Harvesting systems in Hyrcanian Forest, Iran; limitations and approaches

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Abstract:
The Hyrcanian (Caspian) forest in northern Iran has a richness of biological diversity, with endemic and endangered species and improper logging methods are widely seen which tended to cause the greatest environmental problems. About 45% of the Hyrcanian forests are located in mountainous areas, where forest lands are not readily accessible with ground-based logging equipments, but cable yarding technologies are still undeveloped in this forest area. This paper describes the various types of equipment and systems used for harvesting timber in Hyrcanian Forest. Trees to be removed are felled, limbed and topped motor-manually. The combination of the timber type, site, stand characteristic and topography limit harvesting mechanization to perform transport operations. Rubber-tired skidders are used on the more gentle slopes and on skid roads on steeper terrain. Crawler tractors are used on steeper topography to skid direct to the landing. In steep terrain that is not accessible by ground-based machines, Felled trees are processed by chain saw into logs and then hauled by mules. Falling, primary transport processing, and loading phases are discussed in terms of operational and environmental considerations in this paper.

Keywords: Hyrcanian Forest, Timber skidding, Sawn-lumber, Residual stand damage, Soil compaction

1 Introduction

1.1 Hyrcanian zone

Hyrcanian vegetation zone is a green belt stretching over the northern slopes of Alborz mountain ranges and covers the southern coasts of the Caspian Sea. This area stretches from Astara in the northwest to Gorgan vicinity in the northeast of Iran. Based on the latest data from the Iranian Forests and Rangelands Organization, this area is approximately 800 km long and 110 km wide and has a total area of 1.85 million ha comprising 15% of the total Iranian forests and 1.1% of the country's area. Alborz mountains interception between the Caspian Sea and Iran plateau has resulted in a climate with distinct vegetation cover. Hyrcanian forests stretch out from sea level up to an altitude of 2800 m and encompass different forest types thanks to their 80 woody species (trees and shrubs). The area is rich in hardwood species, however there are only four genii of endemic softwood trees including Taxus sp., Juniperus sp., Thuja sp. and Cupressus sp. The primary function of these forests other than wood production is supportive and environmental and their vital role in soil and water sources conservation as well as natural balance distribution in this susceptible mountainous high sloped basin is extremely considerable (Sagheb-Talebi et al., 2004).

1.2 Geology and pedology

Alborz mountain ranges form the folded fringe of the vast Iranian plateau and have been made by two major mountain formations. The first movements leading to the formation of Alborz were initiated in Paleocene epoch. In early Cenozoic, drying up of the northern part resulted in the formation of Alborz mountain ranges. The second phase of mountain formation occurred in early or mid Oligocene which resulted in the elevation and subsequent erosion of central Alborz belt and eventually the thick deposition

of Molas. Alborz mountains cannot be considered the upshot of an individual mountain formation movement instead their formation could be attributed to a part of a considerably wider movement including entire Iran and Caucasian mountains surrounded by Saudi Arabian plate in the south and Russian plate in the north. The most important soil types in the Hyrcanian region are as follows: Brown soils, Alluvial soils, Rendzina soils, Colluvial soils, Rankers, and Lithosols.

1.3 Climatic characteristics

The Hyrcanian zone is a humid zone in the north of Iran. The average annual rainfall ranges between 530 mm in the east and 1350 mm in the west reaching up to an occasional record of 2000 mm in the west. Based on the climatic data from meteorological stations, the maximum annual rainfall is experienced during spring and late fall and winter. Relative humidity is also constantly high with an average value fluctuating from 74.6% in the east to 84.6% in the west, rarely dropping below 60% at the hottest hours. Thus, the region could be considered as one of the world's ever-wet areas. Humidity rise at the highest temperatures results in the saturation of air due to the lowest temperature fall and subsequently cloud formation in the afternoons especially on the northern slopes. Research has indicated the lowest evaporation rate among different stands to be of Buxus sp. and Pterocarya sp. amounting to 0.5 mm/hr at the height of 1.5 m above ground level. According to the climatic data from meteorological stations, the average annual temperature in the Hyrcanian region has varied from 15° C in the west to 17.5° C in the east over the past decade. The warmest month temperature ranges

1.4 Vegetation

In contrast to the Euxino-Caucasian forest lands, no high altitude softwood forest stands are observed in Alborz region and the timber line is characterized by a hardwood species (Quercus macranthera). While the altitude of 2700 m is the limit, individual trees have been reported up to 3000 m. Softwood species would not survive upper than 2700 m due to the warm and dry climate and considerable amount of high pressure snowfall and competition from grasses and shrubs. No softwood seeds were found in the archeological digs in Lar region whereas Fagus, Carpinus, Alnus, Corylus, Quercus, and Betula seeds were abundant. Hence, it could be concluded that the climatic conditions and vegetation cover of the Hyrcanian region did not undergo major changes during the Quaternary Period.

1.5 Silviculture and Forest management

914000 ha amounting to 45% of the Northern Forests are currently managed by governmental, private sector and cooperative contractors in 392 districts. Over the past decade, considerable changes have been made in forest management plan selection criteria due to the reinforcement of ecosystem point of view. Even-aged high stands has been changed into uneven-aged high forests, clear cutting in of restoration areas at vast extents have been stopped, spot cutting in limited areas have attracted attention and harvest rate has been diminished. This means a 32% reduction in forest utilization versus 47% increase in forest planned areas. In plantations, endemic hardwoods were replaced by exotic softwoods. Based on the same report, the average inventory per ha in the Hyrcanian functional forests equals to 280 cubic meters and the annual volume increment ranges between 2 to 8 m^3 per ha depending on the species, site, age and stand density (Sagheb-Talebi et al., 2004).

In Iran, it is about 40 years, which the Caspian beech forests are under management. The dominant silvicultural method, which practiced in these forests, was Shelter wood system to achieve even aged and pure beech stands. Today after 40 years experiences we can say that the shelter wood system is not suitable for the Caspian beech forests. There are many reasons; the most important one is that the Caspian beech forest naturally tends to be mixed and uneven aged. In some exceptional cases, the clear cuttings were done in mountainous oriental beech stands. The result of these experiences was catastrophic, after heavy soil erosion the pioneer succession has started on mentioned sites with Rubus hyrcanus, Matteuccia struthiopteris and Alnus subcordata. According to our experiences, observations and some investigations today we can say that the selection system (both, the single and the group selection system) is a suitable silvicultural system for the Caspian beech forests. Femelschlag system could be theoretically also a suitable silvicultural system in Caspian beech forests, if uneven aged forest is not the aim of management in these forests. It is obvious that ongoing and future researches will show us the appropriate silvicultural

systems not only for the oriental beech forests but also for other forest communities in the Caspian region (Marvie Mohadjer, 2005).

2 Wood production trend

Forest utilization levels from Hyrcanian forests are established by the government. The Forestry and Rang Organization (FARO), under the Ministry of Agriculture, has responsibility for forestry in Iran and prepares and submits forestry plans and projects to the Ministry of Agriculture for approval. Once approved, FARO Contracts with individual companies, cooperatives and governmental entities to harvest timber, construct forest roads and log terminals. In 1979, 1.1 million cubic meters of wood-based products were legally generated from Hyrcanian forests. By 2008, this legal production declined 15.4 percent to 0.93 million m^3. Figure 1 shows that the utilization by product from Hyrcanian forests (Source: FARO, 2008). Figure 2 shows that charcoal production, although still the primary product generated, has declined over this period while logs and pulpwood have increased their share of total production. Forest products harvested in the years 1989 to 1994 has variable trends in the Hyrcanain Forest. From 1989 to 1994, the amount of wood harvested have been increased and consequently the amount of wood products (such as: logs, pulpwood, sawn-lumber, fuelwood, and charcoal) have been an increasing trend, in 1994, wood production has been increased from 1.2 million cubic meters to 1.7 million cubic meters. Reducing volume per hectare and implementing policies related to reducing wood harvested from this forest have caused to wood harvesting and wood products volume have been decreased from 1994 to 2010, and reached to 0.7 million cubic meters.

In viewpoint of timber type produced, in the 30-year period, the percentage of the amount of logs less than 7 percent in 1989 has risen to 35 percent in 2010. This increase has due to the development of basic infrastructure projects like forest roads and skidding machinery. Processing products such as sawn-lumber a decreasing trend in this period were 25 percent of the total volume of products in 1985 to less than 6 percent reached in 2010. Rapid urbanization and industrialization, intensive grazing, over-utilization of forests for firewood production and farming in wooded areas are amongst the main causes of deforestation in this area. One of the most significant impacts of this degradation is the depletion of epiphyte species in the region. Over the last few decades, swift forest degradation has brought about a number of environmental, social and economical impacts including soil erosion, floods, degradation of farmlands and habitats, reduction of biodiversity and natural resources and air and water pollution. Purchasing and importing the new forest machinery and skidding machines to this forest in the last decade have been caused to decreasing the amount of processing wood products, which was consequently lead to optimal utilization of harvested wood in the forest area following tree marking and harvesting processes. Important point is the substantial reduction of wood fuel (charcoal) from 55 percent of total volume of products in 1989 to less than one percent in 2010. This trend is primarily due to the use of fossil fuels in the past three decades, and due to the development of forestry infrastructure, such as optimal density of forest road networks, that caused to extraction of fuelwood and pulpwood from forest area to mills as economically viable operations.

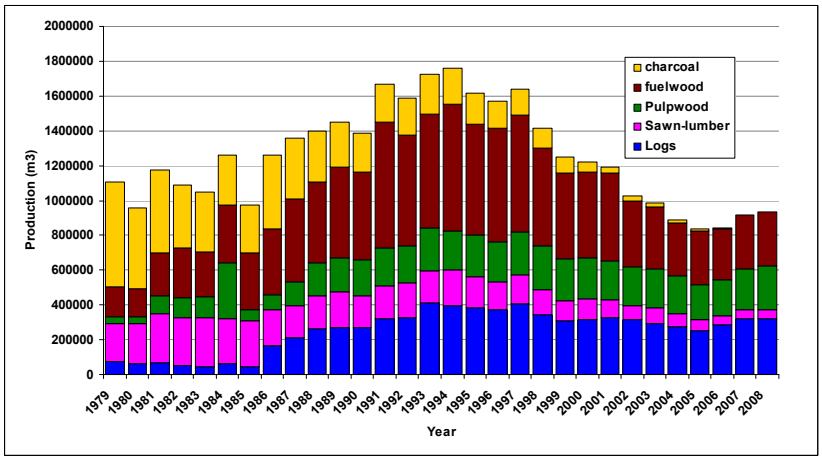

Figure 1: Utilization by product from Hyrcanian forests (Source: FARO, 2008)

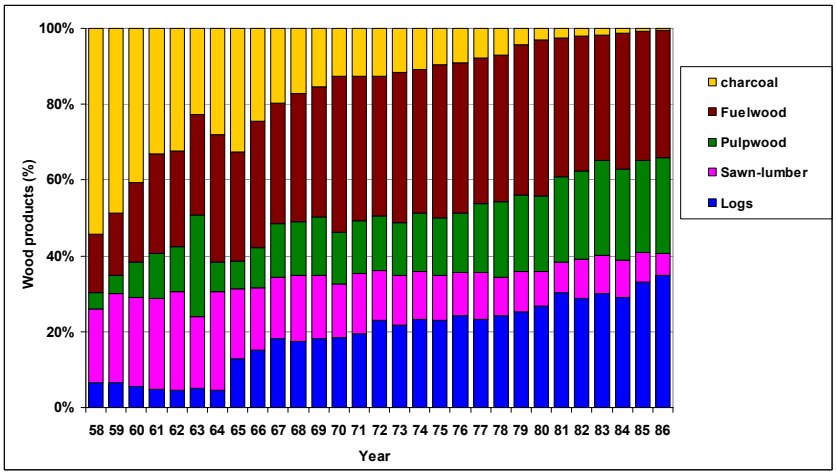

Figure 2: Wood products trend from Hyrcanian forests (Source: FARO, 2008)

3 Harvesting system, limitation and constraints

In the forestry system of Iran, the whole forest area is broken down into watersheds. Every watershed is subdivided into compartments and every compartment is divided into parcels. The average surface area of the watershed, compartments and parcels is 25000, 1000, and 50 ha, respectively. Parcels are mainly used to organize and administer planning and operations. Natural barriers, such as streams, swamps, ridge tops or excessively steep slopes determine the shape and size of the parcel. Sometimes artificial barriers, such as roads, separate parcels from each other. Harvesting performance in Iran consists of measuring the annual increment of forest stands and determination of removable volume from each parcel. A basic assumption is that the amount of timber harvested per year should be the equivalent or less than the annual volume increment. Trees selected for felling are marked before the felling operation. On the basis of volume and type of harvesting determined for each forestry plan in the related Action Plan, the supervisor of the plan performs the tree marking. The planned locations of roads and skid trails are flagged or marked on existing trees after the felling operation. Successful skid trail planning should not be limited to the artificial administrative boundaries (Mousavi, 2009).

Planning of the skid trails affects the wood extraction, and is one of the most important processes in logging. Before extraction begins, the skid trails are opened by a chain saw operator and constructed by bulldozer operator according to the route planned or marked. All trees within the skid trail with a

diameter greater than 15 cm are cut by the chain saw operator before the bulldozer passes, uprooting the remainder of the trees. The basic considerations are terrain, volume per hectare and relative roading and skidding costs.

Hyrcanian (Caspian) forest in northern Iran has a richness of biological diversity, with endemic and endangered species, and a diverse range of economic and social conditions. About 45% of the Hyrcanian forests are located in mountainous areas (Figure 3), where forest lands are not readily accessible with ground-based logging equipments, but cable yarding technologies are still undeveloped in this forest area. Accessibility is the most critical factor influencing feasibility of operations in mountainous terrain (Heinimann, 2004). The national forest inventory (1986) in Hyrcanian forest showed that the base level of 1.9 million hectares of forest, 35 percent of the land has slopes less than 27 percent, 57% of forest land with slope between 27 and 58%, and 8 percent of land that slopes more than 58 percent.

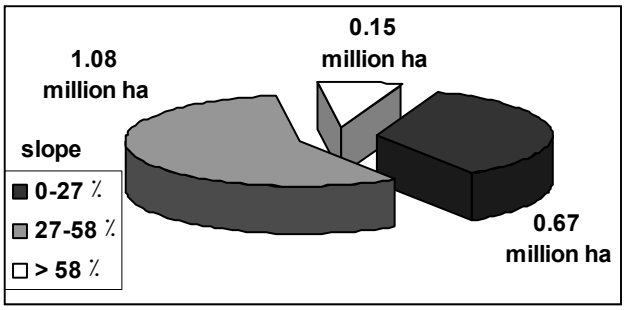

Figure 3: Proportion of Hyrcanian's forests based on terrain slope

Rubber-tired skidders are used on the more gentle slopes and on designated skid roads in steeper terrain. Crawler tractors (bulldozers) are used on steeper topography to skid direct to the landing (Sobhani and Stuart 1991). The use of wheeled and tracked skidders is a widely seen and well accepted practice in Hyrcanian forests. It is also the one that tends to cause the greatest environmental problems. In this forest, the degree and extent in mechanization of skidding operations has greatly intensified over the last decade, and general public and forest managers are currently expressing concern about the compaction and degradation of forest soils and its consequences such as surface run-off, soil erosion, and flood flow risk (Figure 4).

Forest operations consist of all technical and administrative processes to develop technical structures and facilities, to harvest timber, to prepare sites for regeneration, and to maintain and improve quality of stands and habitats. Harvesting is an essential activity in forest management. It involves all operations from tree felling to delivering logs at the mill, rail depot, or ship dock. If carefully planned and implemented, benefits, which were anticipated at the time of the forest investment, are possible. Poor planning and/or poor implementation of forest plans can be costly, result in environmental degradation as well as excessive wood waste, poor utilization of the available resource, and injury to personnel (Sessions et al., 2007).

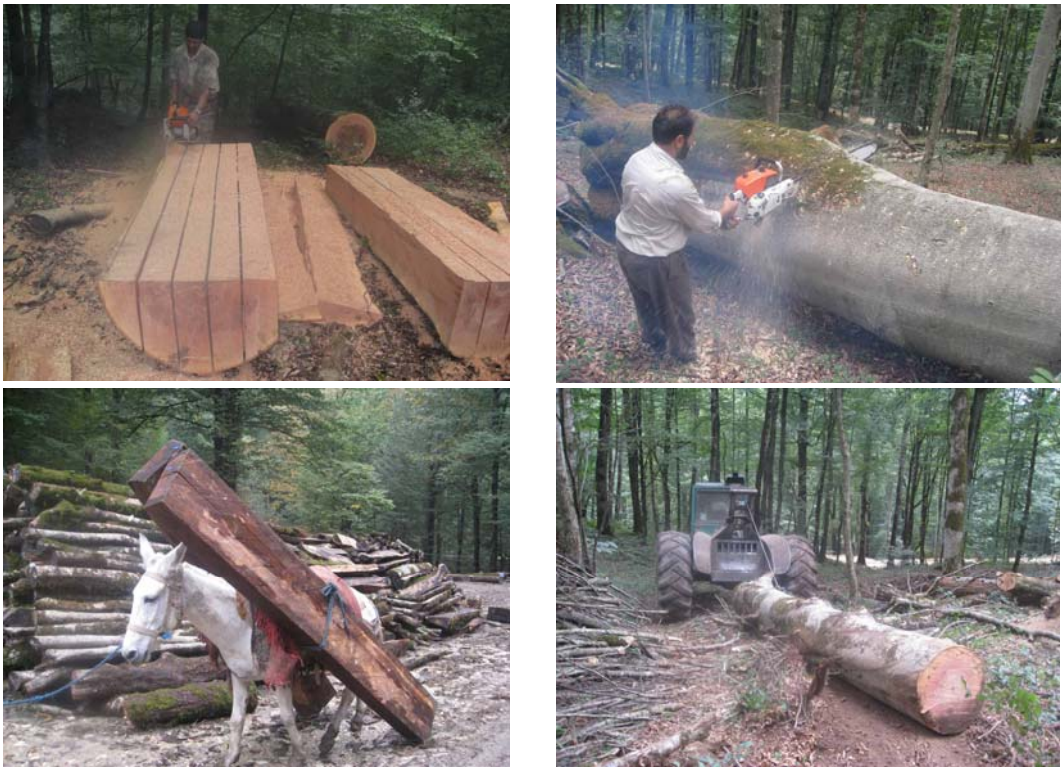

Figure 4: Mechanized and traditional mule logging in Hyrcanian forest area

3.1 Mule logging

Most of the animal logging in Hyrcanian forest is a family tradition and logging operators learned from their fathers. Animal logging in northern Iran is typically comprised of a crew of five or six people and seven or eight mules. Trees to be removed are felled, limbed and topped motor-manually (Jourgholami et la., 2008). Felled trees are processed with chainsaws into lumber and or pulpwood. The dimensions of lumber were 2.2-2.8 m in length, 30-34 cm width and 10-15 cm thickness. These dimensions apply because this is the mule maximum tolerable hauling weight (Sarikhani, 2000). This traditional mule hauling system was established in Hyrcanian forest because the forest management plan and the forest road network were undeveloped. Recently, with increasing of environmental interest, concentration on environmentally sound timber extraction and small scale tree harvesting, the proportion of mule logging was increased in Caspian forest. Basically, mule operations for extracting log in Hyrcanian Forest have a difference with animal logging in other part of world. Lumber, pulpwood and fuelwood sets on the back of mules and wood don't touch the ground or has the least touch and mule hauling the load to the landing but the other place, animal skidding the logs and pulpwood on ground with suitable equipments such as skidding tongs, sled-type equipment and skidding bogies, wagons. Mules move in a narrow path and have a low disturbance on soil surface and stand damage. Hyrcanian Forests, model of broad-leaved forests primary pattern after post-classical period in northern hemisphere. This forest has distinct floristic, ecologic, wildlife characteristics and is the exclusive site for some rare Iranian species. About 40% of the Hyrcanian forests are located in mountainous areas, where forest lands don't accessible with ground-based logging equipments and cable yarding technologies undeveloped in this forest. So, mule logging can provide a solution to accessibility in this critical mountainous terrain. The results of evaluation test or practices indicated that this timber extracting technique are feasible, applicable and reasonable in small tree harvesting with a relatively low impact to environment and a moderate operation cost. The wages paid to forest workers in the North of Iran are low and mule logging was extremely laborious; therefore mule logging is suitable for solving employment problems. Mule hauling operation in Hyrcanian virgin forest and protected forest area can meet economic, silvicultural, environmental, and social objectives.

3.2 Mechanized logging

Unfortunately there are many problems faced by the foresters to keep these plans going on and to develop and try to bring the forests to better and higher quality and quantity stands. Besides the unlawful cutting and destroying the forest lands by people, one major problem which have been there for many years and from long ago even before having management plan, is the presence of domestic animals (cows, sheep and goats) in the forest, the so called forestry animal husbandry (Sobhani, 1998). This is a major problem for carrying an acceptable plan. Another problem for logging practices and executing the management plans as good as they can be is lack of proper and suitable machinery's. This matter causes more damage to the area and also to the timber and wastes quite noticeable percentage of the wood. In many parts of the forest, because the proper machine is not there, the conventional method of harvesting is carried out and the logs are converted by hand. This means a high percentage of loss (about 40%). About 19% of Caspian forests are within slope classes of 60-120. This accounts for 284815 hectares of the thick forested areas. This means we need different kinds of cable systems which are not available as yet and can not be expected for a near future. The skidding or forwarding systems are the dominant systems used in logging practices. But the number of these machinery's are much less than the needed ones and the size of those available machines may not be recommended for use in such areas.

In Iran, ground based harvesting systems (wheeled and tracked skidders) are common types of equipment used in primary transportation. Therefore, Iranian harvest planners must optimize the deployment of skidding machines in order to achieve successful harvesting operations. Developing productivity models for harvesting equipment should help managers achieve greater operational efficiency. The skidders that have been used can be listed as: Timber Jack 450C, Taf, Clark 660, Kumatzo, Zetor track skidders and few caterpillar wheel skidders and agriculture tractors. At this time the only remaining and active ones are Timber Jack, Zetor, and Taf, with tractors for hauling fuel wood and short woods. These machines have been designed for especial conditions with specific load and ground slope and soil mechanics. But, since theses machines are limited and there is no other choice, in most cases are the only chances. Therefore, it may be possible that they will not be used properly and may cause damage to the site or the production rate not being optimal.

The harvesting operation may cause significant damages to the residual stand. This damage might have been avoided through the application of more careful logging procedures and applying low impact logging methods. Most of the bole damage was caused by winching and skidding when logs struck the standing trees. The wounds on the injured trees are located in different areas. In most of the cases, the injuries are situated in the bottom 1 m of stem which represents the most valuable part of the tree. In Iran no studies have documented the progress of wound on the damaged trees in the residual stand. Pathology studies, in order to find the prevalent kind of fungi attack on damaged trees and finding a treatment, helps to improve future stands (Mousavi, 2009). Different species have different susceptibility to damage caused by the harvesting operation. Logically, the thick bark of some species increases the resistance to long term damage. Logging damage can be reduced by promoting damage-free thinning operations. In the past, efforts to protect residual trees have included chemical treatment on the stumps, suspending thinning during sap flow, clearly marking trees, matching the logging system to topography and timber size, short rotation to final harvesting to minimize decay loss, limiting use of drive-to-bunch vehicles to species with deep roots, directional felling, reduced road and trail densities, less curve on skid trails, and temporary buffer trees removed at the end of operations.

Forest soils with high organic-matter, low bulk density, high porosity, low strength and high permeabilities are very susceptible to soil compaction and shear effects. According to our findings, we have to conclude that the most compaction occurred after the initial few passes and reducing the number of trips made over the same trail has not any effect for reducing soil compaction. Hence, even one pass is already sufficient to induce a strong increase in bulk density. Slope gradient and soil moisture have significantly effects on soil compaction. Also, slope gradients on trails should be as low as possible, particularly when vehicles are traveling loaded. Severe compaction of soil adversely affects the growth of plants by a combination of physical soil changes and plant physiological dysfunctions. One strategy to limit soil disturbances is to avoid traffic whenever the water content approaches the limit of liquidity, or even exceeds it. Skidding operations should be planned when soil conditions are dry so as to minimize

rutting, but if skidding must be done under wet conditions, the operations should be stopped when machine traffic creates deep ruts. Another approach is to limit traffic on skid trails. Traffic trails should be developed for forest sites in order to concentrate most forest operations to compacted trails. The distance between these trails must depend on the length of the felled tree and may range between 50 and 70 m distance. Preplanning of skid trails and directional felling will improve skidding efficiency, increase safety, and reduce ground disturbance (Majnounian, 1988).

The use of logging in Iranian Forest Harvesting is quite restricted because of heavy initial investment and foreign currency requirement to buy Cable System. Neither government nor private logging companies show any interest to use this system. Those few systems that were previously available, have already gone out of logging system mainly because of depreciation or no suitable place to use them since they are too big and heavy (Sobhani, 1998). Among the system needed for proper harvesting operations are cable systems. It is now more critical than before to use cable systems because of new trends in silvicultural practices which follow the “close to nature” path. That means no more clear-cutting in most areas. But another important point with regard to using cable systems is the development of new projects and increasing demands for timber which forces the Forest Organization to prepare more management plans for the other parts of the forested areas which include steep terrains. The high percentage of steep forested areas requires the investment on machinery’s and systems to correctly and properly extract the valuable logs.

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