

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

# Risk factor analysis of fatal forest harvesting accidents: A case study in Turkey

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ARTICLE INFO

*Article history:*
Received 13 March 2015
Received in revised form 11 May 2015
Accepted 2 July 2015
Available online 15 July 2015

*Keywords:*
Fatal accident
Forest worker
Forestry operations
Risk analysis
Work safety

ABSTRACT

The aim of this research was to identify the major factors responsible for fatal occupational accidents in forest harvesting operations in Turkey. A model was developed which determined five main factors and forty-five sub-factors leading to accidents during forestry operations, and then the Analytic Hierarchy Process (AHP) was used to determine the degree of importance of the factors and sub-factors in the model. In addition, the faulty behavioural risks of several recent fatal accidents which occurred in the Western Black Sea region of Turkey were identified using the AHP model. In conclusion, personal factors (32%) and organisational factors (22%) were ranked as the two most important causes of the incidences of fatal forest harvesting accidents. Furthermore, the major effective sub-factors causing fatal accidents were found. These included positioning in dangerous zone (5.0%), carelessness (4.9%), disorderly behaviour (4.9%), and unsuitable selection of workers (4.7%). It was observed that the risk level of these recent fatal accidents exceeded the risk limit value, which ranged from 0.578 to 0.718. The analysis revealed that forest managers should assign a more important role to training and selection of workers in order to reduce the number of fatal harvesting accidents. Although the application of the model proposed in this study is specific to fatal forestry harvesting accidents, it could be modified and applied to other types of forestry accidents.



## 1. Introduction

Forestry operations are generally characterised by a combination of natural and material risks to the health and safety of forest workers. Forestry operations take place far from the location of main settlements and usually require long-term accommodation at the work site on steep, rough ground and under varying climatic and environmental conditions (Enez et al., 2014). Forest work is considered to be one of the most dangerous occupations in the world (Lilley et al., 2002; Klun and Medved, 2007). Europe-wide, the number of fatal occupational accidents in the agricultural, hunting and forestry sectors is higher than in any other (Kogler et al., 2015). In all countries where comparative statistics are available, forestry has higher accident rates than most other industries (Poschen, 1993; Staal, 2001; Ozden et al., 2011). Felling, cross-cutting, extraction and skidding operations are the most common operations that result in fatal forestry accidents. Each of the harvesting methods also has its specific features that depend on natural and production conditions, the technology used, and the share of manual operations in the overall process (Gerasimov and Sokolov, 2014). Occupational accidents are followed by costs in the form of injuries, fatalities and material and environmental damages (Barlas, 2012). Fatal accident statistics are generally the most accurate of all accident statistics in that they are not reported by the injured person and must be published in official records (Thelin, 2002; Lindroos and Burstrom, 2010).

The fatal accident figures from forest operations are the most reliable data in the collected and processed accident statistics. They are good indicators of trends in forest work safety development. In the 1990s, the situation did not change in the United States, for the accident death rate amounted to, on average, 4.5 per 10,000 employed in all professions (Klun and Medved, 2007). According to occupational accident reports gathered from a number of selected International Labour Office member states, the average estimated fatal occupational accident frequency rate in forestry, logging and related services was 14/100,000 workers, and the number of fatal accidents was 335,000 (Enez et al., 2014). The number of fatal accidents occurring at work is decreasing in many other countries, but this is not true for forestry operations in Turkey. Possible reasons of this may include employing seasonal forestry workers and the lack of personal protective equipment and safety training. In Turkey, there is no regular data

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http://dx.doi.org/10.1016/j.ssci.2015.07.004
0925-7535/

recording system with respect to forestry and occupational safety (Enez et al., 2014). Statistics on these topics are inadequate, despite the occurrence of accidents and health problems affecting forest workers in Turkey. A total of 96 serious accidents and five fatal accidents occurred in 2010, according to statistics of the Social Security Institution of Turkey (Gumus and Turk, 2012). The number of fatalities is an important indicator of risk prevention and shows the effectiveness as well as the correctness of measures taken by individual countries in their attempts to provide safety at work (Klun and Medved, 2007). Risk assessment consists of three main stages: identification of the potential dangers at the workplace, in the structure of the work or possible external dangers; the calculation of risks by determining the frequency of accident occurrence and severity of dangers; and the determination of preventive measures (Unver and Acar, 2011). Prevention of fatal incidents is one of the primary goals of occupational health and safety programs. Understanding the causes of fatalities can lead to better-focused injury prevention strategies that will also address serious injury and overall injury rates (Holizki et al., 2015).

Examining accident risks and developing accident prevention strategies have become increasingly important. Most fatal accidents are caused by the overlapping of three or more risk factors (Arana et al., 2010). Decision analysis bearing decision matrices and decision trees along with multicriteria decision-making techniques such as the Analytic Hierarchy Process (AHP) (Saaty, 1990) have been used to facilitate making decisions in risky or uncertain situations. The main advantage of AHP is its capability to check and reduce the inconsistency of expert judgments (Aminbakhsh et al., 2013). The AHP was initially applied to occupational health and safety by Freivalds (1987) and Henderson and Dutta (1992). The method was also adopted by Zhang et al. (2009) to compare risk factors associated with human error with the causes of accidents in the maritime transport sector. Kim et al. (2010) proposed a safety risk assessment methodology considering risk influence factors that used expert surveys and the AHP. Badri et al. (2012) proposed a procedure for evaluation of occupational health and safety risks based upon the AHP multi-criteria analysis techniques and expert judgments (Aminbakhsh et al., 2013).

The AHP has characteristics of reliable conclusion, practicability and precision that can be applied in the analysis of fatal accidents in forestry operations as a convenient and effective evaluation method. The AHP techniques have also been successfully applied in the sectors of safety management and risk assessment (Cagno et al., 2003; Chan et al., 2004; Fera and Macchiaroli, 2010; Caputo et al., 2013). The AHP is a mathematical method in multi-criteria decision making which designs the decision factors in a hierarchic problem structure. The determination of focus, or the aim of the problem, is considered the first level of the AHP, multiple criteria that define alternatives form the second level and the last level is represented by contributing alternatives (causes or factors) (Saaty, 1990; Najib et al., 2012). Timber harvesting, with or without machinery, is difficult, especially on steep slopes, and bears high accident risks (Tsioras et al., 2014). There are several survey studies related to forest accident effects in Turkey (Acar and Şentürk, 1999; Menemencioglu, 2006; Acar and Ünver, 2008; Gumus and Turk, 2012). However, many worldwide studies focus directly on work-related forestry fatalities (Paulozzi, 1987; Salisbury et al., 1991; Myers and Fosbroke, 1994; Marshall et al., 1994; Drisscoll et al., 1995; Mitchel et al., 2001; Thelin, 2002; Klun and Medved, 2007; Potocnik et al., 2009). In order to reduce the rate of forestry accidents, many researchers have been investigating the main cause of accidents and the best prevention methods. However, no study to date has examined the causes of fatal accidents in Turkish forestry operations. In fact, in developing countries, accident reporting systems rarely exist in the forestry sector (ILO, 1992).

Countries that do not have effective safety regulations and worker training programmes will conceivably have accident rates several times higher than those in industrialised countries, whether work is done with hand tools or with machines (ILO, 1998; Ozden et al., 2011). Most forest workers can still be found not wearing the compulsory safety equipment and ignoring safety rules and thus, accident rates are fairly high. Neither do most forest workers use personal protective equipment, although it is recommended in order to avoid serious and fatal accidents (Yoshimura and Acar, 2004).

The aim of this study was to determine the risk factors of fatal occupational accidents that occur in forest harvesting operations in Turkey. For this purpose, main factors and sub-factors in the cause of fatal accidents were classified according to related literature, case studies and the opinions of experts, forest workers and managers. The AHP was used to determine the weight of the five main factors and forty-five sub-factors that cause fatal accidents. The most significant factors affecting fatal accidents were identified using the AHP model. Furthermore, an analysis was made using five recent fatal incidents that occurred during various phases of forestry harvesting operations. The faulty behaviour risks of these fatal accidents were calculated by using the global sub-factor weights and linguistic values. Finally, some recommendations for reducing the risk of fatal harvesting operation accidents have been proposed.

## 2. Materials and methods

### 2.1. The study area and local harvesting practices

This study was conducted in the Western Black Sea region of Turkey, an area that is rich in forest resources (Fig. 1). In this region, forestry operations are very intensive and at least one fatal occupational accident occurs every year. Harvesting operations in the region are performed using traditional methods that employ manpower mainly for skidding and tractors for winching and skidding (Melemez et al., 2013). The application of advanced mechanised harvesting in Turkey is limited since harvesting machines are extremely expensive and mechanisation is considered to have negative effects on employment (Melemez et al., 2014). The ground slope of the region ranges from 30% to 70%.

### 2.2. Local workforce

Since the topographical structure in most of the forests in Turkey is not suitable for working with machines, forestry operations are mostly performed in a labour-intensive way. Many workers get a significant proportion of their earnings from harvesting and transportation of forest products. Most forestry operations employ seasonal workers without any social security or work benefits (Unver and Acar, 2011). In Turkey, the total number of the members of the forestry workers' labour union and the seasonal workers employed in forestry operations is about 200,000 (Ozden et al., 2011), most of whom consist of forest villagers. The exact number of the forest workers cannot be estimated from the official data due to the unknown number of the inactive members of forest cooperatives. Nearly 2500 of these are permanent workers and 73,000 are seasonal forest workers, 25% of whom work in the region (Gökbayrak, 2005). In general, the workers do not assign importance to the harvesting operation safety regulations. Despite the high frequency of accidents and health problems caused by forestry operations, no statistics have been compiled on the safety and health conditions of forestry workers in Turkey (Yoshimura and Acar, 2004).