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Review Article

Comparative Evaluation of Conventional and Modern Timber Extraction Systems in Mountain Forests

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Abstract

Exploitation of mountain forests is problematic in all parts of the world because they are particularly vulnerable to uncontrolled exploitation the result of which can be disastrous for environment such as: soil erosion, torrents, mud flows, avalanches, rock-slides. It's essential that mountain forests exploitation should be based on scientific principles and plans drawn up and agreed beforehand. All cutting and harvesting operations must be planned in such a way to ensure permanent forest cover maintenance, improvement of cutover stands and adequate regeneration process. Today, along with the conventional methods of timber extraction there are new technical facilities available for harvesting depending on the nature of forest and ground conditions. Local foresters must decide which methods and technical facilities must be given priority taking into account forest species and environmental conditions.

Keywords: Harvesting; Terrain; Elevation; Skidding; Environment; Cable way

Introduction

From old terrestrial conventional systems of timber extractions are manual and animal skidding. Manual skidding is rare today in industrial countries. They have limited practice in developing countries for extraction of fuel wood on short distances, usually using downhill gravity of moving logs. As to the animal skidding, in spite of the fact that it is less popular in industrial countries today than it was in the past, in some developing countries they are still used for example, oxen skidding: Costa Rica, Malawi, Tanzania. Elephant skidding: India, Myanmar, Sri Lanka, Thailand [1]. The ground skidding system causes major soil disturbance if not planned properly. Resent technical developments include: the use of ground-based machinery like tractors on rubber-wheels, improvements in planning and designing skid trails to minimize soil disturbance.

To old water conventional system belong log driving downstream using the current of a river. This method was widely used in Europe, North America and other countries [2]. The ideal river considered straight and uniformed one with sharp banks and predictable flow of water. The most desirable species considered coniferous once, especially pine trees, because they floated well. Hardwood species being more dense didn't float well. Waterways of course are the most acceptable for wood extraction by economical point of view, but they are not always available, nor their use feasible. After development of railroads and trucks for logging roads, log driving using river current became unnecessary. Though this method is still practiced in some remote locations where such infrastructure as railroads and motor transport don't exist. Log driving in the United States and Canada ended in 1970s and in Scandinavian countries in 1983 [3].

Results and Analysis

Georgia is mountainous country and about 98% of forests grow in mountains. Only 2% of forests grow in plains, mostly in Kolkheti lowlands and flood lands of the rivers: Mtkvari, Alazani, Iori, Khrami and other smaller rivers. About 27% of forests grow under 1000m. of elevation and about 73% above this level. The major part of forests (78%) grow on steep (210-350) and very steep (360) slopes [4,5]. Such disposition of forests determine their extremely environmental protective functions like: protect from soil erosion, regulation of water flood and its penetration deep into ground. Mountain forests protect highland population from

such disasters as avalanches, mud-flows, torrents, rock-slides. They protect highland villages and resorts from strong cold winds. They regulate output of mineral waters of spar resorts and have recreational facility. Due to such environmental importance from the second half of the 20th century local governments began to diminish gradually the amount of annual principal loggings (Table 1), besides in all mountain forests practiced selective loggings. Only in alder forests of Kolkheti lowlands practiced clear loggings.

Table 1: Dynamic of principle loggings in forests of Georgia in 1060-2010 ts.m^3.

Year	1960	1965	1970	1978	1980	1990	2000	2005	2010
Amount	2,089	1,930	1227	535	432	432	442	811	799

Sauce: Forest resources of Georgia 2015 [5].

As we see from table 2.1 annual amount of principle logging decreased from 2,089 ts.m^3 in 1960 to 432 ts.m^3 in 1990. But after breakup of the Soviet system it began to increase again. From selective logging systems used thinning and group-selective cuttings. Timber extraction performed usually with skidding winches and crawler farm tractors. Only from late 1980s began using wheeled farm tractors that wasn't suitable for forest operations and caused extremely detrimental effects on environment especially on steep terrain. As to using railroad transport its share was also limited. In Table 2 are presented data of transport ways on territory of forest fund of Georgia. From total amount of forest fund of Georgia forest roads were 2,754km. and roars for common use 5,808 km. The road density on km/km^2 in forest fund is given in Table 3. It shows that forest roads density was 0.114 and covered roads 0.014. In European countries on 1km^2 forest area forest roads in Germany is 1.9km/km^2, in France 0.8-1.6km/km^2, in Czechoslovakia 0.6-2.0km/km^2 and in Sweden 1.8km/km^2. So, we can conclude that by road density Georgia always legged behind [6].

Table 2: Roads for timber transportation in forest fund of Georgia ,1983.

Type of Road	Length, km					
	Total	Among them				
		Road Category			Forest Roads	of Common Use
		1	2	3		
Roads, total	12890	100	1819	2409	2754	5808
Among them:						
Railroads	101	-	-	-	52	49
Auto-roads	12789	100	1819	2409	2702	5759
Among them:						
Covered roads	3921	54	37	125	342	3363
Ground roads	8868	46	1782	2284	2360	2396
From them:						
For round year use	4851	20	1042	842	938	2009

Sauce: Forest resources of Georgia and problems of their rational utilization 1991 [6].

Table 3: Road density in forest fund of Georgia, km/km^2.

Roars for Common Use		Forest Roads		Total	
Total	Covered	Total	Covered	Total	Covered
0.241	0.14	0.114	0.014	0.536	0.163

Sauce: Forest resources of Georgia and problems of their rational utilization 1991 [6].

In the middle of 1980s by Moscow's initiative have been organized timber extracting trials by helicopters MIL-8 with lifting capacity of 5 ton (about 3.5m^3) [6]. Beech forests have been chosen for these trials in Kakheti region of east Georgia. From logging systems practiced in these forests was taken group-selective loggings. This system provides to spot 4-5 places on one hectare for future windows which will be logged like circles. After 5-7 years from first logging the circles are enlarged and so on during 20-25 years depending on forest condition. If the forest density is high (0.8-0.9) and there are enough young generation in the stand the logging period can be shortened. At the end of the period the circles overlap each other and the whole stand is logged down [7,8]. This method guarantee environmental protection and regeneration.

The flying range of helicopter is usually kept within 2km. from landing or dropping zone for helicopter harvesting to be economically viable. Windows for safe helicopter operation must be enlarged much more than 20-25 m. as provided by logging system. At the same time enlarging windows can cause detrimental consequences like soil erosion and so on. So there are many contradictions. The helicopters involved in this type of work consume large quantity of fuel and have to be refueled nearly

every hour. So, the refuel pads must be located close to the working area. The landing place has to be sufficiently large to accommodate drop zone. There are much emphasis on safety of all aspects of helicopter-harvesting operation from the felling of trees to the landing or drop zone.

To summarize the trials of using helicopters on timber extraction in beech forests of east part of Georgia we must underline positive and negative aspects of this method.

Among positive aspects are:

A. The helicopter can extract logs from the sites that are inaccessible by difficult terrain as well as from environmentally sensitive areas where the use of ground-based and cable systems are impossible and undesirable;

B. There is no exposed ground surface inside the harvesting area due to the absence of skid trails and cableway corridors ;

C. There is reduced harvesting damage to the surrounding trees ;

D. Fewer roads are required because the economic flying range of helicopter is about 2km.;

E. Reduced damage to forest stands and ground surface along with less soil erosion and stream sedimentation make the intangible benefits that should be considered too ;

F. Among negative aspects are:

G. High capital and operating expanses of helicopter exploitation ;

H. By economic point of view only sound and merchantable timber are selected for logging and extraction leaving in forest less valuable trees, that degrades the remained stands;

I. Helicopter MIL-8 lifting capacity is valid up to 1,000m. above this gradient its capacity diminish gradually. So helicopters with more lifting capacity is needed, like Sikorsky S-64F, whose capacity is 11 ton (7.2m^3) ;

J. Helicopter timber extraction cannot be used in selective cuttings as there are not enough timber after each loggings and they are continued for 20-25 years. So they are economically inacceptable. The best way of their use may be clear cuttings when we have enough concentration of logged trees to extract;

K. Helicopter timber extraction may be used in limited way in high-value timber forests when they cannot be accessible otherwise.

Discussion

Among modern harvesting equipment are: harvester/forwarders, cable harvesters, long-distance cable-ways, grapple-yarders, swing-yarders. From aerial systems (Helicopters and Balloons [8,9]. New harvesting equipment, being very expansive, mainly used in industrial countries. Skyline crane that was invented in Switzerland, is a form of cable timber extraction system in which harvested logs are transported by suspended steel cable from where the trees are felled to processing location. Skyline crane is installed on an agricultural tractor. A skyline yarder can pull in load limited to 1.5 tons, though occasional loads can be up to 2 tons. Five experienced men can install a skyline cableway in 3-14 days depending on the length of cable and availability of natural supports. The ordinary operating distance is up to 1.5 miles (2.5km). This method of timber extraction is used in industrial countries like: Switzerland, Austria, Czech Republic, France, Italy, west coast of North America and others [10,11].

Skyline system if different from other cable systems. Logs are conveyed with a carriage moving along suspended cables installed either at the landing or opposite end of the cableway. Besides skyline crane many different types of cable systems are in use now. If the system permits to keep the load in fully suspended position during hauling, soil disturbance is minimal, but generally only one end of the tree is in the air, the other end is usually dragging on the ground destroying it. The whole ground territory under the cableway and it is about 10m. width and 1-2km. length is disturbed greatly and it would need recovering works to be done, otherwise substantial erosion is irreversible. After such extraction natural regeneration cannot be guaranteed and tree planting will be necessary that makes this method dearer. In our opinion this method of timber extraction can be used only in clear-cuttings and it's impossible in selective cuttings. Besides, cableways are mostly used in coniferous forests which characterized by straight stems and narrow branches. In deciduous forests, beech forests for example, their use can cause extra problems with big trees (average 80-100sm wide on 1.3m.) and many strong branches [12,13]. Much hope was for long-distance cable-ways and they worked satisfactorily for decades, but their importance as universal solution of timber extraction declined as they are much more expensive and their loading capacities are limited at the same time they need skilled operating crew.

Under aerial timber extraction methods are united balloon and helicopter extraction [14,15]. Balloons had comparatively few trials in the world. These trials showed their economical and environmental efficiency, but at the same time less loading capacity and immobility. Using balloons in narrow mountain gorges are especially dangerous because during operation they can strike tops of the trees and cause accident. Helicopter timber extraction trials took place in Scandinavian countries, Russia and the United States. These trials proved to be environmentally effective, but no economical conclusions have been made. Using helicopters on timber extraction decrease the need for extra road construction. As the trees are extracted from forest vertically, there is reduced damage to the surrounding trees and ground surface. The post-logging land-slides are less common than after ground extraction. Hely-logging can be used when cable-logging is not allowed for environmental reasons or when roads are lacking. Hely-logging reduces the level of infrastructure required to log in a specific location, reducing at the same time the adverse environmental impact of loggings [15,16].

It must be admitted that roads are the best suited means for all-purpose long-distance transportation on different terrain. Apart

from usefulness for forestry they are unquestionable requirement for introduction of larger forces and mechanical equipment to mountain areas bringing in the regular food and maintenance supplies. Moreover, their use is open for all kind of vehicles from village carts to modern trucks. They contribute also to the general welfare in the broadest sense by facilitating agriculture, local trades, cottage industries, medical care, tourism [17].Their construction and maintenance can be carried out by local labor and provide earnings for mountain population. They are important for forest management, supervision, fire protection and procurement of forest products in the vicinity of forest area. In short roads are essential mean to forest yields and utilization to the maximum level of sustainable production and to keep it there permanently [18,19].

From adverse effects of road construction are: environmental disturbance, like threats of increased erosion, disrupt of water submission, other environmental detrimental consequences as mud-flows, torrents, problems of natural regeneration after loggings. Proper road and skid trail planning can reduce considerably the area disturbed by road construction and costs for timber extraction and transportation. Although the new know-how methods are available their adoption is slow, particularly in the developing countries, due to high costs of their implementation.

Conclusion

Mountain forests are extremely vulnerable to any kind of exploitation as they have essential environmental functions and any uncontrolled operation or improper logging may have irreversible consequences. 73% of forests of Georgia grow above 1000m. of elevation, 78% of them on steep (210-350) and very steep slopes (36= and more). Methods of exploitation and timber extraction must be chosen very carefully. Improper practice of forest exploitation and timber extraction with crawler farm tractors have already destroyed soils and degraded highland forests in last periods and had detrimental consequences on environment like soil erosion, mud-floods, land-slides and stream sedimentation. Logging and timber extraction operations must be planned in such a way to ensure permanent forest cover and adequate regeneration. The comparative analysis of timber extraction systems and facilities showed that forest roads have always been the main sauce of timber extraction and apparently will remain in near future. As trials of using helicopters on timber extraction showed they cannot be used in selective loggings as helicopters need much more free territory for landing and take-off operations than selective method can provide, otherwise the principle of selective method of logging is violated itself. They can be useful only on clear-cutting operations when there are comparatively large concentrations of timber to justify the considerable investments involved.

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