Ranking Health And Safety Factors For Forest Workers: An Analytical Hierarchy Process Approach In Geographic Area Of Northern Of Iran

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Abstract

Forestry workers often work in mountainous areas, hard, difficult to pass and in the conditions of climate change, and most of their work is heavy and dangerous. The death rate in the wood exploitation industry in the United States is 19 times that of other industries, which shows that indicates that the workers in the exploitation and cutting of trees are more at risk. In the studies conducted in Iran, the rate of accidents in the forest was 11 times that of other industries.The purpose of this study was to prioritize the factors affecting the health and safety of forest workers in Guilan province. Topographic factors, having safety equipment, having sufficient education and knowledge, physical characteristics of trees and type and weight of work performed. In order to evaluate the criteria, the analytical hierarchy process (AHP) technique was used. A total of 50 questionnaires related to the research topic were completed and reviewed by relevant[1] professors and experts. The results showed that the overall priority of the criteria of topographic factors, having safety equipment, having sufficient education and knowledge, physical characteristics of trees and type and weight of work performed were equal to 0.072, 0.522, 0.232, 0.037 and 0.137 were obtained, respectively. The results of the sub-criteria also showed that having safety equipment, especially earphones, glasses and helmets, is more important than the other sub-criteria examined. The results of the inconsistency rate showed that the pairwise comparisons of the criteria and sub-criteria have an acceptable consistency (less than 0.1). Safety equipment such as headphones, glasses and hats are very important because in work and industrial environments, the probability of accidents and accidents is very high. The results of the present study show that 47% of forest workers are illiterate in the study of their educational status, which requires a training course to work with tools and cutting machines for the workers.

Keywords: Risk assessment, ergonomic, logging, work accidents in forest.

Introduction

In most countries of the world the working condition of forest workers are gruesome and inefficient. Physical toil- inappropriate methods, technics, approaches, amenities along with exhaustion are the results of the mentioned. 55 percent of the deaths and injuries in the forest exploitation industry between 1980 and 2005 were recorded, which were related to cutting trees, and 70 percent of the injuries between 2006 and 2009 resulted in broken legs, hands, and wrists (Igor etal.,2009). The high rate of injuries and fatalities in the forest

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exploitation industry is a cause for concern. It is crucial for companies to prioritize the safety of their workers and implement strict safety measures to prevent such incidents from occurring. Forestry workers often work in mountainous, hard, inaccessible areas and in climate change conditions, and most of their work is heavy and dangerous . The death rate in the wood exploitation industry in the United States is 19 times that of other industries, which is This shows that the workers in the exploitation and cutting of trees are more at risk in studies conducted in Iran, the rate of accidents in the forest was 11 times that of other industries (Lindroos, etal.,2010) .Therefore, it is important to pay attention to safety issues, resting places and dormitories, health care. In the forest exploitation industry in Indonesia, due to the weather conditions and the lack of mechanized cutting facilities, the workers have been dissatisfied with their jobs .It was passed from one generation to another, but modern forestry cannot be done in this way, and mechanized machines are used to harvest and cut trees. Better harvesting of wood, forest protection, better use of workers' time, which leads to increased production, doubles the necessity of training workers. By increasing the speed of work, while protecting workers against accidents and injuries, training also increases their health factor .Another research conducted on workers in the exploitation industry in Mazandaran province showed that 47% of accidents are due to unsafe working conditions.Additionally, proper training and equipment maintenance are essential in minimizing the risks associated with tree cutting and other hazardous tasks in the industry. The main prerequisites of development and progress are the improvement of safety, hygiene, welfare and efficiency are the main conditions for improvement along with advancement and ergonomics is an important instrument for achieving the mentioned (Majnounian, etal.,2015). Like many other countries, working in forest is a very important source of employment in Iran. Northern forests with the area of 8.1 million acres entails 15.1 percent of Iran's forest (Nikooy, etal.,2017) . Although they are a small portion, they play a vital role in Iran's employment. Most of the jobs in these places are handled manually or semi-automatically. Considering the advancement of technology, working in forests is one of the most dangerous occupations specifically in the conditions that the workers are not properly trained (Klun, etal.2007). Lack of information is prevalent in developing countries workers, and it will lead to their death in most of the cases; most of the accidents that lead to death are because of the dearth of knowledge and occupational safety; other accidents are not reported because there is no compensation for them (Lindroos, etal.2010).

The amount of accidents in forestry is high compared to other jobs and due to this rate, this occupation is very hazardous; the death rate of forestry in America is 19 times more than other jobs, while this amount in New Zealand is 5.11. the mentioned rate shows the amount of danger forest workers are dealing with (Lefort, etal.2018) .

The Analytic Hierarchy Process (AHP) is the most widely used multi-scale decision-making method in risk assessment. It is highly effective and preferred for its flexibility, simplicity in calculation, and integration with other techniques AHP is a mathematical method that analyzes complex decisions using both quantitative and qualitative data based on the decision maker's experiences and intuitions (Subramanian. etal.,2017). This method allows for hierarchical modeling that illustrates the relationship between the goal, main and sub-criteria, and alternatives . By using the geometric average of individual decisions, bias in the decision-making process can be reduced. A key advantage of AHP is its ability to present decisions regarding the goal and related criteria in a balanced hierarchical structure and determine the priorities between the criteria(Vaidya etal.,2006,Seyedmohamadi etal.,2022). .AHP has been widely adopted in various fields such as project management, resource allocation, and risk analysis due to its robustness and ability to handle both quantitative and qualitative data. Its flexibility and simplicity make it a valuable tool for decision-makers seeking to integrate multiple factors into their decision-making process(Seyedmohammadi etal.,2018). The hierarchical modeling approach of AHP provides a clear illustration of the relationships between different criteria and alternatives, allowing decision makers to gain a comprehensive understanding of the decision context.

Furthermore, the method's capability to reduce bias through the geometric average of individual decisions enhances the reliability of the decision-making process. Overall, AHP's structured approach and balanced hierarchical representation make it a preferred method for complex decision-making scenarios.

The mentioned rates call for research, forestry worker's education and practical measures to improve occupational conditions related to the profession. Annually a lot of accidents take place in different ventures of forestry leading to deaths and financial damages. In order to prevent such accidents first and foremost we have to analyze the reasons behind these accidents to prevent them from happening again. Nikooy and colleagues (2016) investigated the felling operation and logging in the tropical forests of ShafaRood and they mentioned that most of the worker's head, face and hands are damaged (6). In another research Rahimi et al., 2018 have investigated the hazards that are caused by the utilization of chainsaw, in felling operation in the forests of the western Gilan and they demonstrated that hazardous trees, reverberation, and chainsaw's backfire are the most important dangers of working with the mentioned (7). Arman and colleagues (2020) conducted a postural risk assessment of felling operation in a poplar plantation in Iran (Shanderman of Gilan) and demonstrated that backache was the most common problem reported by forestry workers (Arman, etal.2020).

In another research Alibizu et al., 2013 demonstrated that in developing countries compared to other occupations forestry has the highest rate of jeopardy and factors like experience, age, temporariness, training, protective instruments, and level of mechanization are introduced as the main factors of accidents (Albizu, etal.2013).

Melemez 2015 conducted a risk factor analysis of forest facilities in Turkey and showed that personal factors, high-stake behaviors, carelessness, and bad choice of workers is very important considering accidents that will lead to death in forest and logging utilization operations (Melemez, etal.2015)

Phairah et al., 2016 investigated operator's work-related musculoskeletal disorders during forwarding operations in South Africa and demonstrated that the main factors of ergonomic problems include inappropriate posture, repetition, duration, reverberations and psychological factors (Phairah, etal.2016). Considering all of the mentioned factors a comprehensive analysis of different aspects is needed to choose a proper method of facing accidents and diseases which are caused by work in forestry; along with investigating and coming up with methods for improvement of hygiene level, safety and worker's job satisfaction. In this vein, one of the most important measures for preventing accidents in analyzing accidents at the time of happening. The objective of this study is prioritizing of the factors affecting the health and safety of forest workers based on analytical hierarchy process in Gilan's eastern forest.

Material and method

This research investigates forestry workers safety and health during felling operations and logging in Langarud City. In 2022, in order to determine the health and safety of forest workers, information on workers' occupational health was collected in the form of a questionnaire. In total, 50 questionnaires were completed by face-to-face interviews of workers working in the forest. In the questionnaire, information such as age, educational status, type of work The duration of employment, individual injuries, days of hospitalization and treatment, safety equipment used while working, and the amount of job satisfaction were asked. Considering, by the use of existing resources, data and interview with the injured workers, the effective factors that are relevant to their health and occupational safety was determined. Within the next step the effective factors on forestry worker's health and occupational safety was divided into the following five categories: topographic factors, safety equipment, sufficient training and knowledge, tree's physical characteristics, type and weight of the work performed. It was conducted by interviewing

20 occupational health experts with 10 years of work experience and scoring between different factors of 5 classes, including topographical factors, having safety equipment, having sufficient education and knowledge, physical characteristics of trees and the type and severity of work. This method has been used before(Nikooy,eta .,2010).

The necessary information related to the occupational health and safety of forest workers was collected in the form of a questionnaire. In this letter, information such as age, educational status, marriage, type of work, duration of work, type of work, personal injury, type of work, method of use at work, level of satisfaction with working conditions were asked. For this purpose, 50 questionnaires were completed through face-to-face interviews with forest workers. This study is descriptive analytical and cross-sectional. The population investigated in this study is 50 workers of forest departments in Gilan province, each of them has work experience in 4 main sectors of forest activities, including revitalization and afforestation, cutting and conversion, logging and road construction.

The first stage: assessment of occupational health and safety of forest workers

The necessary information related to the occupational health and safety of forest workers was collected in the form of a questionnaire. For this purpose, 100 questionnaires were completed through face-to-face interviews with forest workers. In the occupational health questionnaire, the information included the following four sections:

The first section: In this section, information includes gender, marital status, education status (illiterate, elementary school, middle school, high school, university), employment status (seasonal, contract, daily wage, contract, official type), work (chainsaw operator, machine tools). Lee, labor, protection force and others). Land duration (less than 10, 10-20 and more than 20 years) and age status (less than 30, 30-40 and more than 40 years) were recorded.

Second part: In this part, questions with two options including yes and no have been raised.

Third: In this section, information about the injuries of people from different stages of exploitation will be noted, which includes the stages of cutting, logging, loading and transportation.

Fourth: In this section, the information that is recorded includes the safety equipment used (including phones, glasses, helmets, gloves, safety work clothes, safety work pants, safety shoes, none), accommodation equipment at the workplace (breaks, tents, ready shed, cottage, office).

Table1 The criteria and sub-criteria are presented

Criteria: topographic factors--- sub-criteria	(1) sea level	(2) slope	(3) direction
Criteria: safety equipment--- sub-criteria	(1) headphone-goggles-hat	(2) gloves and clothes	(3) shoes
Criteria: sufficient education and training	(1) related education	(2) experience	(3) related expertise
Criteria: Physical characteristics of trees	(1) straight and gargantuan trees	(2) slanted trees	(3) uprooted trees

Criteria: type and weight of performed work	sub-criteria (1) felling operation	(2) transportation	(3) leading operation

Afterwards a questionnaire and interview with the experts were drawn to, and the criteria and sub-criteria were compared based on analytical hierarchy process. All in all, 50 questionnaires on the mentioned title were completed by experts and Expert Choice 11 Software was used to prioritize the data. In this method criteria and sub-criteria were analyzed in a pairwise comparison. In each comparison if the value of **I** entity on **J** element equals **K**; then, **J** on **I** equals **K/J**. comparingly the result of their quantitative comparison based on their value is brought in table 2.

The AHP process is a mathematical method for determining the importance and priority of criteria in the evaluation and decision-making process. The following steps are performed to determine the weights:

1. Definition and organization of criteria in a hierarchy (forming a criteria matrix).

2. Performing pairwise comparisons of the relative importance of criteria to establish weights.

3. The consistency index is used to determine the degree of accuracy and consistency of the weighting.

It is calculated based on the eigenvector approach in graph theory. If the consistency index is equal to or less than 0.1, the weighting is considered valid. Additionally, the AHP analysis provides a clear and transparent logic for selecting different options (Dey et al., 2000).

Initially, the factors influencing the health and occupational safety of forest workers were identified. Then, through a questionnaire and interviews with experts and specialists in the field, the factors were ranked using the Analytic Hierarchy Process technique and Expert Choice 11 software(Seyedmohammadi etal.,2018). For this purpose, using available resources and information and interviewing workers who had suffered injuries, the factors affecting the health and occupational safety of forest workers were determined. In the next stage, the factors influencing the health and occupational safety of forest workers were categorized into five groups: topography factors, presence of safety equipment, sufficient education and knowledge, physical characteristics of trees, and type and heaviness of work.

Table 2- Importance coefficient in pairwise comparison based on Saaty (1980)

2,4,6,8	1	3	5	7	9	Importance
Inbetweeners	Equally important	A little important	Important	Very important	The most Important	Interpretation

In order to analyze the justifiability of the data, the discrepancy index was used. The use of the mentioned helps the final choice of the effective factors by analyzing the decision-making process.

The discrepancy index shows how the gathered data can be trusted from the perspective of each expert. The base for hierarchy analysis process is the primitive decisions of decision-makers in the form of pairwise matrixes. Therefore, any kind of error and discrepancy in element comparison affects the final result of calculations. The acceptable amount for this index is less than 1, and the cases that discrepancy index is more than 1, the pairwise comparison should be revised.

Results

Descriptive information of the forest workers studied

The results of the workers' demographic information are shown in Table 3. The study of the forest workers' marital status showed that 83% of the workers were married, while 17% of the forest workers were single, equal to 17 people. The results of the marital status of the studied workers are presented in Table 3. Examining the education status of the forest workers studied showed that 40% of the forest workers have a middle school diploma and 47% of them are illiterate. The results of the education status of the forest workers studied are presented in Table 3. Examining the age status of the forest workers studied showed that 60% of the forest workers studied were between 30 and 40 years old, and the age groups less than 30 years and more than 40 years old accounted for 15 and 24%, respectively. The results of the age status of forest workers are presented in Table 3.

Table 3 Frequency distribution of demographic variables in workers in the forest exploitation industry

		Percentage frequency classification
status	Married	83
	Single	17
Age	less than 30	15
	30to40	16
	>40	24
education	Illiterate	47
	Diploma	53
Work experience	Less than 10	28
	10 o 20	50
	>20	22

The investigation of criteria which are effective on the health and safety of forest workers shows that five factors including physical characteristics of trees, having sufficient education and knowledge, safety equipment and topography factors are the effective factors among which proper safety equipment is prior others based on the hierarchy analysis process. Moreover, the discrepancy rate shows that this index equals 0.06 for this research which verifies the result of this research (Figure 1).
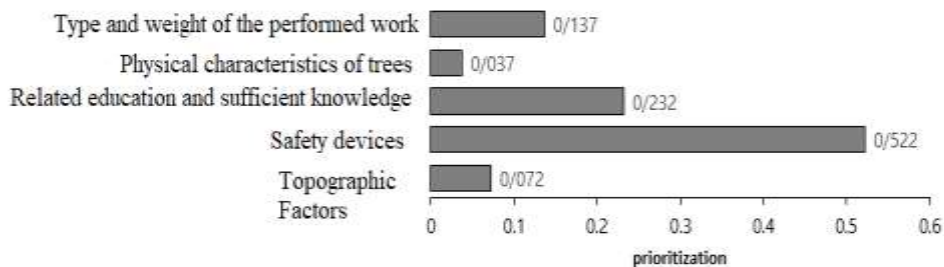

Figure 1- Results of prioritization of criteria affecting the occupational health of forest workers studied

The sub-criteria with the highest weight in the safety risk class (0.55) were determined, while the lowest weight was determined as follows. Physical characteristics of trees (0.037). (Figre1)

Results of prioritization of criteria affecting the occupational health of forest workers studied shows that the slope sub-criteria have priority over the other two sub-criteria (0.655). Moreover, discrepancy results show the 0.08 index (Figure 2).
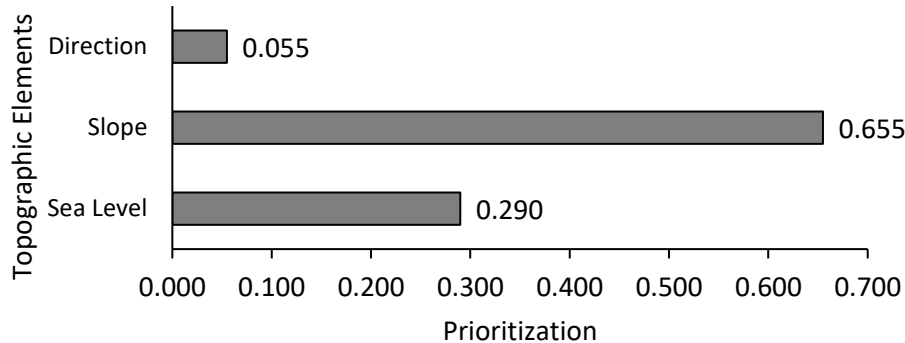

Figure 2 - Results of prioritization of sub-criteria of topographic factors

Examining the sub-criteria related to the criterion of topographic factors showed that the slope sub-criterion is more preferable than the other two sub-criteria (0.655). Also, the results of inconsistency rate showed that the value of this index is equal to 0.08. The results of these sub-criteria are presented in Figure 2.

Results of prioritization of sub-criteria of safety devices like headphones, goggles and hat have priority over gloves, Clothes and shoes and the amount of priority equals (0.669). the discrepancy rate equals 0.01. (Figure3)
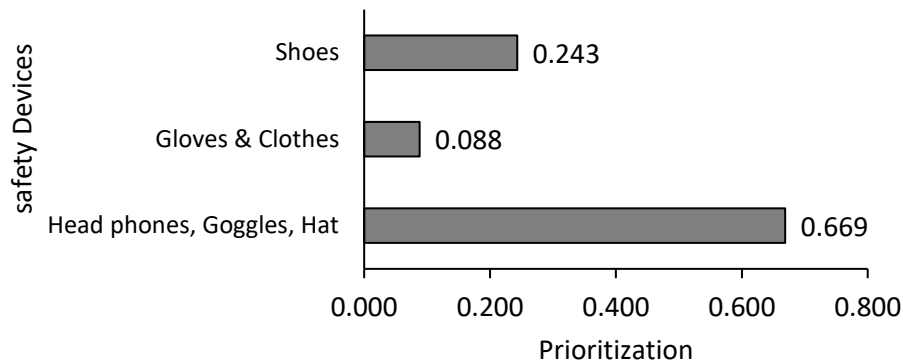

Figure 3- Results of prioritization of sub-criteria of safety devices

Results of prioritization of sub-criteria of sufficient education and knowledge, the possession of required skills had the highest importance 0.582, and the result of discrepancy rate 0.01 also approves the result of this comparison (Figure 4).
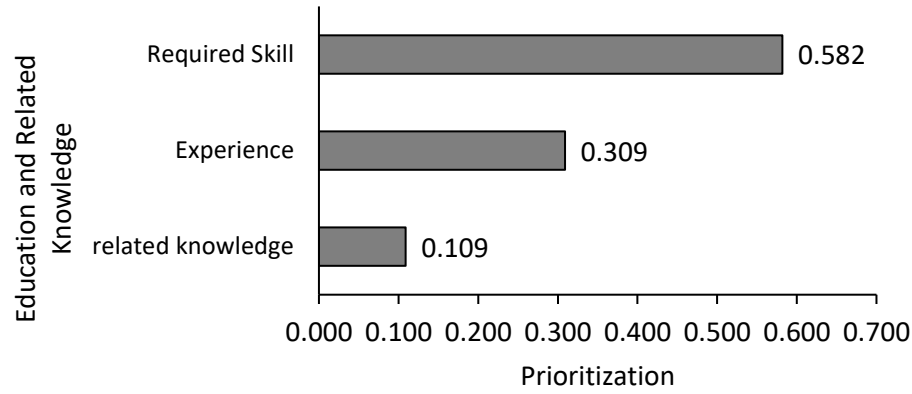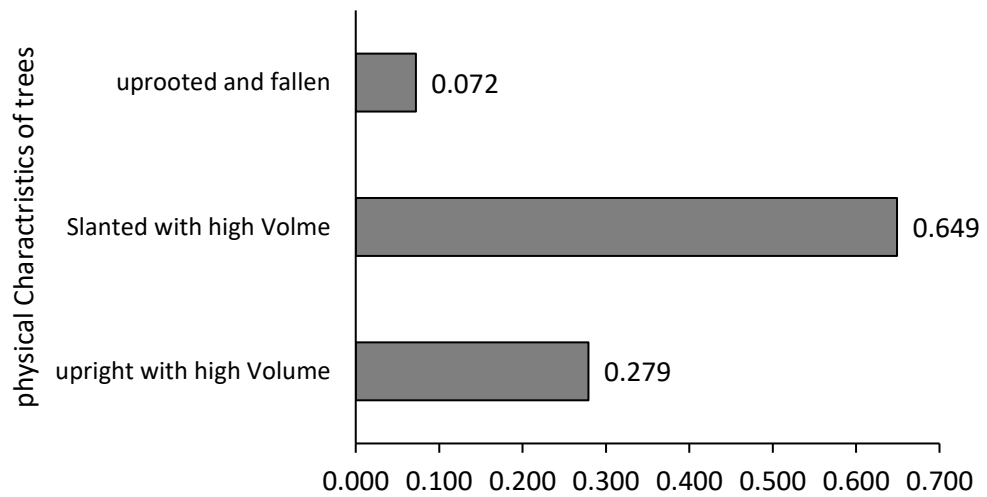
Figure 4 - Results of prioritization of sub-criteria of sufficient education and knowledge

The investigation of sub-criteria related to physical characteristics of trees shows that slanted trees with high volume have priority over the other two sub-criteria (0.649). moreover, the discrepancy rate shows that the mentioned equals 0.06. (Figure 5).

Prioritization Results

Figure 5 - Results of prioritization of sub-criteria of physical characteristics of trees

Results of prioritization of sub-criteria of type and weight of work performed shows that the felling operation with the importance of 0.731, transportation with the importance of 0.188, loading with the importance of 0.081 have the highest importance. The discrepancy rate shows that this index for this criterion equals 0.06. (Figure 6)
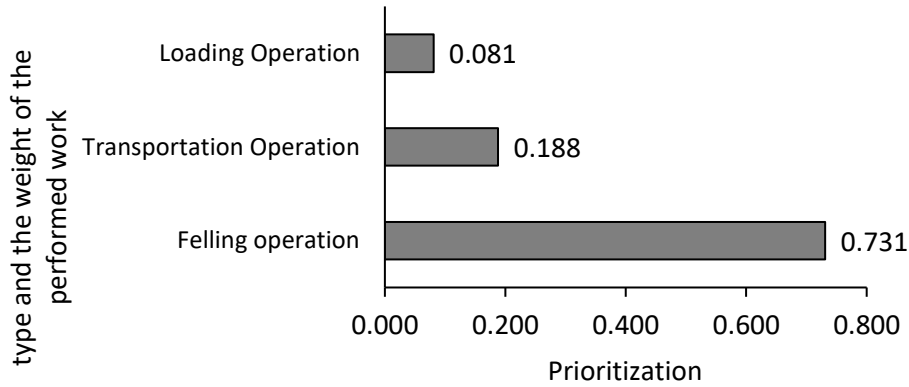
Figure 6- Results of prioritization of sub-criteria of type and weight of work performed

Results of sensitivity analysis of factors affecting the occupational health of forest workers studied shows that considering the final weight of criteria and sub-criteria based on their importance having headphones-goggles-hats sufficiency skills and safety shows have priority over other sub-criteria and they have been chosen as the effective factors affecting forest worker's health and occupational safety(Figure 7).
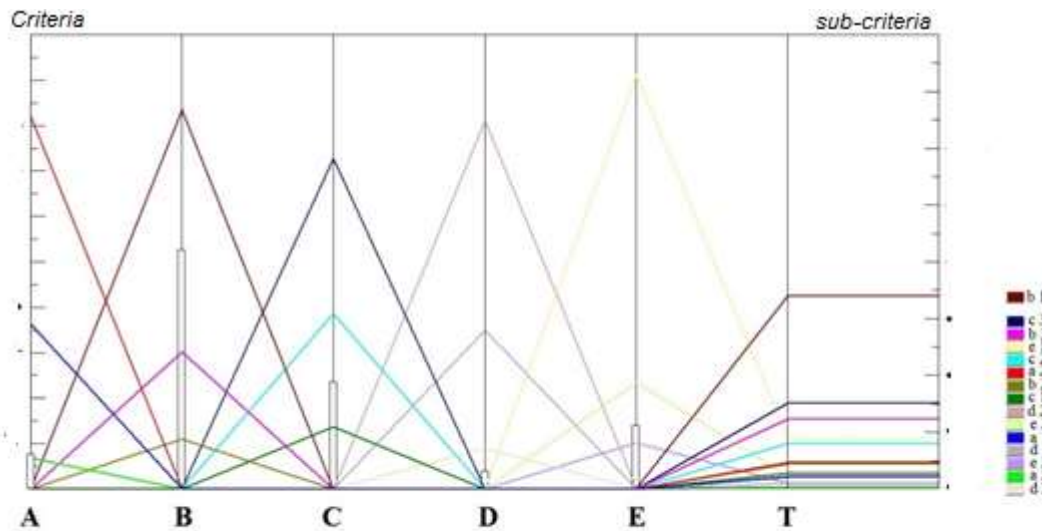

Figure 7- Results of sensitivity analysis of factors affecting the occupational health of forest workers studied

The results of sensitivity analysis in figure7 includes A. topography, B. Safety devices, C. sufficient education & knowledge, D. physical characteristics of trees, E. weight of the performed work and sub-criteria include: A1. Sea level, A2. Slope, A3. Direction, B1. Goggles, headphones, hat, B2. Gloves and Clothes, B3. shoes. C1. Related education, C2. Experience, C3. Having the required skills, D1. Monolithic trees, D2. Huge slanted trees, D3. Uprooted trees, E1. Felling operation, E2. Transportation, and E3. Loading operation.

Discussion and Conclusion

The results of the present study show that the study of the agricultural education situation showed that 53% of the forest workers have a middle school degree and 47% of them are illiterate. A training course is needed to work with tools and methods of cutting trees (Table 3). Based on the results, this research has been too much happening in people's leg organs, recently, companies are required to have gloves, pants, shoes and hats for forest work that are used and can also use them to prevent accidents. Workers who work with their hands and tools such as scythes and axes are more dissatisfied, and a survey of forest occupational health and safety in Turkey showed that 24% of workers have experienced accidents with tools such as axes and chainsaws in logging(Yoshimura, etal.,2009). From the forests of Croatia, it was also shown that there are too many occupational accidents in cold weather when performing activities without gloves. The examination of safety equipment for the use of the forest showed that it is the most convenient tool for using gloves and 47% of the work. it shows(Potočnik, etal.,2009) . It does not use any safety devices. Working in a safe environment is an inalienable right of each worker and this matter should be considered by the utilization commissioner of forests especially that of felling operations. The workforce inside forests need to be procured with educational course, on required first aid, recognition of dangers and safety approaches. The results of this research showed that among the criteria and factors investigated, the safety devices have had priority over other criteria. Nikooy et al., 2012 investigated the safety of operation in felling operation and logging in Gilan's ShafaRood and they demonstrated that processing safety devices will prevent accidents and damages to the workers; in 1.7 of the accidents the workers did not have any safety devices(Nikooy, etal.2013) . Reasons like not using safety devices on the part of forest workers, lack of educational courses for using safety devices, using inappropriate devices, misusing the equipment causes the forest workers not to use safety devices or use them selectively.

Nikooy and colleagues 2017 expressed about Gilan's jungles that apart from the fact that safety devices are compulsory more than 20 percent of the forest workers do not use them at all (Nikooy,etal.2017) .Bentley and colleagues (2005) state that most of the workers were injured in their face and hand (14) and this factor confirms the results of the research. The investigation of topographic elements affecting worker's health shows that the slope sub-criteria is the most important factor (0.655). generally, the steeper the terrain, the harder forest workers posture and the higher the susceptibility of the workers.

Potocick and colleagues (2009) and Melemez 2015 stated in their research that the slope and steepness of the terrain affects the forest worker's safety, the result of this research concurs with the result of this research (15-10). Prioritizing the safety devices utilized owing headphones, goggles and hat are all related to head and face; therefore, they are more important because the mentioned areas are the most vulnerable. The amount of injuries to these areas have caused catastrophe for the forest workers in a way that two of the workers died during the felling operation.

Mohammadfam 2009 also expressed that 50 percent of the accidents which happens to workers are because of not using the safety devices; the findings of the present research are in line with this research (Bentley, etal.2005).

Tsioras et al., 2014 along with Enez and colleagues 2014 in order to decrease the accidents in jungle paths specifically that of mountainous areas; workers should use safety devices and cleat(Tsioras, etal.2014; Enez, etal.2014) . The result of investigating the effect of sufficient knowledge and education on worker's health shows that having the required knowledge on different fields of forestry knowledge is more important than other sub-criteria. Revising workmanship approaches, organizing work and development of worker's skills mostly need meager capital while they can be really efficient. Education is a very effective criterion for improving performance, efficiency and safety of forest workers and it is easily utilized on a worksite.

Inoue and colleagues 1999, investigated the risk factors within Japan demonstrated that supervisor's lack of knowledge on safety management and revising the working relationship between workers and supervisors is of utmost importance for reducing the risk at the workplace(Inoue, etal.1999) . Melemez 2015 investigate the risk factors in accident which led to death in Turkey concluding that forest managers have a high impact on selecting forest workers and training them, and via these factors they can reduce accidents that will lead to death(Melemez, ,2010).

The results of prioritizing the sub-criteria of tree's physical characteristics shows that slanted trees have a higher effect on forest worker's health and safety; because of the fact that tree's lack of balance causes them to have the ability of falling down in any possible direction. Sygnatur 1998, states that windowing branches are one of the most important dangers that are caused by felling operations and each year they kill lots of workers. Due to this reason, within the perimeter of widowing branches the felling operation must not take place; in these conditions the fall of the traces must be investigated closely and trees must not be thrown at each other. The result from the type and weight of the performed work shows that the mentioned are more important than the felling operation considering the health of the forest workers.

The felling operation is one of the most dangerous operations of forest workers. Moreover, the chainsaw is the most important instrument of forestry that will lead to accidents; primarily, chainsaw endangers limbs causing workers to be unemployed for an elongated duration . Moreover, in another research Nikooy and colleagues 2010 investigated the accidents in western Gilan, the felling operation responsible for 24 percent of the accidents inside jungles and these results are in line with the present research(Nikooy, etal.2010).

Bently and Parker 2001 investigated the accidents of New Zealand jungles and they showed that the felling operation entail 20-30 percent of the jungle work accidents (Bentley, etal.2001). Generally, the results of research show that considering all of the criteria and sub-criteria investigated shows that possession of safety devices related with the protection of face and head is of utmost importance in forest workers. Kohadei et al., 2013 investigated the factors leading to accident in forests of Sari concluding that the main reason behind injuries is not using personal protective devices (Khodaei, etal.2013). Nikooy et al., 2011 & 2017 along with Bently and Parker 2001 stated not using safety devices is one of the most important factors affecting forest worker's health and safety . The sensitivity analysis showed that, considering the final weight of the criteria and sub-criteria, having a phone-glasses-hat, having the necessary skills and having safety shoes are more preferable than other sub-criteria. The results of the sensitivity analysis are presented in the figure7.

Therefore, the results which were drawn from this studied showed that utilizing personal protective devices is one of the most substantial measures imperative for worker's safety and conducting the duties without them seems to be impossible. Generally, management quality of worksite accidents is only possible through annual analysis and retrieval of data. Examining the sub-criteria also showed that having safety equipment, especially phone, glasses and hat, is more important than other sub-criteria examined. According to the obtained results, the use of personal protective equipment as a basic measure for the safety of the environment and around the worker is necessary and necessary, and personal protective equipment is considered as a work tool without which it is impossible to do the job in question. In general, the quality of work accident management in the forest is only possible through the collection of statistics and its annual analysis. The results of such researches can be used as a general guide for work safety experts in the forest.

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