FOREST INVENTORY OF DISTRICT ASTORE, GILGIT-BALTISTAN

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ABSTRACT

A forest inventory was carried out in Astore District in 2016 to find out the total growing stock in the forest. A total of 98 sample plots were laid out randomly in different forest strata for data collection. It was found that Kail is the dominant species followed by fir and spruce. Juniper and Chilghoza pine are also present in very small proportion. Birch is the only broad-leaved species recorded during the inventory. Stand structure is almost young as most of the trees fall in immature (38%) and sub-mature (44%) development stages. On the other hand, 14% of the trees are mature and 3.64% are over-mature which together constitute 18%. The current total growing stock in the forest of Astore District is estimated at 7,165,012 m^3 with an average of 327.60±31.81 m^3/ha. The total timber in the forests of District Astore is estimated at 6,010,475 m^3 with average of 274.81 m^3/ha. Similarly the total small wood/fuelwood is estimated at 1,154,537 m^3. The future growing stock for 2026 is estimated at 8,368,376 m^3 with average of 382.62m^3/ha. This is equal to annual increment of 5.50 m^3/ha. The study noted lack of regeneration in most of the forest areas due to open grazing.

INTRODUCTION

Forest inventory is the procedure for obtaining information on the quantity and quality of the forest resource and the main characteristics of the forest area. Forest inventory is the pre-requisite for sound forest planning. It basically is aimed at estimating, growing stock, timber, small wood and annual increment in the forest (Husch *et al*., 1982). Forest inventory is the core component of any forest working plan or management plan.

District Astore is part of Gilgit-Baltistan lying in Northern part of Pakistan between 34.8°-35.8° N latitude and 74.4°-75.2° E longitude. The area has altitudinal and topographical variation, lower valley parts are arid, dry and warm and upper parts of the valley are cold and moist. The valley extends over the major part of the Western Himalayas; it is ranging from sea level to 1200m (Noor and Khatoon, 2013). Astore is bounded to the west by Diamer District, to the north by Gilgit District, to the east by Skardu District and to the south by Khyber Pakhtunkhwa and Azad Kashmir. According to the 1998 census, the population of Astore District was 71,666. Total area of the district is 501,668 ha, out of which 21,871 ha (4.36%) are classified as forest (GB, Forest Department, 2016). Major forest tree species of Astore include *Pinus wallichiana* (Kail), *Abies pindrow* (Fir), *Picea smithiana* (Spruce), *Pinus gerardiana* (Chilghoza) and *Betula utilis* (Birch). Forest vegetation of Astore District have been studied by several authors (Akbar, 2013; Ahmed *et al*., 2006; Akbar *et al*., 2011). However, no proper inventory has been carried out in the forests of Astore District.

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REDD+ Project of Gilgit Baltistan attempted to prepare an Integrated Resource Management Plan for District Astore. The current forest inventory was carried out as a baseline study for this management plan with the objective to estimate total growing stock, timber and small wood in the forests and project these estimates for future 10 years.

MATERIAL AND METHODS

Partial enumeration on the basis of Stratified random sampling was carried out in the forest areas of District Astore. The forest area was stratified into different strata on the basis of canopy cover and species composition. There are two main strata of forests i.e. dense forests with canopy cover as more than 35% and sparse or open forest with canopy cover less than 35%. Dense forests were further classified as pure conifer and mixed forests. Pure conifer stands have predominantly coniferous species cover more than 80% of the total stand. Mixed forests were those where conifer and broad leaved species are growing together with none of them having more than 80% stock.

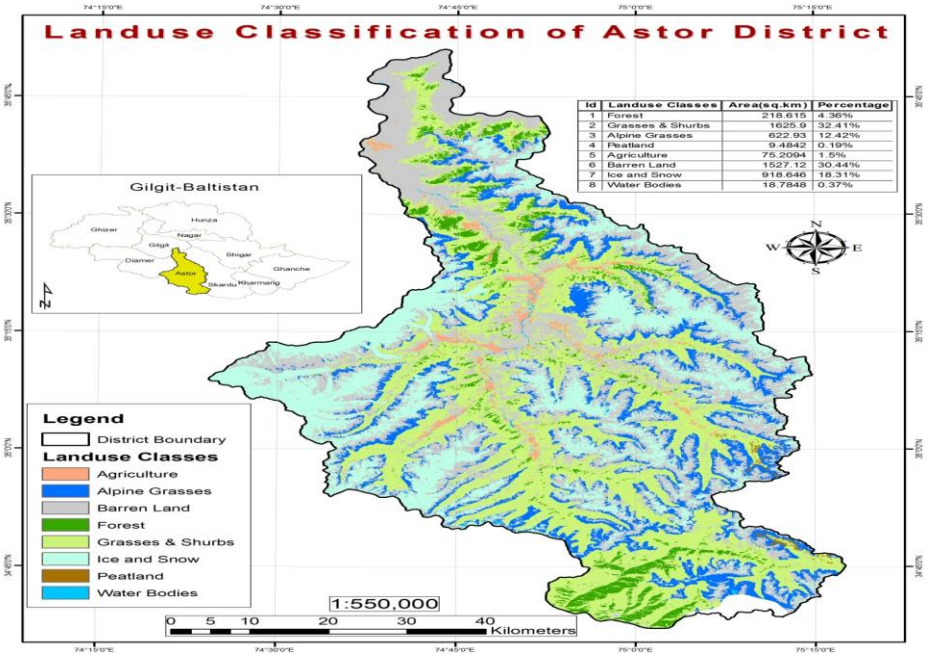

Fig. 1. Landuse Map of district Astore

Sample size for forest inventory was determined using the following formula:

$$N = \frac{(CV)^2 x t^2}{E^2}$$

Where

N = Number of required sample plots
CV = Coefficient of Variation
t = Student t-test value (1.96 at 95% Confidence Level)
E = Allowable Error

CV was determined on the basis of data collected through a pilot survey in the forest areas of different districts. As the average growing stock in the sampled area is 356.5 m3/ha and standard deviation is 204.58. Thus the CV was calculated as 57.38%. Putting these values into the above formula we get:

$$N = \frac{(57.38)^2 x 1.96^2}{12^2} = 87$$

Thus 87 plots were required but instead we took 98 plots in the field. As the inventory is not aimed at prescribing commercial yield from the forests, it is sufficient to conduct inventory with 12% sample error to get insight into the overall condition of the growing stock in the forest.

The sample plots were assigned to different strata randomly using GIS software for randomization. The coordinates of the centers of the sample plots were noted from the geo-referenced map. The coordinates were uploaded onto GPS and navigated in the field accordingly. The distribution of sample plots in the District is shown in the Figure 2.

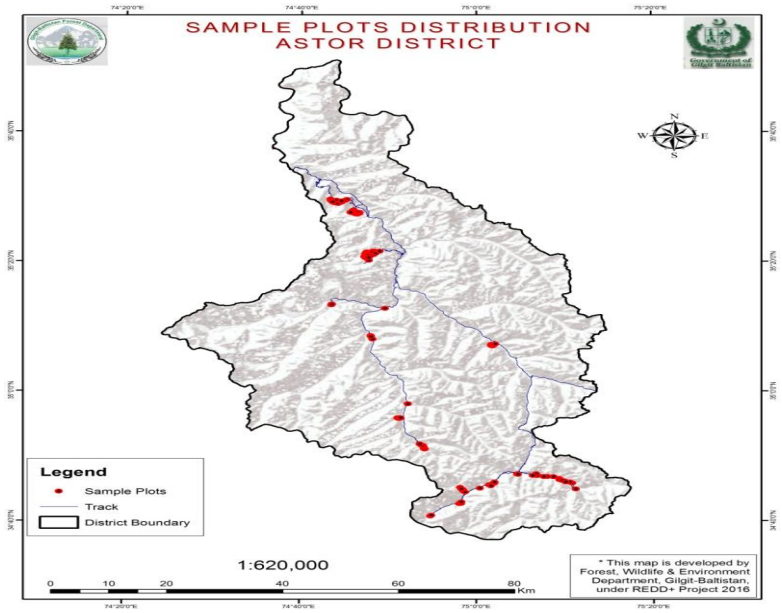

Fig. 2. Distribution of Sample Plots in Astore Forests

A team of 4-5 professional including three foresters, one GIS Specialist and a helper was constituted for conducting inventory in the field. They navigated to the sites of sample plots with the help of GPS and GT sheets. When reached to the actual sample site, a circular plot of 17.84 m (0.1 ha area) was laid out on the ground with Vertex Hypsometer. This device is very effective in laying out plots in hilly areas avoiding the incorporating of slope correction factors. In each sample plot, all trees with minimum 5 cm diameter at breast height (DBH) and 2m minimum height were measured for their DBH and height. DBH was measured at 1.37 m aboveground on uphill side with a diameter tape and tree height was measured with Vertex Hypsometer.

Data was fed into Excel sheets in proper format. Volume was calculated using the Local Volume Tables and Volume Equations prepared by Pakistan Forest Institute for Gilgit-Baltistan (Ali, 2015).

RESULTS AND DISCUSSION

Occurrence of tree species

The tree species sampled during inventory consisted of conifer and broadleaved species as given in Table. Kail is the dominant species (33.6%) followed by fir (33.3%) and spruce (13.2%). Juniper and Chilghoza pine are also present in the area but in very small proportion i.e. less than 1% (Table 1). Birch is the only broad-leaved species recorded during the inventory. Being multi-stem species birch has higher number of stems (19%) but low in terms of basal area and growing stock.

Table 1. Occurrence of Tree Species

Species	No of trees sampled	%age
Kail (*Pinus wallichiana*)	1064	33.6
Fir (*Abies pindrow*)	1055	33.3
Birch (*Betula utilis*)	603	19.0
Spruce (*Picea smithiana*)	417	13.2
Juniper (*Juniperous spp*.)	17	0.5
Chalghoza (*Pinus gerardiana*)	10	0.3
Total	3166	100

A view of Dense Coniferous Forest in Rama

A view of sparse Coniferous Forest in Rama

Growing Stock Composition

About 96% of the growing stock consists of Kail, fir and spruce. In terms of total volume Kail is the dominant species (54%) followed by Fir (28%) and Spruce (14%). Juniper and Chilghoza have meager growing stock. Birch is the only broad leaved species constituting 4% of the total growing stock sampled during the inventory as given in the Table 2.

Table 2. Growing Stock Composition

Species	Sample Plots Volume (m^3)	%age
Kail	1747	54.41
Fir	887	27.63
Spruce	450	14.02
Birch	123	3.83
Juniper	3	0.08
Chilghoza	1	0.03
Total	3211	100

Diameter Class Distribution

Diameter class distribution of the trees sampled during the inventory is shown in Figure 3. It is evident that all diameter classes are almost amply represented. However, more number of trees are present in diameter classes 21-

30 cm and 30-40 cm. The proportion of trees in the next higher classes is decreasing which shows a satisfactory trend. For regular and sustainable forest stands more number of trees should occur in the younger classes and less in the older classes which is somewhat exhibited in the study area. However, the number of trees in diameter classes 5-10 and 11-20 is relatively less which shows some gaps in the regeneration and younger classes.

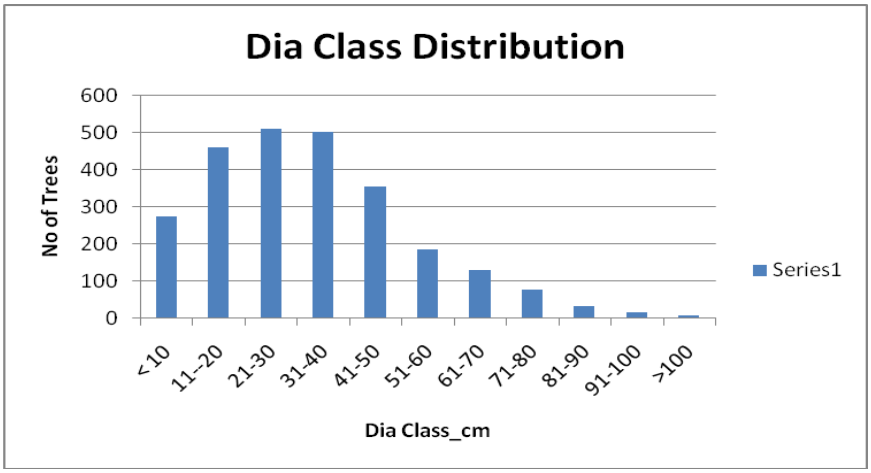

Fig. 3. Diameter class distribution of sample trees

Stand Structure

The results of the inventory show that all developmental stages are amply represented in the target area (Figure 4). Stand structure is almost young as most of the trees fall in immature (38%) and sub-mature (44%) development stages. On the other hand, 14% of the trees are mature and 3.64% are over-mature which together constitute 18%. Thus it is clear that almost one fifth of the total trees are ready to be harvested. Leaving these trees in the forests without harvesting may jeopardize the economic benefit which can be accrued from the harvesting of these mature trees. These older trees are also suppressing regeneration which is seriously lacking in most of the mature stands.

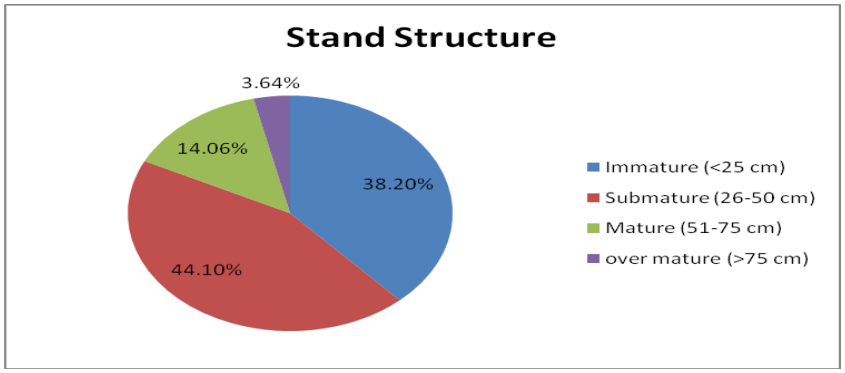

Fig. 4. Stand Structure

Present Growing Stock

The current total growing stock in the forest of Astore District is estimated as 7,165,012 m^3 (252,924,922 cft) with an average of 327.60±31.81 m^3/ha (95% CI). In dense pure coniferous forests the total growing stock is 852,350 m^3 with average of 334.78 m^3/ha. In sparse pure coniferous forests, the total growing stock is 2,698,667m^3 with average of 265.80 m^3/ha. The statistical analysis of the current growing stock is given in Table 4. This shows that the forests of Astore District are well stocked due to presence of mature trees in substantial proportion. In terms of growing stock, these forests are at par with commercial forests of Khyber Pakhtunkhwa. In the adjacent Kohistan District, the growing stock in well stocked forests has been estimated as 234 m^3/ha (Working Plan of Kohistan Forest Division, 2005). The detail of growing stock in the other strata is given in Table 3.

Timber and Small Wood

The total timber in the forests of District Astore is estimated at 6,010,475 m^3 with average of 274.81 m^3/ha. Similarly the total small wood/fuelwood is estimated at 1,154,537 m^3.

Table 3. Present Growing Stock

Strata	Area (ha)	Growing Stock (m^3/ha)	Total Growing Stock (m^3)	Timber (m^3/ha)	Total Timber (m^3)	Total Small Wood (m^3)
Dense Mix	2546	334.78	852,350	253.17	644570.8	207,779
Dense Pure Conifer	8349	411.95	3,439,371	339.93	2838076	601,295
Sparse Mix	823	212.18	174,624	189.41	155884.4	18,740
Sparse Pure Conifer	10153	265.8	2,698,667	233.62	2371944	326,723
Total	21871	327.6	7,165,012	274.81	6010475	1,154,537

Table 4. Statistics regarding current growing stock

Strata	N	Mean Growing Stock (m^3/ha)	Standard Deviation (m^3/ha)	Standard Error (m^3/ha)	t-value (95%)	Sampling Error (%)
Dense Mix	7	334.78	160	7.04	2.45	5.15
Dense Pure Conifer	54	411.95	227	12.13	1.96	5.77
Sparse Mix	9	212.18	80	1.09	2.31	1.18
Sparse Pure Conifer	17	265.8	102.6	11.55	2.12	9.21
Total	87	327.6		31.81	1.96	19.03

Future Growing Stock

Future growing stock was also projected for the area for the next 10 years using increment of the coniferous species for the past 10 years. The future growing stock for 2026 is estimated at 8,368,376 m^3 with average of 382.62m^3/ha (Table 5).Thus an increment of 1,203,364 m^3 is expected in the next 10 years. However, this does not include the increment of broad-leaved species for which increment calculation could not be made.

Table 5. Future Growing Stock

Strata	Area (ha)	Growing Stock (m^3/ha)	Growing Stock (m^3)
Dense Mix	2546	398.81	1015370
Dense Pure Conifer	8349	488.96	4082327
Sparse Mix	823	232.04	190968.9
Sparse Pure Conifer	10153	303.33	3079709
Total	21871	382.62	8,368,376

Annual Increment

Annual increment was determined for coniferous species based on the growth rate for past 10 years. It is projected that the forests of Astore District would put in about 1,293,364 m^3 in the next 10 year. This is equal to annual increment 5.50 m^3/ha. This estimate does not account for illegal cutting, fire or other natural or anthropogenic disturbances. For which allowance must be made while prescribing annual yield from the forest. The detail of increment for different strata is tabulated below (Table 6).

Table 6. Annual Increment

Strata	Area (ha)	Total Increment for 10 years (m^3)	Increment (m^3/ha/yr)
Dense Mix	2546	163,020	6.40
Dense Pure Conifer	8349	642,956	7.70
Sparse Mix	823	16,345	1.99
Sparse Pure Conifer	10153	381,042	3.75
Total	21871	1,203,364	5.50

CONCLUSIONS

The forests of Astore District are generally well-stocked and relatively well protected. Most of the forests consist of coniferous species. Few broad-leaved species are found such as birch at upper elevations. Stand structure is almost young as most of the trees fall in immature (38%) and sub-mature (44%) development stages. On the other hand, 14% of the trees are mature and 3.64% are over-mature which together constitute 18%.

The current total growing stock in the forest of Astore District is estimated at 7,165,012 m^3 (252,924,922 cft) with an average of 327.60±31.81 m^3/ha. The total timber in the forests of District Astore is estimated at 6,010,475 m^3 with average of 274.81 m^3/ha. Similarly the total small wood/fuelwood is estimated at 1,154,537 m^3. The future growing stock for 2026 is estimated at 8,368,376 m^3 with average of 382.62m^3/ha. This is equal to annual increment of 5.50 m^3/ha.

Regeneration is generally deficient due to open grazing of livestock and closeness of canopy in the dense forest. Due to excessive grazing pressure, the forest floor is naked with very little grass cover. Open grazing and Fuelwood collection are the major threats to the forest. It was observed in Gudai that profuse regeneration of Fir is coming out due to ban on grazing imposed by the forest owner. This clearly indicates that the forests can be regenerated and restored through social fencing. Local people are generally friendly towards forests and are aware of the importance of the forests for tourism and local economy. It is, therefore, recommended to prepare and implement an integrated resources management plan with active involvement of the local communities.

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