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Structure and Regeneration Patterns of *Pinus gerardiana* (Wall. ex Lamb) Forest Zhob District, Balochistan, Pakistan

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Key words: Basal area and density, Floristic composition, Class frequency distribution, Physical condition, Sex distribution and Soil analysis.

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Abstract

The aim of this study was to examine the Structure and Regeneration Patterns of *Pinus gerardiana* (Wall. ex Lamb) Forest Zhob District, Balochistan. The study was conducted during July and August 2018 in Zhob District, Balochistan. Different parameters included, basal area m^2 ha^{-1}, density ha^{-1}, physical condition, floristic composition, physio-chemical of soil and sex distribution, were determined through standard techniques. Results indicated that's in field area herbs, shrubs and although grasses were found 50%, 37% and 13%). The average density was 321 ha^{-1} with a range from 15 to 717 of trees ha^{-1} and with an average 378 basal area m^2ha^{-1}. Basal area and trees density of Chilghoza were significantly correlated (r= 0.37) at 0.001 significant level. A complete seedling density **(**<6 cm) was found from 113 to 947 ha^{-1} with an average (448) ind/ha, varied considerably. Population of sex ratio displayed 44 % bisexual with a prevalence of denomination, followed by male 36% while female was 20%. Soil characteristics indicated that the soil was free from salinity, basic in reaction and calcareous in nature.

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Introduction

Pinus gerardiana Wall. Ex Lamb universally called Chilgoza Pine. It thinly distributes in India, some areas of Afghanistan (Champion *et al.,* 1965) and also from some isolated dry regions of Pakistan which include Suleiman mountain range and Kashmir. This species is found in the Suleiman mountain range of Pakistan, with an altitude that ranges from 2700 to 3400 m above the sea level (Rafi, 1965). Plants of the study area are very heterogeneous and have a rich endemic flora. In Pakistan, forest cover has been declining very rapidly. Most of the remaining forests of the country are confined to north and north–western parts of the country (Sarangzai, 2010). The current rate of deforestation and loss of fertile topsoil results in enormous environmental degradation (Ahmed *et al.,* 1991). Most of its biodiversity is being now threatened, endangered and some are also locally extinct. This is due to habitat destruction and over exploitation of the forest products (Ahmed *et al.,* 2006). There are not any comprehensive quantifiable studies carried out to delineate population forms different forests trees in Pakistan. Investigation studies relating to its usual regeneration of the species in its natural habitat.

The number of forests reduced due to its natural poor regeneration and pre dominance of over mature trees (Sharma *et al.,* 2010). The natural regeneration and development of the forest is badly affected by the living factors, which may result in reduced resources and conforming change in the physio-chemical properties of forest soil.

The Phytosociological structure presented by Ahmed, (1988) in Quetta of tree planted species, whereas, in Rod-Mullazai, Balochistan (Ahmed *et al.,* 1990) the population of *J. excelsa* and their structure and dynamics was reported. *Pinus gerardian*a and Juniper tract reported by Ahmed *et al.,* (1991) of district Ziarat. The regeneration potential and population dynamics of Juniper forests were carried out by Sarangzai, (2000) in north eastern part of Balochistan. Investigated by Ahmed *et al.,* (2006) the structure and Phytosociological of various climatic regions of different forests of Himalayan. Near the border of Pakistan some of pine forest in Afghanistan their phytosociology and dynamics, were described by Wahab *et al.,* (2008), whereas, the same kind of work Ahmed *et al.,* (2009), was conducted in *Olea feruginea, Pinus roxberghiian* forests respectively. The regeneration and vegetation composition process at higher altitudes of *P.gerardiana* are highly affected by the anthropogenic disturbances during the last 100 years (Ahmed *et al.,* 1991). Though, the species is nearly abolished at lower altitudes.

The species may be extinctic from the whole region, because of the current anthropogenic disturbances. The presence strong anthropogenic influences in the area needs for an immediate conservation action plan, in order to ensure the sustainable utilization and management of these forests. Therefore, the current research is extending its significance to evaluate the structural distribution together the status of *P. gerardiana* regeneration in the highlands of District Zhob, Balochistan.

Materials and methods

Study area

The northeastern region in Sheen Gher valleys of District Zhob, Balochistan, was selected for study. The elevation of entire sampling area ranges from 1937m to 2816m and is between latitudes 31°30´N to 31°40´N and longitude 69°36´E to 69°44´E, geographically. Irregular, rugged and steep ridges are elements of compositions found in the field area.

In the investigated zone the highest peak is Zarona (2816m). The research zone as dry temperate conifer forest described by Rafi (1965) and Champion, Seth and Khattak (1965). The latest data of meteorological of these mountains is not available, nonetheless these mountains obtain precipitation more than at the elevations of lower area. The range which is approximately 45 km away from the meteorological station at Zhob city, has precipitation average of annual 267 mm. Monsoon rainfall occurs in month of July & August whereas, Winter rain falls in the month of February & March.

Fig. 1(A). Satellite Map of Sheen Gher, (the main study area) located in Zhob district of province Balochistan, Pakistan.

The monthly average temperature varies from 12.6°C (January) to 37.5°C (July). Generally, that in the month of December toward February Snow falls occurs on the mountains approximately 2 m. Triassic to Jurassic ages of Limestone and shale are included by geological substrate (Rafi, 1965).

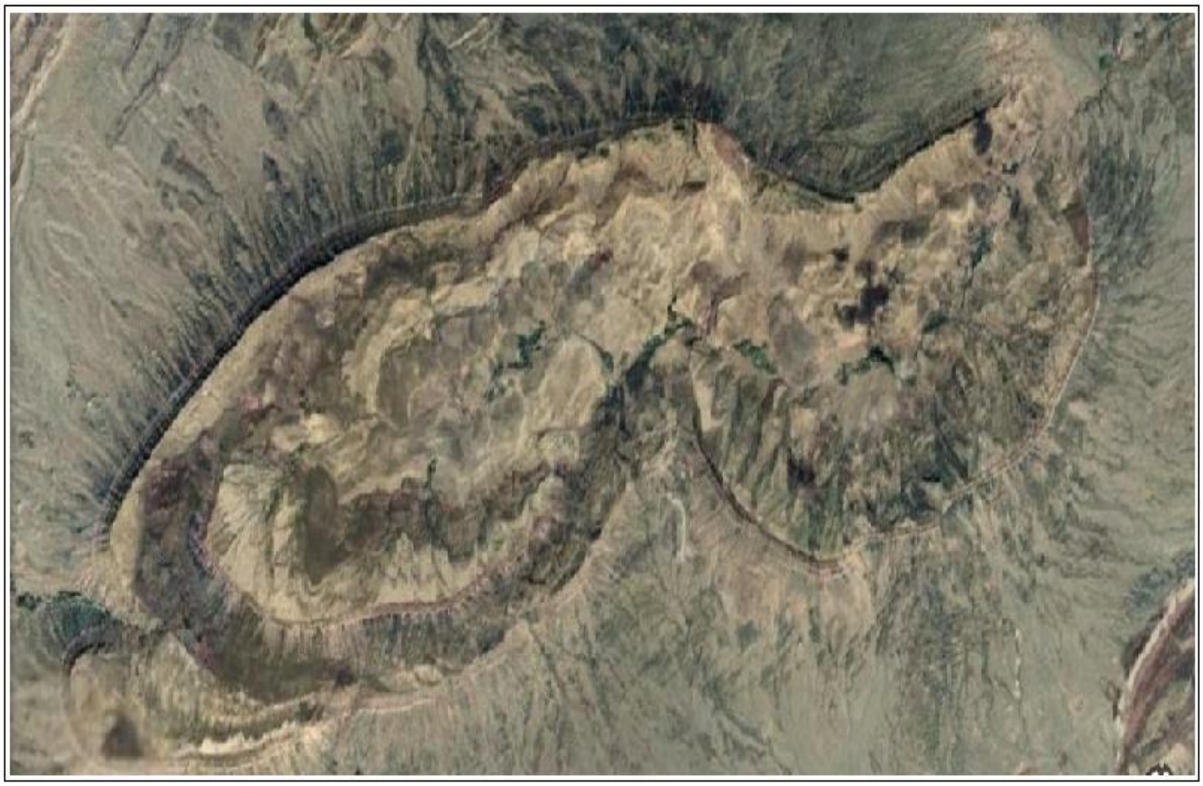

Fig. 1(B). Site locations of the study area.

Field sampling and data collection

Field sampling and data collection was carried out during 2018 and 2019. By the method of (Cottom and Curtis, 1956) Point Centered Quarter (P.C.Q) was used for sampling the tree species (>6cm DBH). On every stand at 30-meter intervals, 10 points were taken over 3/ha in random way of a stratified along (Ogden and Powell, 1979). Importance value of different aspects like elevation, density and basal area of all tree species were reported and will be determined according to Muller-Dombois and Ellembery, (1974). Seedlings (< 6cm DBH) thickness of Chilghoza pine and comparative occurrences of related shrubs and herbs were obtained by using the circular 2.5 m radius quadrat method of Raunkier, (1961) at each Point Centred Quarter (P.C.Q) method. Thick and least troubled stands only was chosen as a sample. Dead pine trees and logged remnants in every stand were also recorded. GPS was used to determine the position of stands, aspect & elevation whereas, slope meter was used to determine the slope degree. *P. gerardiana* frequency distribution of diameter size class (DBH) was obtained as follows: initially into six classes the Chilghoza of seedlings were distributed, including the zero class in seedlings from 0.5-1 cm diameter, classes 2-6 had 1 cm intervals. Individuals with the diameter of individuals greater than 6cm, were considered as trees. Generally, the interval of size class tree size structure was set up 10 cm. A soil sample (0-25) was taken from various sites of each stand and composite sample mixture was obtained, gravel was separated after drying by air and passing through a sieve 2 mm. The soil part was chosen for the chemical and physical analysis that was finer than two mm. Bouyocous hydrometer method (1951) was used to determined soil texture. The capacity of soil for water holding using by Hussain, 1989. The soil pH was observed by following soil saturated paste Jackson, (1962). For the determination of conductivity of electrical by the help of electrical conductivity meter by soil saturation paste. The matter of organic was determined by the method of Ignition. Soil with 5 grams in crucible were taken and for 254 hours at 500C placed in muffle Furness. $CaCO_3$ was used to determine by the method of Rapid titration of Kumar, (2006).

Results and discussion

In field study, main things that were recorded were the basal area m²/ha, density/ha, regeneration, sex ratio and physical condition. Mean relative frequency used as a base for listing and classifying the ground vegetation. The ecological characteristics of a single stand like main locations, latitude. Longitude, slope, elevations and aspect are given in the (Table 1) of the study area.

Table 1. *Ecological Characteristics of Stands and Sampling Sites (Sheen Gher).*

Stand #	Site Name	Site Code	Latitude (N)	Longitude (E)	Elevation (meters)	Aspect	Slope (m)
1	Zahir Pangi 1	SZP	$31^0.30´$	$69^0.36´$	1937	S	30
2	Zahir Pangi 2	SZP	$31^0.30´$	$69^0.36´$	1937	S	30
3	Khorjan Payal 1	SKP	$31^0.35´$	$69^0.44´$	2618	SW	36
4	Khorjan Payal 2	SKP	$31^0.35´$	$69^0.44´$	2618	SW	36
5	Sarghondi	SSG	$31^0.35´$	$69^0.43´$	2623	E	36
6	Sarghozi Nari 1	SSN	$31^0.35´$	$69^0.44´$	2639	ES	36
7	Sarghozi Nari 2	SSN	$31^0.35´$	$69^0.44´$	2639	ES	36
8	Lolai Area	SGL	$31^0.34´$	$69^0.44´$	2604	NW	35
9	Branga Area	SGB	$31^0.35´$	$69^0.43´$	2414	N	33
10	Shana Payala	SSP	$31^0.34´$	$69^0.43´$	2490	E	33
11	Gadki Area	SGG	$31^0.35´$	$69^0.44´$	2563	E	34
12	Shoro Koshti	SSK	$31^0.35´$	$69^0.44´$	2634	NE	35

13	Pati Wabti	SPW	31^0.35´	69^0.44´	2625	NE	35
14	Daberi Area1	SGD	31^0.35´	69^0.44´	2631	NW	35
15	Daberi Area 2	SGD	31^0.35´	69^0.44´	2631	NW	35
16	Loinashpa	SLS	31^0.35´	69^0.44´	2562	N	34
17	Zarjangal 1	SZJ	31^0.36´	69^0.43´	2567	NE	34
18	Zarjangal 2	SZJ	31^0.36´	69^0.43´	2567	NE	34
19	Marmanda Ghar	SMG	31^0.36´	69^0.43´	2755	N	37
20	Zarona Area 1	SGZ	31^0.36´	69^0.43´	2816	W	37
21	Zarona Area 2	SGZ	31^0.36´	69^0.43´	2816	W	39
22	Palan Khan 1	SPK	31^0.36´	69^0.43´	2612	NW	35
23	Palan Khan 2	SPK	31^0.36´	69^0.43´	2612	NW	35
24	Sur Kumar 1	SSK	31^0.36´	69^0.43´	2627	N	35
25	Sur Kumar 2	SSK	31^0.36´	69^0.43´	2627	NE	35
26	Sur Kumar 3	SSK	31^0.36´	69^0.43´	2627	NE	35
27	Kasa Ghar 1	SKG	31^0.36´	69^0.43´	2618	S	35
28	Kasa Ghar 2	SKG	31^0.36´	69^0.43´	2618	SW	35
29	Marmandi	SMM	31^0.36´	69^0.43´	2612	SW	35
30	Koti Area	SGK	31^0.36´	69^0.43´	2755	E	37

Ground Vegetation

The ground flora (including Chilghoza seedlings) was assessed by the circular plot sampling. Around 30 species included herbs, shrubs and grasses were reported in the area. A total of 20 families out of them 4 monocot (4 spp) and 16 dicots (26 spp), were reported. In each of the family the number of species varied from 1 to 4. On the basis of average family member density and frequency values percentage out of 20 families such as Lamiaceae (4 spp), Poaceae (4 spp) were establish the largest part plentiful families followed by Lilaceae (2 spp), Rosaceae (2 spp), Malvaceae (2 spp), Fabaceae (2 spp) as the second noted families while the remaining as third ruling (single species with each) families were found of the research area (Fig 3). Generally, indicate relative frequency values of vegetation that was reported, herbs were (50%), (37%) shrubs although grasses (13%) were marked in the field area of all stands (Fig. 2).

Table 2. Summary of the floristic list of Circular Plot Quadrates in 30 stands in Pinus forest of Zhob, Balochistan. Note: P.O.O =Point of occurrence in which species occurs; F=frequency; F_r = Mean relative frequency and Ranking represents the dominated species in the field area/study.

S. No	*Plant Name*	*Family*	*Local Name*	*P.O.O.*	*F*	*Fr*	*Ranking*
1	*Arisaema flavum* (Forssk.) Sc hot	Araceae	Zarotai	300	3010	14.02	1st
2	*Asparagus capitatus* Baker.	Lilaceae	Harsukh	45	450	2.09	
3	*Astragalus coccineus* Brandegee-scarlet milkvetch	Fabaceae	Kundalai	12	120	0.5	
4	*Aster altaicus* Wild.	Asteraceae	Spanguli	27	270	1.25	
5	*Asparagus persicus* Baker	Violaceae	Faribagh	19	190	0.88	
6	*Berberis calliobotrys* Aitch.ex Kaehne.	Berberidaceae	Korha,Zaraig	64	640	2.98	
7	*Capparis spinosa* Linn.	Capparaceae	Khawarg	14	140	0.65	
8	*Chenopodium album* Linn.	Chenopodiaceae	Torsag	22	220	1.02	
9	*Cotoneaster nummularia* Fisch. & Mey	Rosaceae	Sharu	296	2960	13.79	2nd
10	*Cymbopogon iwaranousa* Schiilt.	Poaceae	Grass	87	870	4.05	

11	*Cynoglossum glochidiatum* Wall.ex Benth.	Boraginaceae	Grass	45	450	2.09	
12	*Daphne mucronate* Royle.	Thymelaeaceae	Walaghuni	73	730	3.40	
13	*Dianthus crinitus* Smith.	Caryophyllaceae	Surzana	31	310	1.44	
14	*Eremurus aucheriana* Bornm.	Malvaceae	Shezi or Shezgi	102	1020	4.75	
15	*Ephedra intermedia* Stapf.	Ephedraceae	Ghat Oman	195	1950	9.08	
16	*Lonicera quinquelocularis* Hardw.	Caprifoliacee	Sparea	11	110	0.51	
17	*Malva neglecta* Walls.	Malvaceae	Tekai	45	450	2.09	
18	*Marrubium vulgare* Linn.	Lamiaceae	Shinshobai	5	50	0.23	
19	*Mellica persica* Kunth.	Poaceae	Lewanai booti	210	2100	9.78	3rd
20	*Nepeta juncea* Benth.	Lamiaceae	Sungarai	21	210	0.97	
21	*Peganum harmala* Linn.	Zygophyllaceae	Spanda	36	360	1.67	
22	*Phlomis spectabilis* Falc.ex Benth.	Lamiaceae	Kundulay	24	240	1.11	
23	*Pteropyrum olivieri* Jaub.et Spach.	Polygonaceae	Gharwanga	17	170	0.7	
24	*Rosa lacerans* Boiss & Bushe	Rosaceae	Soori	4	40	0.18	
25	*Sacchrum griffithii* Munro ex Aitch.	Poaceae	Sarghasi	21	210	0.97	
26	*Sophora mollis* (Royle) Baker	Fabaceae	Ghuzara	165	1650	7.68	
27	*Stipa pennata* Linn.	Poaceae	Washti	41	410	1.91	
28	*Tulipa Polychrome* L.	Liliaceae	Khatol	15	150	0.69	
29	*Thymus linearis* Benth.	Lamiaceae	Moverii	191	1910	8.90	
30	*Vitex negundo* L.	Verbinaceae	Marmandai	3	30	0.13	

Density and basal area

Both *Pinus gerardiana* trees (>6 cm dbh) and seedlings (<6 cm dbh), basal area m^2ha^{-1}, density ha^{-1} values largely differed from place to place, throughout the sites as provided in table 3.

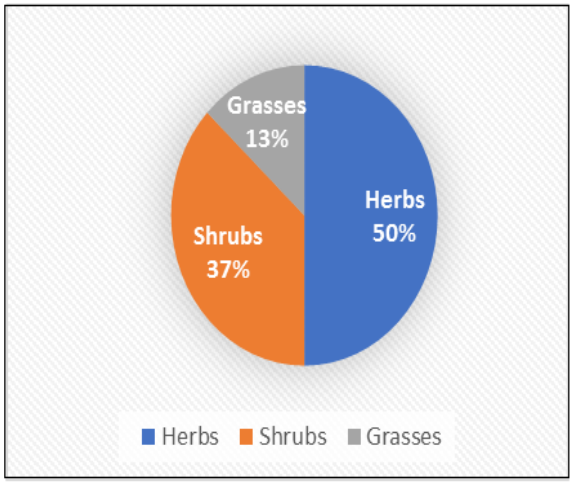

Fig. 2. Overall mean percentage values of associated in the study area.

In the site of Lolai (stand 8) has showed highest density 717 ind./ha at elevation 2604m from north west facing slopes whereas on an elevation 2623 m the site of Sarghondi (stand 5) facing east slopes display lowest stand density 15 stems/ha. However, stands at Pati Wabti (stand13) as well indicates a larger density of 658 ind./ha. Generally average density of Chilghoza plants was (321/ha) in Table 3. *Pinus gerardiana* trees' basal area was in addition approvingly up-and down mutually inside and between the sites, with a mean 378 m^2/ha and varied from 20 to 981 m^2/ha. Density of *P. gerardiana* mean of (226 trees ha^{-1}) with a range from (24 to 930 stems ha^{-1}) recorded by Ahmed *et al.,* (1990a). The overall average basal area of current Chilghoza strip was elevated (378 m^2 ha^{-1}) than the forest of *P. gerardiana* 25.5 m^2/ha and strip of Juniper 41 m^2/ha (Table 3). Chilghoza density and basal area were significantly correlated ($r= 0.37$; $P< 0.001$). Out of 30 stands in 26 stands the seedlings of Chilghoza were found. A complete seedling density ranged mainly from 113 to 947 stems/ha, on an average; 448 ind./ha (Table 3).

The site of Kasa Gher (stand 28) showed highest stand density of seedlings with low basal area 83 m^2/ha while the lowest stand density 113 ind./ha with higher basal area 947m^2 ha^{-1} were recorded from Kasa Gher (stand 28). Significant correlations were established between seedling densities and both tree density and basal area ($r= 0.24$; $p< 0.001$; $r = 0.25$;

p< 0.001) respectively. The comparison of these close at hand forests, the density of *P. gerardiana* varied 15 – 658 trees /ha, with a mean of 321 trees ha-¹. (Shaheen *et al.,* 2011), explained that due to increase the population of human and livestock interference resulted decrease the forest vegetation which was recorded in Bagh District, Kashmir. Sarangzai *et al.,* (2010), reported that the factors like diseases, insects etc that assume the health and productivity were comparatively less than of Juniper forests in Ziarat District of Balochistan province, Pakistan. To explain this difference an earlier time estimate was based upon the complete Chilghoza strip, our mean 321 /ha refers to 30 random Chilghoza stands, not from selective stands in the areas.

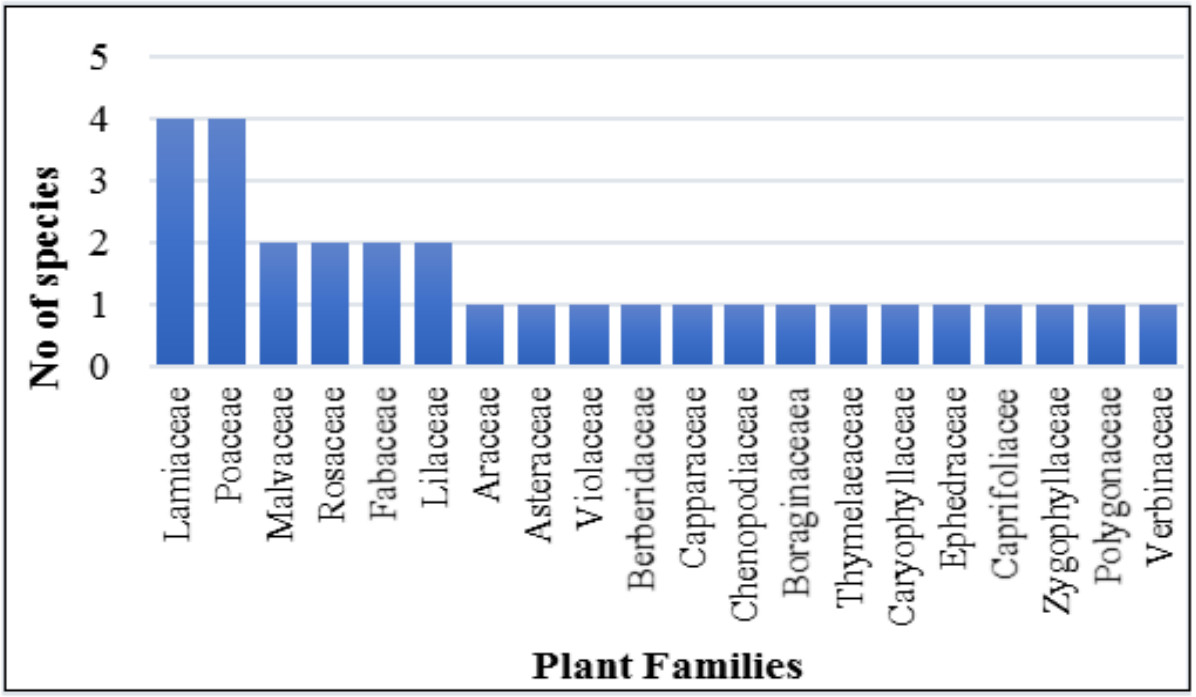

Fig. 3. No of plant species of reported families' flora in the study area.

The area of study mainly connected to anthropogenic disturbance and ancient agent and near to physiographic extent. Such factors of the structure of tree indicates clearly a deficient recruitment Knight, (1975). Wahab *et al.,* (2008) and Khan *et al.,* (2008) reported an alike kind of examination. In the put-on research paper, the basal area and density was originated highly unevenness on both the distance from the ground and diverse outlook capacity be correct to individual instability and climate change. Muhammad *et al.,* 2017 stated that Chilghoza forests and it redevelop are incapable because due to high value of anthropogenic is now in the condition of critical state, in the province of Balochistan. Distribution of complete size class frequency of *Pinus gerardiana* indicating enhanced opportunity of recruitment with the trees (> 6 cm dbh) and frequent down in insignificant range class of their component progressively greater than before in the larger extent classes. Correspondingly seedlings showed very nearly an uneven division pattern. Stands with an outsized density showed an exceedingly partial mass frequency scattering with the means in the minimum (20-60 cm dbh) per class. Certain stands provided additional than a single mode. Short down stands of density had butter up structure, frequently with different modes. Moderate density stands unexceptionally created intermediate class size frequency distribution. Size class structure of last class showed higher in dbh but other display a balanced size class structure in the combine data (Fig. 4). About 60% of the plants were found in small size classes (class1-7). A gap was recorded in all the stands structure of size class, (in some of the classes the

individuals are missing). In the ground, however, a huge figure of young trees and seedlings of assorted classes size recorded that recommended that regeneration in the area is relatively better, in spite of sky-scarping the difficulty for extensive grazing, partially cutting of timber for fuel and assortment of Chilghoza nuts. In the face of the turbulence into the field, the structure for size class in the current stands of Chilghoza is regular and a satisfactory quantity of individuals of the size of small classes are found.

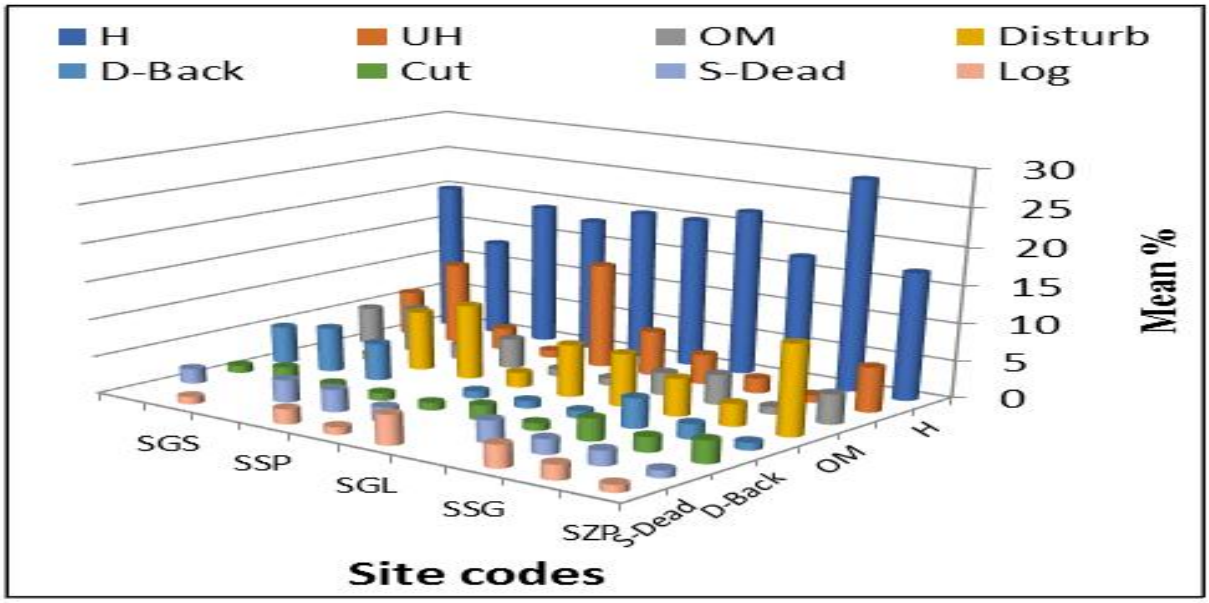

Fig. 6A. S=Sheen gher; SZP=Zahir Psngai; SKP=Khorjan Payal; SSG=Sarghondi; SSN= Sarghozi Nari; SGL=Lolai; SGB=Branga; SSP=Shana Payala; SGG=Gadki; SSK=Shoro Koshti; Spw=Pati Wabti; SGD= Daberi.

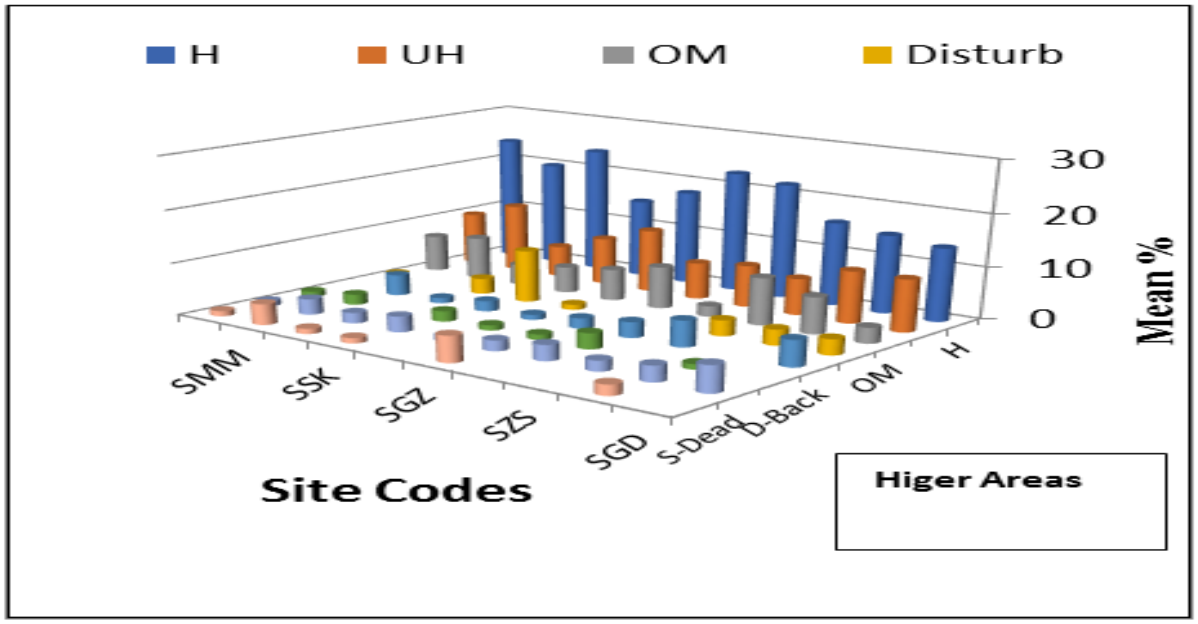

Fig. 6B. S= Sheen Gher; SLS=Loinashpa; SZJ=Zarjangal; SMG= Marmanda Ghar; SGZ=Zarona; SPK= Palan Khan; SSK= Sur Kumar; SKG= Kasa Ghar; SMM= Marmandi; SGK=Koti.

It indicates satisfactory digit of recruitments. Blend records demonstrate a structure of balanced size class. Ahmed *et al.,* (1989a) reported the Chilghoza seedlings and Juniper in their early stages need shade for the development therefore, it is likely low vegetation cover, distance between Chilghoza trees, exposed soil surface with grazing more than enough and climate variability are the major agents involve

for the absence of usual regeneration that in the zone of research. But, in some stands of entirely logged or eroded sites no seedlings were recorded, which shows that well soil conditions or shade (or both) are needed in the stages of early development. For other population also these conditions have additionally been reported (Ahmed, 1984; Norton, 1983; Veblen and Stewart, 1982).

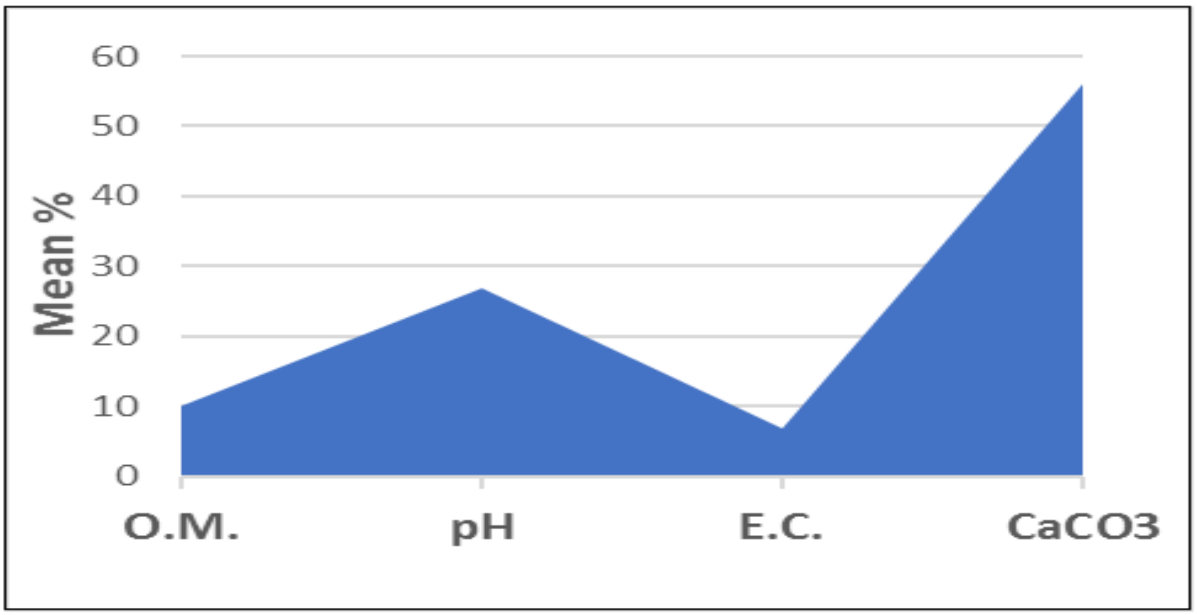

Fig. 7. Mean percentage of 30 stands, all soil chemical characteristics of study area. O.M =Organic matter; pH. = Hydrogen concentration; E.C =Electrical conductivity; $CaCO_3$= Calcium carbonate.

Sex distribution

The relative abundance of bisexual, male and female of Chilghoza diverse largely from place to place. Bisexual has larger density but male plants predominated in a number of stands while female plants were abundant in others. Female plants were rarely occurring, establish about 20% of the overall samples. Basically, the recorded ratio of sex showed prevalence bisexual with a denomination 44 % of the population. Stand density of male was noted 36% in the current study (Fig. 5). Such condition recorded by Ahmed *et al.,* (1990b) in strip of Juniper.

Physical condition

A physical condition of Chilghoza plants were noted that most of plants were alive (82%) while (5%) of the trees were standing dead and (3%) of the stumps were recently logged. Generally healthy (45%) trees were in the best condition with their branches bearing living leaves while hollow and twisted stems of over mature Chilghoza trees with the population found by (11%), the unhealthy Chilghoza (17%) and (3%) of the stumps were cut respectively. (Ahmed *et al.*, 1990b) reported healthy plants densities, disturbed Juniper and over mature individuals on the Juniper strip from (Chautair to Kuch). However, both lower and higher elevation area showed similarity in physical condition but in lower altitude area exhibits more cut and disturb trees as compared to higher altitude area (Fig. 6).

Soil analysis

Great unevenness was seen of the soil in the area of study, both among stands and sites. The soil sampling analyzed sandy-loam as the chief soil in nature, which was the basic ingredient. Sand, silt and clay were in a fraction of Sand fraction 66%, 12% and 6%, respectively (Fig. 8). Hussain and Rizvi, (1974) was supported the conclusion of these findings.

The capacity of water holding was16% that showed medium of low that may be due to low contents of organic matter and coarse textured nature. The soils were well drained that is indicated by analyses.

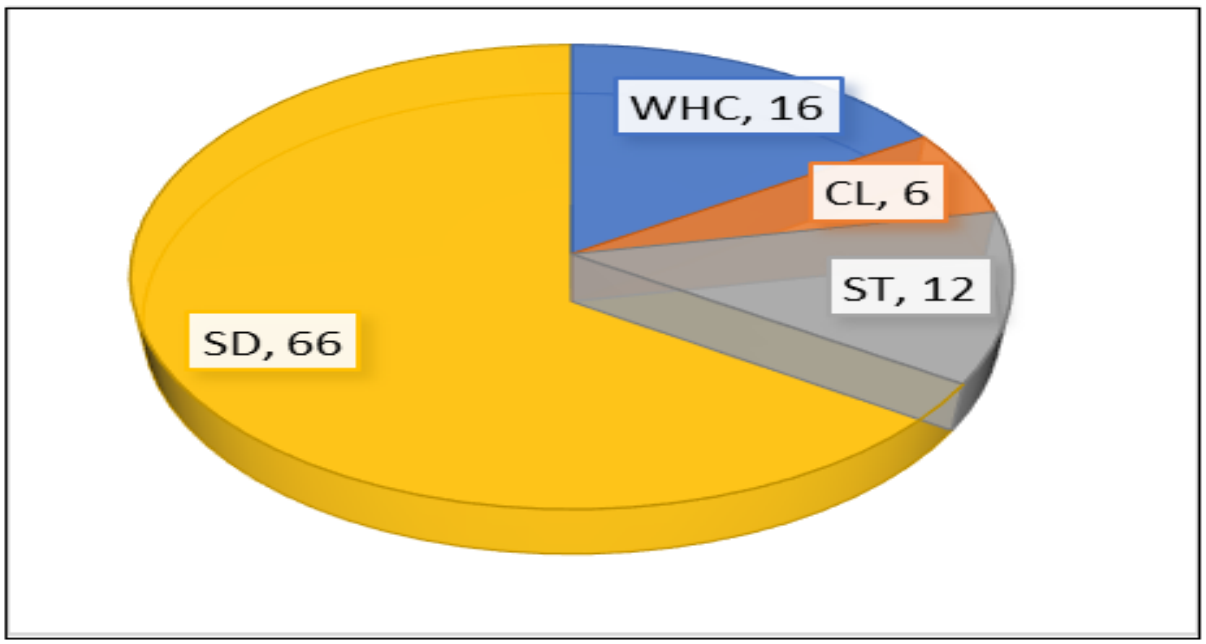

Fig. 8. Overall percentage values (mean of 30 stands) of soil physical characteristics in the study area. ST= Silt; CL = Clay; SD = Sand; WHC = Water Holding Capacity**.**

The soils of the Hazar Gangi National Park near Quetta were also reported similar to this by (Qadir and Ahmed 1989) and Majeed, (1985). Scarcity of organic matter was noted, in a single it was recorded between; 1.44 % to 3.94 %. Nearly in the area of study no salinity was found. Conductivity of electrical and PH values were ranging from 0.39% to 3.13% ds/cm and 7.3% to 8.55% respectively. Complete samples of soil were naturally in abundance. Moderately contents of lime were recorded ranging between; 15 % to 25% in the all stands (Fig. 7). In the current study, samples of soil appear moderate to low calcareous in nature. (Shafeq, 1987), reported the survey of soil in the strip of Juniper. A strong correlation has been recorded only among soil texture values; Sand ($r= 0.053$; $p>0.05$) and Clay ($r= 0.1$; $p< 0.001$) representing that of Chilghoza density of trees and seedlings are significantly depends upon the soil which contains clay, sand and calcium carbonate may be due to human disturbances, animal grazing, climate change, chiefly prevailing drought situations in the recent past.

Conclusion

In short, *Pinus gerardiana* is ecologically and an economically valuable species with thin allocation in the globe. Our data has shown that the current status and natural process of regeneration of *P. gerardiana* has enough recruitment yet. Subsequently, if a conservation and management organisation for the Chilghoza forest were put into action quickly, the forest could be defended.

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