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# PAST AND PRESENT SILVICULTURAL SYSTEMS AND TENDING OPERATIONS IN HIMALAYAN MOIST TEMPERATE FORESTS OF PAKISTAN

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## Abstract

Himalayan moist temperate forests have the highest contributing values in the forest resources of Pakistan. These forests provide timber for commercial and domestic use, non-wood forest products that are abundantly available for local farmers and the international market. These forests are also source of fresh water to the lowlands. Locals and nomads are highly dependent on these forests for their livestock production. Silvicultural systems and tending operations are important management tools for the optimization and utilization of forest resources. Edaphic and biotic factors are also influenced by these systems for biomass production. There are two different silvicultural systems applied in the management: protection and conservation, i.e. selection system (also including group selection) and clear felling system. The group selection and clear felling system were applied for experimental purpose in the 1980s. At present, only selection system with 3D's (dead, dying and diseased), and damaged trees logging is accepted in different parts of the Himalayan moist temperate forest. Before 1992, 1.9 % and 88.6 % of activities were found for clear felling and selection system, respectively. Tending operations are also inactive in different parts of the forests. Tending activities i.e. weeding 21.1 %, cleaning 88.6 %, thinning 16.1 % and improvement felling 1.43 % average, were recorded to examine the active status in the study area. Studies must be conducted for the protection, conservation and management optimisation of these valuable forest resources.

**Key words:** afforestation, harvesting system, Himalayan temperate forest, management activities, species composition.

## Introduction

Ecologically and biologically Pakistan is one of the richest countries, including high mountains of Himalayan, Karakorum and Hindu Kush and deep Indian ocean with high diversity (Hussain 1984). Forest ecosystems are one of the major parts of the natural richness. Production is one of the key elements of forest resources and their services especially in the coniferous forests (Müller et al. 2019). These forests are the major source of palatable plant species (Khan 1985), they also provide fuel-wood and medicinal plants to the local community (Sher and Al-Yemeni 2011). Due to the heavy exploitation, intensive utilization and recreational activities (Rashid et al. 2011) in these valuable ecological niches, the fauna and floristic community become near to extinct (Al-Yemeni and Sher 2010, Sher and Al-Yemeni

2011). Special management is demanded, for wildlife biodiversity maintenance in many cases (Moser et al. 2002).

To get maximum benefits without destroying these forests, foresters need sustainable management rules and integrated plans. Harvesting or silvicultural system is the scientific method to utilize these forests properly. Silvicultural systems are the ′set of silvicultural operations by which forest crops are tended, harvested, and replaced by new crops – this constitutes a Silvicultural Systems′ (Troup 1952) for standard definition (Association 1953, Champion et al. 1965b). Availability of environmental resources to establish and create new individuals and survivors are provided by the silvicultural treatments and tending operations (Harper et al. 1965, Lewandowski et al. 2015). According to studies during four decades of span, plant compositions, differences were significantly shifted through the years, the sites were degraded due to reduction (35 %) in species richness, forbs and grasses ratio was increased due to an increase in acidity and change of the soil chemical composition (Mcgovern et al. 2011). The distribution of natural regeneration, its amount and types are also determined by the interaction of a wide range of overstorey and understorey vegetation with climatic and edaphic factors (Bataineh et al. 2013). The soil have undergone large changes in the past years due to environmental pressure (Mcgovern et al. 2013), which affects the species composition, structure, and diversity of the forest stands. That ultimately influenced the choice of silvicultural systems and tending operations in the mountainous forest with scattered vegetation.

Outdoor recreation is the key eco-commercial service of these mountainous forests. Flora and fauna are highly diversified in its nature, great importance for protection and scientific management is required, for forest resources conservation and sustainability. Silvicultural systems and tending operations are important management tools for the optimization and utilization of forest resources. The present study is focused on identifying management activities and status of forest for conservation, protection and production level.

## Material and Methodology

Moist temperate forest of Pakistan – Ecological consideration: Forests in Pakistan cover about 6.6 % of the country area (5,832,506 ha), where Himalayan moist temperate forests cover about 0.7 % (572,508 ha) of the total country area. These forests are found in Khyber Pakhtunkhwa (P), Punjab (P) and Azad Jammu and Kashmir (S) (Province (P), State (S)) at high altitudes (900–3500 m) (Bukhari et al. 2012) (Fig. 1). Typically represented by conifers, vertically on the down from these forests subtropical pine forests and on top sub-alpine and alpine pastures are found (Champion et al. 1965a). Dry temperate forests are found while moving horizontally from these ones which are surrounded by great mountainous ranges of Asia, recorded rainfall in the area is 635 mm to 1524 mm (detail is given in Table. 1).

The Himalayan moist temperate forest is further classified for more precise and accurate research work as shown in Table 2 and Figure 2 (Champion et al. 1965a). The geological formations of Himalayan moist temperate forest areas are mainly occurring on gneisses and schists (Shah and Moon 2004), also extended over shales, conglomerates, limestone, granites and quartzites (Champion et al.

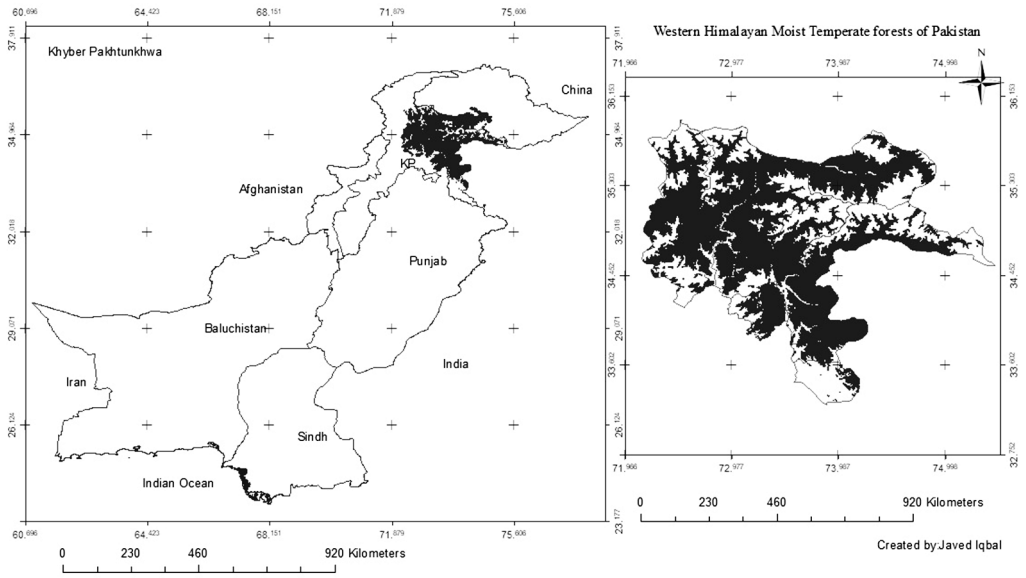


**Fig. 1. Study area (ArcGIS 10.6 Academic version).**

1965a). Loamy soils are predominant in the area showing a wide range of distribution and accumulation of acid humus of a considerable depth likewise those found in the spruce forest (Tayor and Hoon 1934). According to the forest working plan of Himalayan moist temperate forest these forest stands fall in site quality II (moderate) for vegetation growth and rarely sites are with site quality I (high) (Lughmani 1961, Shah 1967, Yusuf 1955).

## Data collection and analysis

Data were based on working/management plan of the forest divisions. The data were categorized into management activities (cultural operation, tending operation, and silvicultural system) along vegetation type and stand density shown in Table 1. Data was collected through random selection of forest division. For statistical analysis, frequency distribution and percentage for activities were examined. Thirty forest divisions were examined for past and present management practices; due to variation in the area of forest, percentages of different activities were recorded. Rstudio, Sigmaplot and PAST statistical packages were used. Data were representing through bar chart, histogram and line graph.

## Problems of the area

Due to limited access to the study area (April to September) and also limited growing season (June to August), the research activities need extensive planning. Due to the high influence and pressure of tourist activities (infrastructure), the study area is exposed to degradation during the summer season. Population pressure (encroachment, shifting cultivation, grazing, extensive fodder and medicinal plant collection) also plays its negative role in the degradation of the forest cover, enhancing the erosion activities (Saeed 2003). Terrain and topography also affect the

**Table 1. Description of the research areas.**

| Description | Khyber Pakhtunkhwa | Azad Jammu and Kashmir | Punjab |
|---|---|---|---|
| Area, ha | 391,769 | 161,842 | 17,249 |
| Soil/topography | Steep Northwestern slope on limestone shales, Lower on clod northern slopes | On a moderate slope with Northern aspect, Steep northern aspect on coarse granite, | Moderately steep sheltered North-western aspect on limestone, |
| Climate | MAR 1600 mm, MAT 3.2℃ | MAR 660 mm, MAT 2.1℃ | MAR 1506 mm, MAT 4.9 ℃ |
| No of plots for Selection System/area | 25/2.5 ha | 25/2.5 ha | 25/2.5 ha |
| No of a plot for Clear-cut system/area | 2 ha (Full enumeration of the plot) | 1 ha (Full enumeration of the plot) | Nil |
| No of a plot for Group selection system/area | 1 ha (Full enumeration of the plot) | Nil | Nil |

Note: Mean Annual Temperature (MAT), Mean Annual Rainfall (MAR). Source: Champion et al. (1965a).

**Table 2. Distribution and floristic composition of Himalayan moist temperate forest of Pakistan (Champion et al. 1965a, Efloras 2008).**

| | Forest subdivision | Localities / Altitude | Species |
|---|---|---|---|
| **A** | **Lower Western Himalayan Temperate forests** | | |
| i | Low-level blue pine forest (*Pinus wallichiana* A.B. Jackson) | Loon Bagla, Jhelum division, Kashmir / 1982–2134 m | *Pinus wallichiana, Quercus dilatata* Royle*, Taxus baccata* L.*, Viburnum nervosum* D. Don, *Indigofera heterantha* Wall.*, Paeonia emodi* Wall. |
| ii | Moist deodar forest (*Cedrus deodara* Roxb.) | Malkandi Compartment 1/2, Shogran, Kagan Valley / 2286 m<br>Ashkot Compartment 13, Keran division, Lower Nilam valley, Kashmir / 1676–1982 m | *Cedrus deodara, Pinus wallichiana, Picea smithiana* Wall., *Abies pindrow* Royle*, Quercus dilatata, Quercus ilex* L.*, Aesculus indica* Wall.*, Prunus cornuta* Wall.*, Acer caesium* Wall.*, Viburnum nervosum, Rosa macrophylla* Lindl.*, Berberis lycium* Royle in Trans.*, Hedera nepalensis* K. Koch, *Clematis montana* Buch.-Ham. |

| | | | |
|---|---|---|---|
| iii | Western mixed coniferous forest | Ashkot, Lower Nilam valley, Kashmir / 2286–2438 m<br>Shogran, Kagan valley / 2362 m<br>Dungagali water catchment, Murree Hills / 2438–2591 m | *Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow, Taxus baccata, Aesculus indica, Prunus padas* L., *Juglans regia* L., *Ulmus wallichiana* Planch., *Populus ciliata* Wall., *Acer caesium, Viburnum nervosum, Anemone obtusiloba* D. Don, *Actaea spicata* L., *Hedera nepalensis, Rosa moschata* Herrm. |
| iv | Ban oak forest (*Quercus incana* Roxb.) | Sehri Bari Reserve Forest compartment 58, Ghoragali, Murree Hills / 1829 m<br>Loon Bagla (near Chakar), Muzaffarabad forest division, Swat, Abbottabad / 1646 m | *Quercus incana* Roxb., *Cornus macrophylla* Wall., *Pistacia integerrima* J. L. Stewart, *Quercus dilatata, Pinus wallichiana, Pyrus pashia* Buch.-Ham., *Diospyros lotus* L., *Ficus palmata* Forssk., *Pinus roxburghii* Sargent, *Prunus padas*., *Indigofera heterantha, Rhamnus virgata* Roxb., *Viburnum grandiflorum* Wall. ex DC., *Hedera nepalensis, Quercus glauca* Thunb., *Olea glandulifera* Wall. |
| v | Moru oak forest (*Quercus dilatata* Royle) | Loon Bagla compartment 3, Muzaffarabad division, Kashmir / 1829–2134 m<br>Near Dungagali, Murree Hills / 2438 m | *Quercus dilatata, Pinus wallichiana, Populus ciliata, Ulmus wallichiana, Abies pindrow, Taxus baccata, Prunus cornuta, Juglans regia, Cornus macrophylla, Viburnum nervosum, Berberis lycium. Fragaria nubicola* (Hook.f.) Lindl., *Viola kashmiriana* W. Becker, *Hedera nepalensis, Euphorbia wallichii* Hook. f. |
| **B** | **Upper West Himalayan fir and mixed broadleaved forest** | | |
| i | Upper West Himalayan fir and mixed broadleaved forest | Upper Mushkin, Astor Valley, Gilgit / 3200 m | *Abies pindrow, Pinus wallichiana, Picea smithiana, Betula utilis* D.Don, *Sorbus aucuparia* L., *Salix flabellaris* Andersson in Kung., *Lonicera webbiana* Wall., *Fragaria nubicola.* |
| ii | Kharsu oak forest (*Quercus semecarpifolia* Smith in Rees) | Keran division, Upper Nilam Valley, Kashmir / 2900 m<br>Swat / 2896–3200 m<br>Kagan division, Hazara / 3200 m | *Quercus semecarpifolia* Smith in Rees, *Abies pindrow.* |
| **C** | **Edaphic, seral and Degraded type of Himalayan moist temperate forests** | | |
| i | Moist temperate deciduous forest | Pahlgam, Lidder Valley, Kashmir / 2134 m<br>Makanai Forest, Shogran, Kaghan division / 2591 m<br>Dungagali, Murree Hills / 2438 m | *Padus cornuta* Wall. ex Royle, *Aesculus indica, Juglans regia, Acer caesium* Wall. ex Brandis, *Ulmus wallichiana, Corylus colurna* L., *Viburnum grandiflorum*, *Acer pictum* auct., *Parrotia persica* (DC.) C.A.Mey., *Salix flabellaris*, *Hedera nepalensis, Rosa moschata, Populus ciliata, Ulmus wallichiana, Quercus dilatata, Clematis montana* Buch.-Ham., *Fragaria nubicola*. |

| | | | |
|---|---|---|---|
| ii | Populus-Salix flabellaris Andersson in Kung. forest | Upper part of moist temperate forest / 2743 m | *Populus ciliata, Salix flabellaris* Andersson in Kung. *Pinus wallichiana*. |
| iii | Alder forest | Kagan, Siran Valley Dir and Swat / 915–1829 m | *Alnus nitida (*Spach*)* Endl.Gen.*, Salix flabellaris* Andersson in Kung. *Populus ciliate.* |
| iv | Riverain blue pine forest | Extended into the dry zone, recorded in Kagan, Dir and Nilam Valley / 1524–3048 m | *Pinus wallichiana, Alnus nitida (*Spach*)* Endl.Gen.*, Populus ciliata, Salix flabellaris.* Some *Cedrus* and *Picea* on a higher level and on lower *Pinus roxburghii.* |
| v | High-level blue forest | Upper Mushkin Forest, Astor Valley, Gilgit / 2743 m | *Pinus wallichiana, Picea smithiana, Rosa webbiana* Wall.*, Berberis lycium, Lonicera webbiana, Rubus armeniacus* Focke.*, Ribes himalense* Decne. *Populus alba* L.*, Betula utilis, Salix flabellaris*. |
| vi | Secondary blue pine forest (*Pinus wallichiana* A.B. Jackson) | Paryai Reserve Forest, Siran division / 1981 m<br>Shinkiari-Kund ridge, Siran division / 1829 m<br>Miandam Forest, Swat / 2073 m<br>Ghoradhaka, Murree Hills / 2286 m<br>Loon Bagla, Muzaffarabad division, Kashmir / 1981–2133 m | *Pinus wallichiana, Cedrus deodara, Populus ciliata, Quercus dilatata, Rhododendron arboreum* Sm., *Prunus cornuta* Wall.*, Viburnum nervosum, Berberis lycium, Rubus armeniacus, Viola kashmiriana, Hedera nepalensis, Quercus incana, Indigofera heterantha, Fragaria nubicola. Diospyros lotus, Aesculus indica*, *Ulmus wallichiana, Taxus baccata, Cornus macrophylla.* |
| vii | Himalayan moist temperate scrub | Lower Jhelum Valley or areas where trees are eliminated through biotic agencies / 1238 m | *Plectranthus barbatus* Andrews*, Berberis lycium, Indigofera heterantha, Cotoneaster humilis* Dunn*, Sarcococca saligna* (D.Don) Muell.-Arg. |
| viii | Pohu Scrub (*Parrotia persica* (DC.) C.A.Mey.) | Kashmir in the valley to the north of Jhelum, Swat Valley and Kagan / 1828–2438 m | *Parrotia persica* |
| ix | Himalayan temperate parkland | Middle and higher elevations Kagan Valley and Kashmir valley / 2286 m | Coniferous and broadleaved mostly forbs and grasses. |
| x | Himalayan temperate pastures | Last stage of degradation of the original broadleaved and coniferous forests. Better-drained slight banks between the flatter trampled ground / 2145–2655 m | *Pinus wallichiana,* and mostly forbs. |

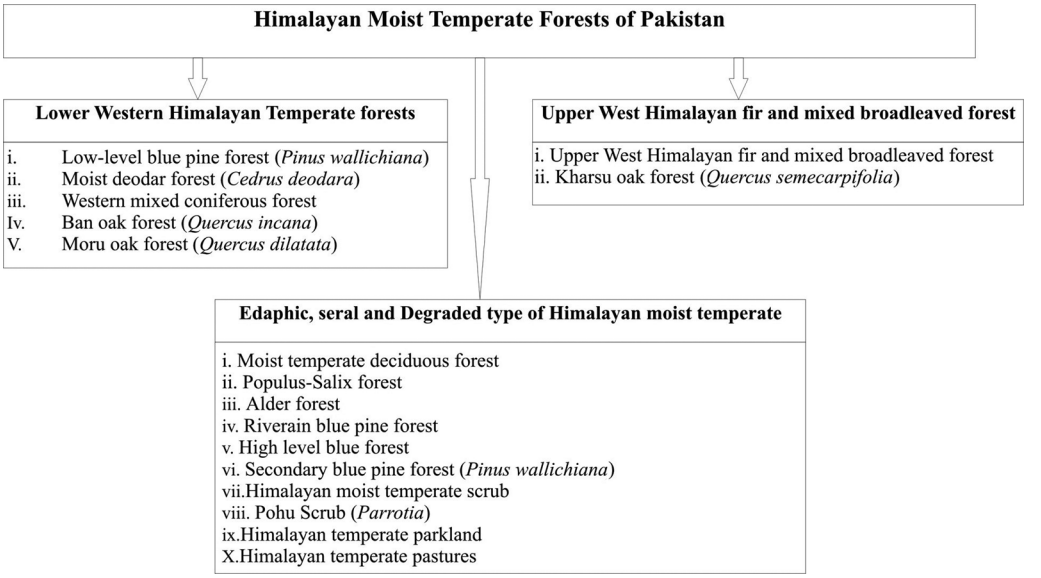


**Fig. 2. Structure of forest types in Himalayan moist temperate forests of Pakistan (Champion et al. 1965a).**

research activities in the area for the purpose of improvement and development of forest stands (Champion et al. 1965b).

## Results and Discussion

**Past and present silvicultural or harvesting systems:** Due to the limited forest resources and less intense vegetation cover in Himalayan moist temperate forests, the silvicultural (harvesting) systems have very limited application. In the past (1947–1992) these forests were harvested under proper silvicultural system, i.e. selection system (this system is applied due to low vegetation cover, steep terrain and also due to recreational activities in the area). In the 1980s one-hectare plot were harvested for research purposes under group selection system, and one-hectare plot were clear felled under clear felling system. Besides that, strip clear-felling were also observed in Kund forest in the 1980s. Since 1993 until present, green felling were banned, only 3D (dead, dying and diseased), wind fallen, top/half broken and snow damaged trees are harvested under prescribed selection system. The presentation of the research plots is given in Table 1.

The period before 1992 shows clear indication in Fig. 3 of scientific and management activities in the study area (average of percentage is about 1.9 % in clear felling area, whereas an average of 88.6 % activities was found in the selection system). After 1992 there is a clear indication of less management activities in the study area shown in Fig. 4 (no evidence of clear felling system were found, whereas selection system was partially working after 1999 by the government and average 14.56 % activities were active). The comparison between the periods is also illustrated on Fig. 5, which graphically represents the activities before and after 1992.

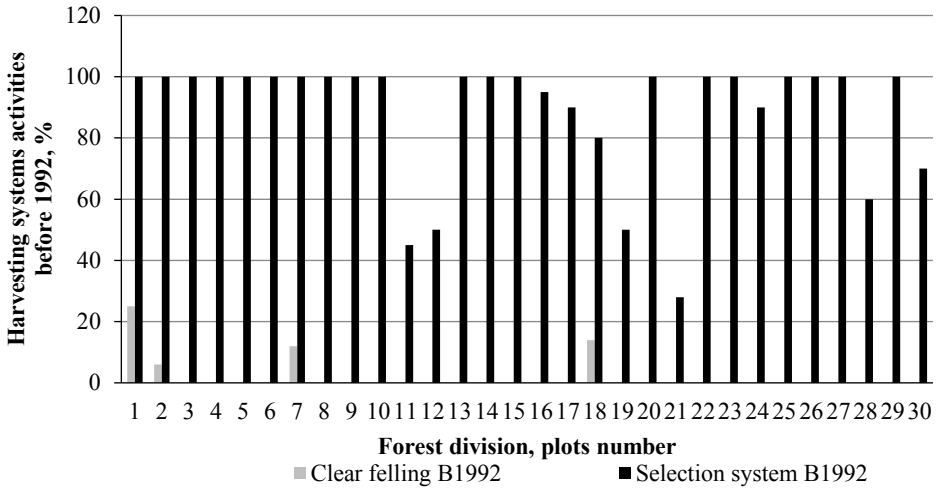


**Fig. 3. Silvicultural system (Harvesting system) – past.**

Note: X-axis – Forest division as plots (administrative zones for forest management), Y-axis – harvesting system share of activities, %.

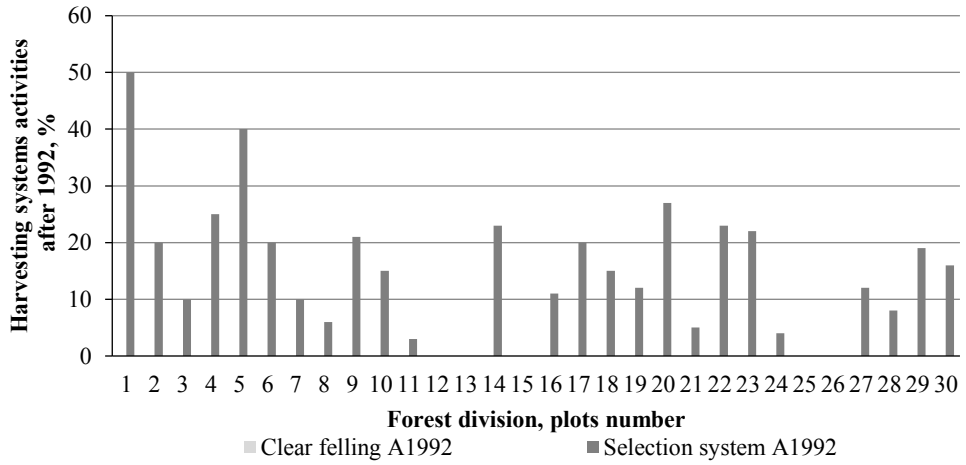


**Fig. 4. Silvicultural system (harvesting system) – present.**

**Silviculture or tending operations:** Silviculture or tending operation tends toward the improvement of the forest crop (Short and Radford 2008) by providing species selection and reducing the canopy, as well as the intensity of damages. The tending operation may be defined as 'any treatment or tending designed to enhance growth, quality, vigour, and composition of the stand after establishment or regeneration and prior to final harvest' (Helms 1998). According to the species composition, the operations were carried out in the forest area. Weeding is not com-

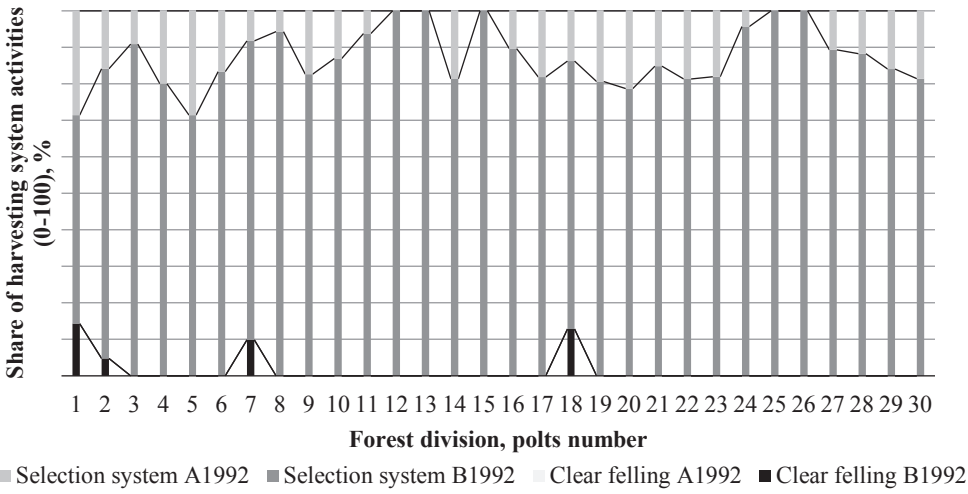


**Fig. 5. Combined representation of harvesting data in the research area.**
Note: X-axis shows forest division as research plots as administrative zones, Y-axis shows the share of harvesting activities in the region before and after green felling ban.

pulsory because weeds are very rare in the area and mostly highly nutritional and palatable plant species were found due to favourable growth condition. Cleanings was done just before the plantation or afforestation activities. Due to the low density and cover in the study area, thinning operation is very limited except for some special treatment. Pruning was also done during summer and before winter for fuel-wood collection and also for seed collection (Lughmani 1961, Shah 1967, Yusuf 1955).

Combine representation of tending operation before 1992, whereas the activities after green felling ban were discounted in the research area. Weeding (WD) activities were about 21.1 % on average, cleaning (C) activities are higher in number but they are not clearly categorized by the department (88.6 % average), thinning (T) and improvement felling (IF) were found 16.1 % and 1.43 % average, respectively shown in Fig. 6.

## Conclusions

The discussion for conclusion is based on the available literature and past history of silvicultural operation in the mountainous region. Mountain forests show many problems worldwide (Borůvka et al. 2005). Due to the high recreational (tourism), conservation (wildlife), commercial (timber, medicinal plants and livestock), protection (watershed) and historical/geological (Himalayas) values of the Himalayan moist temperate forests, sustainable management of the forest must be focused for the future development of the area, as well as of the rest of the country (Champion et al. 1965a). For the sustainable development of these mountainous forests, developmental indicators must be defined before aim towards strategic and operational activities (Golusin and Ivanović 2009). The socio-economic condition and livelihood of communities living in or adjacent to these forests are completely dependent

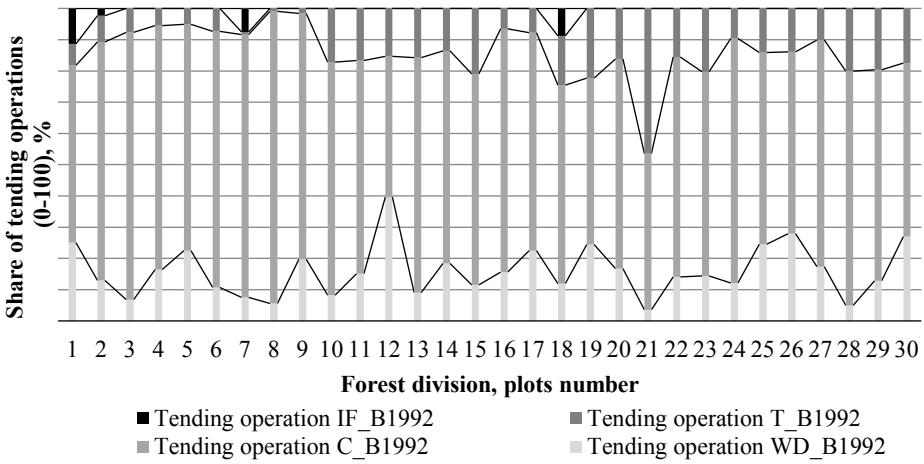


**Fig. 6. Tending operations or silviculture practices in the research area.**

on these forests (De Sousa et al. 2015). These forests have high potential as a watershed for the water reservoirs (Tarbela and Mangla) and also a source of fresh water to all reservoirs of Pakistan. Study areas are highly productive for the fodder collection, livestock grazing and high value of medicinal plants, which are affected by the lack of research (Abbasi et al. 2012). Present and past harvesting system and management systems in the area are only focused on trees (main crop), very little importance was given to the understorey vegetation or undergrowth.

**Impacts of harvesting or silvicultural systems:** Organizationally, as well as technically, timber harvesting or silvicultural systems are complex systems due to the advancement in the technology (Shegelman et al. 2015). These systems exposed the area for many environmental, biological and social factors, research study related to the impact of harvesting system on the undergrowth, site index and site quality, growth of the regeneration, composition, yield production, tree growth, diversity, and economic consideration must be taken into account for the sustainable management of the area (Chaudhary et al. 2016). These areas are very sensitive to erosion, to reduce the rate of erosion or its control, vegetation cover plays a vital role for the protection and conservation of these watersheds (Bataineh et al. 2013).

**Impact of silviculture/tending operations:** Tending operations also plays an important role in the growth and establishment of forest stands (Novák et al. 2015, Short and Radford 2008). Impacts of these operations affect the growth of the main crop, regeneration establishment, growth, space to the undergrowth, biomass production, and soil potential for the growth and also for supply fuel-wood. Tending operations will also help the livelihood and socio-economic conditions of the local communities. Studies aimed in the future will also provide a good understanding of the management of these forests, to reduce the high flood risk, land destabilization, sustainable eco-tourism, and ecological diversity. The integrated management plan for the optimum production and

contribution to climate change, mitigation/ adaptation, and carbon sequestration is also required for future management and development of forest resources (Kumar et al. 2016).

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