Research Article

Survival Rate, Regeneration Status and Growth Performance of Plantations Raised Under the Billion Trees Afforestation Project in District Karak

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Abstract | The present research aimed to evaluate the survival rate, status of natural regeneration, and growth performance of plantations established under BTAP in Karak district. A total of 99 sample plots measuring 0.1 hectares were established across the selected sites. Data collection included information on regeneration, species planted, pit density, survival rate, aspect, and species composition. Analysis of the field data revealed a pit density below the required 10x10 spacing, with only 663 pits found compared to the required 1075 pits per hectare. The average regeneration per hectare was estimated at 75 plants in pits and trenches at the plantation, with a composition of 70% *Prosopis juliflora,* 19% *Zizyphus nummularia,* and 7% Phoenix. The study identified established regeneration, while unestablished regeneration (below 9 inches) was not observed. The data showed an average survival rate of 93% in both subdivisions (Teri and Karak) of the Kohat forest division, with Karak Forest Subdivision recording a 92% survival rate and Teri Forest Range having a 93% survival rate. Species composition in the plantation consisted of 55% eucalyptus, 18% phulai, 16% Shisham, 7% kikar, and 3% sanatha. *Acacia modesta* exhibited an average girth of 3.4 cm and a height of 0.4 m in 15 months, while *Acacia nilotica* reached an average girth of 5.8 cm and a height of 1 m in 16 months. Eucalyptus had an average girth of 4.4 cm and a height of 1 m in 12 months, *Dodonaea viscosa* reached an average girth of 4 cm and a height of 0.5 m in 20 months, *Tamarix aphylla* had an average girth of 1 cm and a height of 0.4 m in 18 months, and *Dalbergia sissoo* exhibited an average girth of 5 cm and a height of 0.4 cm in 8 months.

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Introduction

In Pakistan, the definition of a Forest encompasses a land area of at least 0.5 hectares, characterized by a tree crown covering more than 10%, composed of trees capable of reaching a minimum height of 2 meters (Government of Pakistan, 2017). Another interpretation describes a forest as a collection of plants, predominantly trees and other woody vegetation, typically forming a dense canopy (British Council of Forest Terminology, 1953). The field of Forestry, as defined by the British Council of

Forest Terminology (1953), involves the theory and practice of conservation and efficient utilization of forest resources. According to Khattak (1965), forestry entails the practical application of scientific, economic, and social principles for the management of forests to achieve specific objectives. Forests offer a multitude of social, economic, and ecological benefits and services. They serve as habitats for 80% of the Earth's land-based biodiversity and support the livelihoods of diverse human communities, including 60 million indigenous people. Additionally, forests provide habitat for a staggering 300 million persons, encompassing 60 million indigenous people (WWF, 2017).

Forests provide essential ecosystem services that are crucial for human well-being. These services include the assimilation of detrimental greenhouse gases that are accountable for climate change. The biomass above and below ground in tropical forests alone stores 250 million metric tons of carbon (WWF, 2017). In addition, they provide potable water for consumption, bathing, and other domestic requirements, preserve watersheds, and mitigate erosion and chemical pollution reaching water bodies. Forests contribute to medicine and food provision, act as buffers in natural adversities such as floods and rainfall, and sustain habitats for about half of the terrestrial species, including plants with medicinal properties that are employed in the treatment of a range of diseases. Furthermore, forest plays a vital role in watershed protection by regulating water flow and filtering pollutants, primarily through their leafy canopy that intercepts rainfall (WWF, 2017). Forests serve as forage areas for one-third of Pakistan's 86 million livestock (Food and Agriculture Organization, 2006).

Forests also play a major role in influencing climate and the causes of climate change by releasing carbon from soil, leaves, and wood into the atmosphere after land clearance and forest fires. More than a third of the world's woods are primary forests, characterized by native species with minimal human intervention. Some of the most biologically varied and species-rich terrestrial ecosystems on Earth can be found in primary forests, particularly tropical moist forests. Reclassification of primary forests to other types of naturally regenerated forests has occurred as a result of human actions such as selective logging and other forms of intervention, which have been causing a 0.4% yearly decline in primary forest area over the past decade (Food and Agriculture Organization, 2010). Pakistan faces a shortage of forests, with the country's total forest area covering about 4.51 million hectares, constituting 5.1% of the total land surface (Booth, 2013). Despite its relatively small size, Pakistan's forests exhibit significant diversity due to climatic and geographic variations, ranging from sea level to the highest mountain peaks in the north. Billion Tree Afforestation Project has completed a Bonn challenge and increased forest cover in Khyber Pakhtunkhwa (BTAP, 2017). Pakistan is home to nine forest types, including Mangrove forests, Tropical Thorn Forests, Tropical Dry Deciduous Forests, Subtropical Broad-leaved Evergreen Forests, Moist Temperate Forests, Dry Temperate Forests, Sub-Alpine Forests, and Alpine Scrub Forests. These forests harbor rich biodiversity and safeguard the country's upland watersheds (Khattak, 1965). Billion Tree Afforestation project was started for the first time in 2013 and there is no research work available on this project. Additionally, this project has achieved many fruitful targets and challenges, hence mitigating Climate change (BTAP, 2017).

1. To evaluate the general survival rate of plantations in the Karak Forest sub-Division, District Karak.
2. To determine the status of regeneration in the study area.
3. To assess and compare the growth performance of Various tree species that grown in the target locations under the BTAP program.
4. To suggest measures for improvement in the plantation activities

Materials and Methods

Description of study area

The research was carried out in Karak which comes within the extensive Kohat Forest Division, covering an expansive area of 699,258.25 hectares, which includes Kohat, Hangu, and Karak districts. Karak is located at 33°7'12N and 71°5'41 E the headquarter of Karak is located on Indus Highway just 123 km away from the capital of Khyber Pakhtunkhwa at south of Peshawar. This entire expanse lies within the subtropical zone ecologically, where common species such as *Acacia modesta*, Eucalyptus, and *Nannorrhops ritchiena* (mazri) thrive. Additionally, *Zizyphus jujoba*, *Acacia nilotica,* and *Salvadora oleoides* are prevalent in Kohat and certain areas of Karak, particularly in the extreme southern zone. The Kohat Forest Division

comprises the following subdivisions (Khattak *et al.*, 2015).

1. Kohat Forest Sub-division
2. Karak Forest Sub-division
3. Hangu Forest Sub-division.
4. Teri Range
5. Thall (BTAP website)

Climate

The region is situated within a semi-arid climatic zone characterized by intensely hot summers and bitterly cold winters. Rainfall is sparse and unpredictable, with winter rains typically lasting long but with low intensity. Conversely, summer monsoons bring torrential downpours with heavy, shore-pounding intensity. Over the period from 2001 to 2010, the district experienced an average rainfall of 121.6 mm per decade. June and July emerge as the peak months of scorching heat, while December and January mark the depths of winter cold. In June, the mean maximum temperature soared to 39.5°C, while January witnessed a chilling mean minimum temperature plummeting to 4.26°C (Khattak *et al.*, 2015).

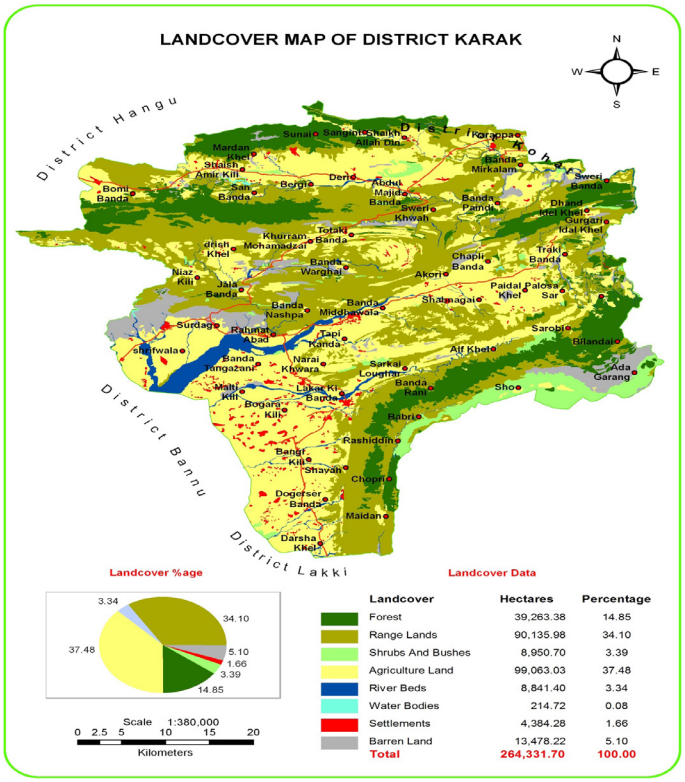

Figure 1: *Land cover map of District Karak (Source: BTAP website).*

Sampling procedure

The sample plots were chosen using a two-stage random sampling process. At first, ten locations were picked at random from the list of plantations that the Billion Tree Afforestation Project's project management unit had supplied. The second step was to randomly select five to twelve plots from each site for the sample. The approach resulted in 99 sample plots, which were used to collect data for the study. Further details regarding the sites and sample plots can be found in Table 1.

Table 1: *Detail of site and sample plot.*

S. No	Sub division	Location	Area (Ha)
1	Teri	Shewaki	42
		Gagari	108
		Khader Khel	30
		Kot Banda	29
		Akhoon Baig	60
2	Karak	Chak Manzi	27
		Alwar Banda	30
		Jangrezi	45
		Toor Dhand	25
		Umer Din	65
	Total		461

The subdivision-wise distribution of total plantation area, Sample plantation area and no of sample plots are given in the following Table 2.

Distribution of sample plots

A total of 99 sample plots were surveyed across the Karak Forest Subdivision and the Teri Range, comprising the sample area. In the Karak Subdivision, the plantation area was 558 hectares, with a sample area of 192 hectares, and data were collected from 41 plots. Meanwhile, in the Teri Range, the total area amounted to 1126 hectares, with a sample area of 269 hectares, and data were gathered from 58 sample plots.

Table 2: *Distribution of sample plots.*

S. No.	Sub division/ range	Plantation area (ha)	Plantation area sampled (ha)	No. of sample plot
1	Teri	1126	269	41
2	Karak	558	192	58
	Total	1684	461	99

Sampling intensity

Sampling was conducted in two stages. Initially, the adviser randomly selected plantation sites from the list provided by the project management unit of BTAP. Subsequently, within each site, five to twelve sample

plots were randomly chosen, maintaining a sampling intensity of 1%. As per the methodology, the sampling intensity was set at 10% of the total area. The total area planted in the Karak Forest Subdivision and the Teri Range (Departmental Plantation) amounted to 1684 hectares, from which 461 hectares were sampled. Then, within the 461 hectares, 1% sampling was carried out at each site.

Data collection

The collection of data in the field was conducted between September 25th, 2017, and October 13th, 2017. Data was gathered from ten locations using circular sample plots with an 18-meter radius, taking into account slope correction. The overall number of sampling plots fluctuated following the dimensions of the planted areas.

For data collection, a measuring tape and a clinometer were employed. First, a point was chosen at random to serve as the ercenter of the sample plot. Then, a measuring tape was stretched to a length of 18 meters, taking into account the slope by using a clinometer. Subsequently, we proceeded in a circular path around the midpoint, counting the regeneration within the circle and measuring the girth and height of approximately 20 plants in each sample plot, recording the data in the designated form. To prevent overlap, we moved 200 steps forward in the plot, established the second plot, and repeated the same procedure with a rope, recording the data in the proforma for each sample plot.

Data compilation and analysis

The gathered data was uploaded to a Microsoft Excel spreadsheet to compile and organize it. Statistical techniques such as averages and percentages were employed to interpret the data. Conclusions were drawn based on the analysis, and relevant recommendations and suggestions were formulated. The Microsoft Excel sheet was organized according to the proforma for ease of reference and analysis.

Results and Discussion

This chapter outlines the principal outcomes of the investigation concerning the survival rate, status of regeneration, and growth performance of plantations in both the Karak Subdivision and Teri Range. Analysis of data gathered from 99 sample plots was conducted to derive results, which are elaborated and deliberated upon in the subsequent sections.

Pit density

Pit density, indicating the number of pits per unit area, serves as a crucial measure for evaluating the effectiveness of a plantation initiative. Typically, in Khyber Pakhtunkhwa, plantations are established at a spacing of 10x10 feet, resulting in a density of 1075 pits per hectare. However, upon processing and analyzing the gathered data, it was observed that the average pit density in the study area was 663 per hectare. Interestingly, WWF (July 2017) has reported varying findings, suggesting that plantations in the southern region are spaced at 9.65 x 9.65 feet, resulting in a density of 1155 pits per hectare. The pit density in different sites of the study area is presented in Table 3.

Table 3: *Pits density site-wise.*

S. No	Site	Average pits per plot	Average number of pits per hectare
1	Gagari	54	540
2	Akhoon Baig	61	619
3	Kot Banda	70	709
4	Shewaki	56	562
5	Khader Khel	58	589
6	Alwar Banda	81	818
7	Jangrezi	76	766
8	Chakmanzi	73	736
9	Umer Din	59	592
10	Toor Dhand	69	698
	Total average	66	**663**

The Table 3 depicts that pit density in all sites is less than the number of required pits which is 1075 per hectare. The underestimated result is probably due to rough topography and also harsh environmental conditions.

Table 4: Distribution of sample plots.

S. No.	Subdivision/ Range	Plantation area (ha)	Plantation area sampled (ha)	No. of sample plot
1	Teri	1126	269	41
2	Karak	558	192	58
	Total	1684	461	99

In the Teri Range, the departmental plantation covers a total area of 1126 hectares, from which approximately 269 hectares were sampled, with 41

sample plots distributed across five randomly selected sites. Meanwhile, in the Karak Forest subdivision, the departmental plantation spans 558 hectares, of which around 192 hectares were sampled, and 58 sample plots were established across five random sites. The combined total area of departmental plantation in both subdivisions amounts to 1684 hectares. Out of this, 461 hectares were sampled, and a total of 99 sample plots were laid out across ten random sites.

Table 5: *Plantation survival rate of sub division.*

S. No	Subdivision/ Range	Survival rate (%age)	Standard deviation
1.	Teri	93	5
2.	Karak	92	10
	Total	93	8

Data from 99 sample plots were gathered to assess the survival rate of plantations, revealing a 92% survival rate in the Karak subdivision and a 93% rate in the Teri range. The average survival rate across both ranges amounted to 93%. Additionally, the standard deviation for survival rates in the Teri range was found to be 5%, while in the Karak subdivision, it was 10%, resulting in an average standard deviation of 8% for both ranges.

Similar findings by WWF (March 2017) estimated a survival rate of around 86%, while WWF (July 2017) reported rates of up to 78%. They also highlighted an overall survival rate within the Billion Tree Afforestation Project (BTAP) ranging from 70% to 90%. A plantation coverage of approximately 230 million hectares out of the total 3.4 billion hectares of the world's forests in 1995, projecting a significant increase in plantation rates up to 50% by 2020.

The forest department of the Nashik West division has implemented drives to enhance plant survival rates in areas with low tree density. Deputy Conservator of Forest (West), Anita Patil, noted that these efforts have resulted in an increase in the survival rate of trees within forest areas. Patil emphasized ongoing endeavors to safeguard existing forest areas and expand them, citing an increase in the survival rate from 80% in 2012 to over 90% in the present year

The comparatively high rate of survival is probably due to the choice of species i.e. eucalyptus, proper watering and intensive care by the department.

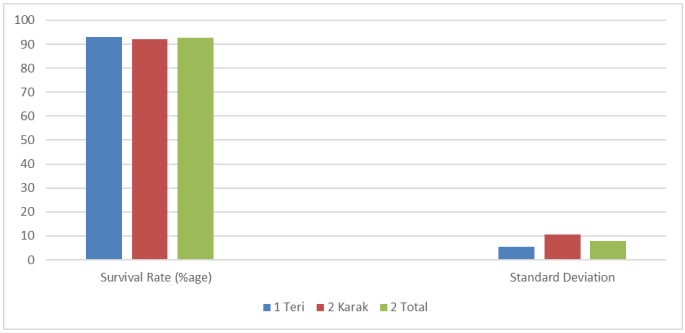

Figure 1: *Plantation survival rate of subdivision .*

Table 6: *Species survival rate.*

S. No	Species	Survival rate	Standard deviation
1	Acacia modesta	95	6
2	Eucalyptus	92	9
3	Acacia nilotica	93	6
4	Tamarix aphylla	94	0
5	Dodonaea viscosa	90	12
6	Dalbergia sissoo	92	7

We also examined the survival rates of different species and calculated their respective standard deviations. Acacia modesta exhibited the highest survival rate at 95%, with a standard deviation of 6. Following closely are *Acacia nilotica, Tamarix aphylla,* and Eucalyptus species, each with survival rates of 93%, 94%, and 92%, respectively. *Dodonaea viscosa* and *Dalbergia sissoo* showed slightly lower but still commendable survival rates of 90% and 92%, respectively.

The relatively high survival rates across all species can be attributed to various factors such as the careful selection of species, adequate watering practices, active community involvement, and intensive care provided by the department. These efforts have collectively contributed to the success of the plantations and the thriving survival rates observed.

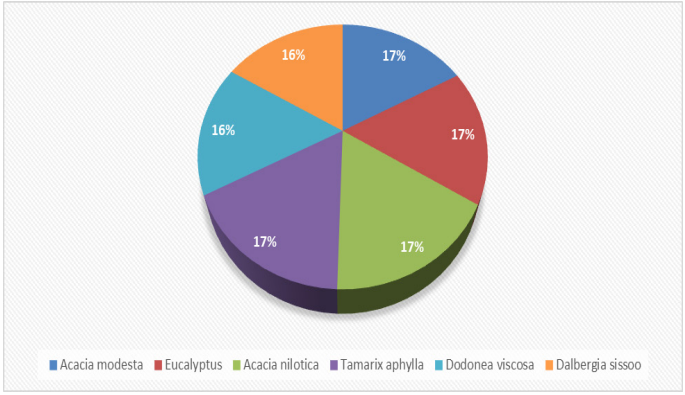

Figure 2: *Species survival rate.*

Links Researchers

Survival rate site-wise

Survival rate was also recorded in different sites. It was found that the highest survival rate has been achieved in Alwar Banda followed by Kot Banda and Khader Khel. The high survival rate is due to proper care and proper maintenance. The data with respect to the survival rate in the selected sites is given in Table 7.

Table 7: *Survival rate site-wise.*

S. No	Site	Total pits	Empty pits	Survival
1	Gagari	482	58	88
2	Akhoon Baig	433	31	93
3	Kot Banda	638	25	96
4	Shewaki	281	29	90
5	Khader Khel	584	24	96
6	Alwar Banda	982	30	97
7	Jangrezi	919	63	93
8	Chakmanzi	883	53	94
9	Umer Din	740	62	92
10	Toor Dhand	698	43	94
	Total	6640	418	93

Species composition in plantation

To assess the species composition in the plantation areas, the number of plants for each species was recorded in the randomly selected sample plots. It was observed that six different species were planted under the BTAP in the selected sites. Among these species, Eucalyptus accounted for the highest share at 55%, followed by *Acacia modesta* at 18% and Dalbergia sissoo at 16%. The remaining three species had minor shares in the total plantations, with *Acacia nilotica* comprising 7% and *Dodonaea viscosa* with 3%.

In both the Karak sub-division and Teri range, more than six species have been planted. Eucalyptus and Acacia modesta emerge as the major species in these plantations. This preference for Eucalyptus is partly due to farmers' preferences and partly due to its rapid growth rate and better chances of survival in arid conditions. *Acacia modesta* , on the other hand, contributes positively to promoting biodiversity. However, Acacia nilotica faces challenges due to frost and termite attacks, resulting in its lower percentage in the plantations. By the end of December 2016, the KP Forest Department had completed plantations covering a total area of 70,448 ha, achieving the target set for the same. WWF Pakistan monitored 15,888.73 ha across 177 sites, with 40 sites in the southern region. The KP Forest Department has planted more than 27 species across the entire province, including major species like *Eucalyptus, Pinus roxburghii, Robinia pseudoacacia, Acacia modesta, Acacia nilotica, and Dalbergia sissoo*. Compared with the previous year, Eucalyptus plantations have increased significantly from 17% to 48% in 2017, primarily due to farmers' preferences.

Table 8: *Species composition.*

S. No.	Species	No. of plants
1	Eucalyptus camaldulensis	495
2	Acacia modesta	161
3	Acacia nilotica	62
4	Dalbergia sissoo	147
5	Tamarix apylla	5
6	Dodonaea viscosa	30
	Total	900

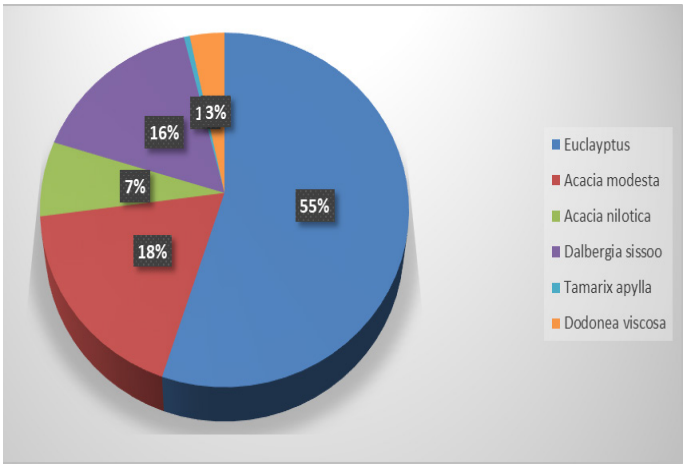

Figure 3: *Species composition.*

Regeneration status

To quantify natural regeneration in the plantation areas within the study area, the number of regenerations was counted in the sample plots. It was observed that the average number of regenerations per hectare was 74.8. Out of these, 222 regenerations were established, while no unestablished regenerations were found in any site. These findings align with those of WWF (2017), which reported an average natural regeneration of 25.1% in the southern region, with an average of 27 seedlings recorded per hectare.

This natural regeneration serves as an additional benefit and indicates effective maintenance and management practices. The status of regeneration across different sites is summarized in Table 9.

Table 9: *Status of natural regeneration in sites.*

Subdivision/ Range	Site	<9"	> 9"	Total	no of plots	average no of regeneration per site	regeneration per ha
Teri	Akhon Baig	0	53	53	7	6	66
	Gagari	0	25	25	10	5	50
	khedar Khel	0	52	52	10	4	43
	Kot Banda	0	9	9	9	9	90
	Shewaki	0	33	33	5	6.6	66
Karak	Alwar Banda	0	32	32	12	36	366
	Chak Manzi	0	0	0	12	0	0
	Jnagrezi	0	13	13	12	3	32
	Toor Dhand	0	3	3	10	1	15
	Umer Din	0	2	2	12	2	20
	Total	0	222	222	99	7	75

Composition of natural regeneration (>9")

To assess the natural species composition in the plantation area, the numbers of plants belonging to each species were recorded in the randomly selected sample plots. It was observed that four different natural species were present in the selected sites. Among these, *Prosopis juliflora* constituted the highest share, accounting for 70%, followed by *Zizyphus nemularia* at 19%, and palm trees at 7%. The remaining species, including *Acacia modesta*, comprised a minor share of the total plantations, amounting to approximately 4%, as depicted in the Figure 4. *Acacia nilotica* constituted up to 7%, while *Dodonaea viscosa* accounted for 3%. *Prosopis juliflora* and *Zizyphus nemularia* emerged as the major natural species in these plantations. This is partly attributed to the fact that Karak and Teri are dry areas where these species thrive well under dry conditions.

Table 10: *Composition of natural regeneration (>9").*

S. No	Specie	No of plants
1	Prosopis juliflora	155
2	Zizyphus nemularia	42
3	Palm tree	16
4	Acacia modesta	9
	Total	222

Status of natural regeneration in sub-division

We find out the status of natural regeneration in -sub-divisions also. We recorded the data from randomly selected plots. We have only established natural regeneration in all sites and plots. In Teri Forest Range Natural regeneration is found up to 77% while in the Karak Forest -sub-division, the status of Natural regeneration is up to 23%.

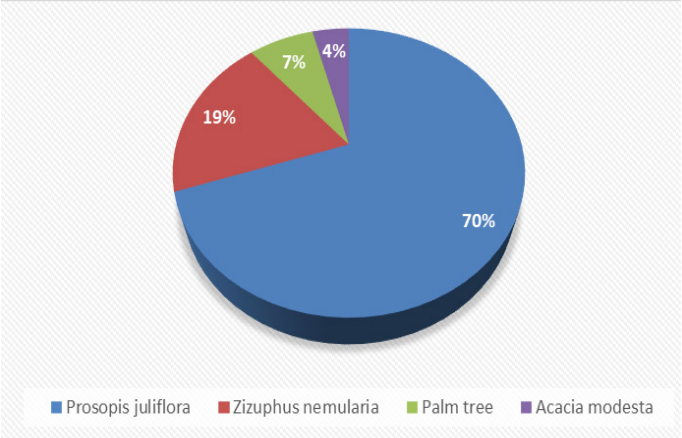

Figure 4: *Composition of natural regeneration.*

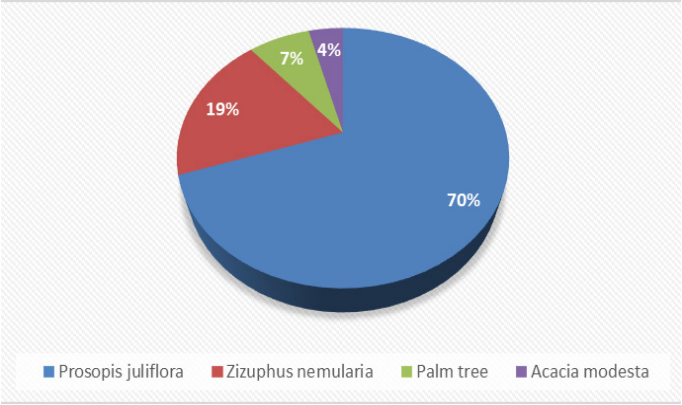

Figure 5: *Composition of established natural regeneration.*

Table 11: *Status of natural regeneration in sub division.*

Subdivision/Range	<9"	>9"	Total
Teri	0	172	172
Karak	0	50	50
Total	0	222	222

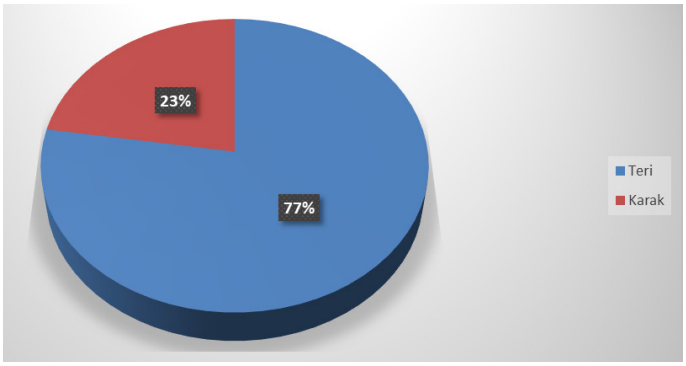

Figure 6: *Status of natural regeneration in subdivision.*

No of plants at sites

We also recorded the plants in each site. In different sites different numbers of plants were recorded in Gagari 50760 plants were recorded followed by Umer Din with 35100 plants and in Akhoon Baig 34800 plants were recorded. In all ten sites total number of plants is up to 268130. The data with respect tono of plants in the selected sites is given in Table 12.

Table 12: *No of plants at sites.*

Site	No. of plants /0.1 (Ha)	No. of plants/ (Ha)	Area planted (Ha)	Total No. of plants
Akhon baig	58	580	60	34800
Gagari	47	470	108	50760
khedar khel	56	560	30	16800
kot banda	66	660	29	19140
Shewaki	50	500	42	21000
Alwar banda	79	790	30	23700
Chak manzi	69	690	27	18630
Jnagrezi	71	710	45	31950
Toor dhand	65	650	25	16250
Umer Din	54	540	65	35100
Total	1215	12150	461	268130

No of plants sub divisions wise

We also concluded the data subdivision and range-wise. In the Teri range, 142500 plants are recorded in five different sites while in the Karak subdivision, 129792 plants are recorded in five different sites. The data with respect to no of plants in the selected sites subdivision-wise is given in Table 13.

Table 13: *No of plants subdivision-wise.*

Forest division	Average no. of plants/(Ha)	Area planted (Ha)	Total plants
Teri	554	269	142500
Karak	676	192	125630
Total	1230	461	268130

Growth rate of different species in different phases

To assess the growth rate of different species in the Karak and Teri study area, data on plant girth, height, and age was collected from various plantation sites. The data was compiled according to different phases.

In Phase 1, Eucalyptus and *Dodonaea viscosa* exhibited the highest growth performance. Eucalyptus achieved an average girth of 8.17 cm and a height of 1.5 m in 28 months, attributed to the suitability of the site for Eucalyptus. Moving to Phase 2, *Acacia modesta* and Eucalyptus showed the highest growth performance. *Acacia modesta* attained an average girth of 5.7 cm and a height of 0.5 m in 18 months. Phase 3 demonstrated high growth performance by *Dalbergia sissoo* and Eucalyptus. *Dalbergia sissoo* achieved an average girth of 4.62 cm and a height of 0.41 m. The average girth and height of different species in different phases are detailed in Table 14.

The observed high growth can be attributed to the favorable conditions of the planting sites. However, it's important to note that species diversity was limited in some sites, with Eucalyptus being predominant.

Table 14: *Growth rate of different species in different phases.*

Phase	Specie	Girth (cm)	Height (m)
1 (2015)	*Acacia modesta*	6	0.9
	Acacia nilotica	5	1
	Dodonaea viscosa	6	0.6
	Eucalyptus camaldulensis	8	1
	Average	6	1
2 (2016)	*Acacia modesta*	5	0.5
	Acacia nilotica	3	0.5
	Dodonaea viscosa	3	0.5
	Eucalyptus camaldulensis	5	1
	Tamarix aphylla	1	0.4
	Average	3	0.6
3 (2017)	*Acacia modesta*	1	0.3
	Acacia nilotica	1	0.3
	Dodonaea viscosa	1	0.3
	Eucalyptus camaldulensis	2	0.7
	Dalbergia sissoo	4	0.4
	Average	2	0.4

Subdivision-wise growth rate

The investigation into the growth performance of different species in the two selected subdivisions

revealed that the growth rate of plantations in the Karak Forest subdivision exceeded that of the Teri Forest Range. This disparity can be attributed to the more favorable climatic conditions for the selected species in the Karak Forest subdivision.

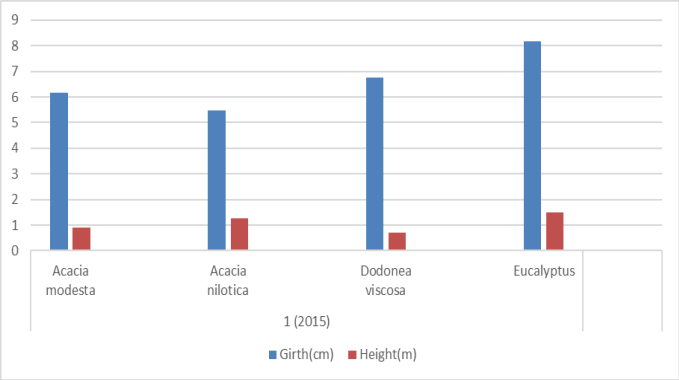

Figure 7: *Growth rate of species in phase 1.*

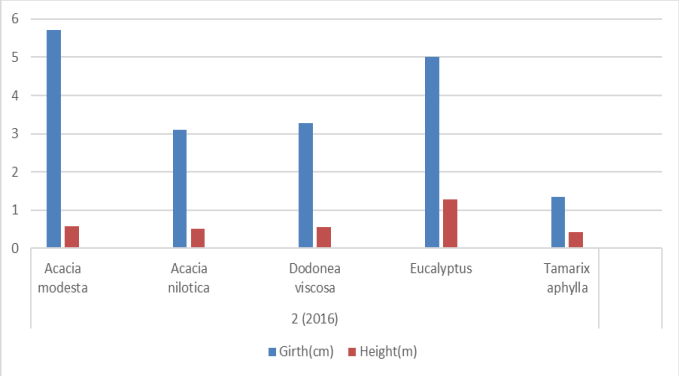

Figure 8: *Growth rate of species in phase 2.*

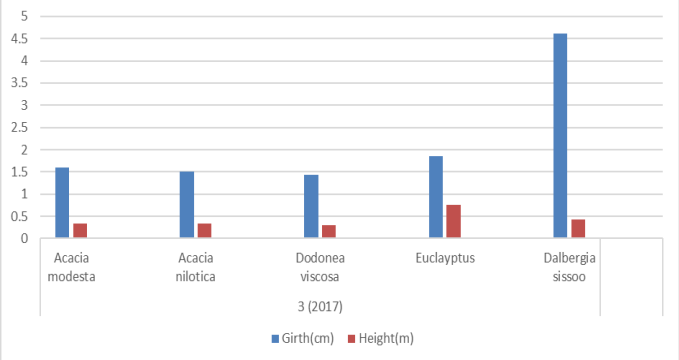

Figure 9: *Growth rate of species in phase 3.*

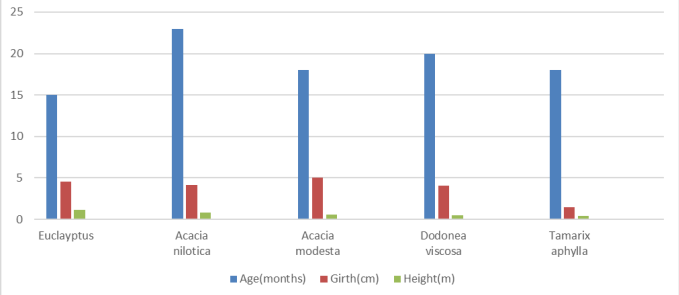

Figure 10: *The growth rate of the Teri Forest Range.*

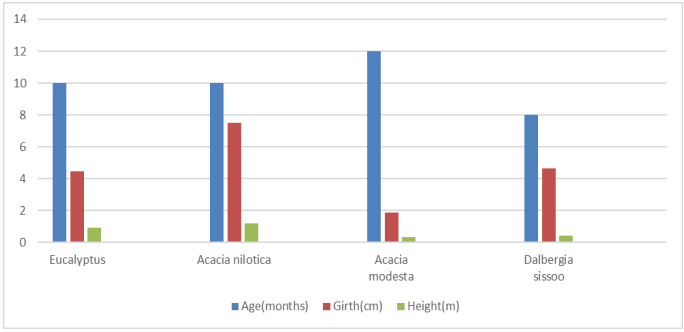

Figure 11: *Growth rate of Karak Forest subdivision.*

Table 15: *Subdivision wise growth rate.*

Subdivision/ Range	S. No	Specie	Age (months)	Girth (cm)	Height (m)
Teri	1	*Eucalyptus camaldulensis*	15	4	1
	2	*Acacia nilotica*	23	4	0.8
	3	*Acacia modesta*	18	5	0.5
	4	*Dodonea viscosa*	20	4	0.5
	5	*Tamarix aphylla*	18	1	0.4
		Average	19	4	0.7
Karak	1	*Eucalyptus camaldulensis*	10	4	0.9
	2	*Acacia nilotica*	10	7	1
	3	*Acacia modesta*	12	2	0.3
	4	*Dalbergia sisso*	8	5	0.4
		Average	10	**5**	0.7

Conclusions and Recommendations

The objective of this study is to assess the status of regeneration, composition of species, survival and growth rate of plantations in the Kohat forest division. For this purpose data was collected from the selected sites. After data collection and analysis, the following conclusions have been drawn.

The pit density was found to be less than the required 10x10 spacing, with only 663 pits per hectare observed compared to the necessary 1075. The average regeneration per hectare was estimated at 222, with major species including *Prosopis juliflora, Zizyphus nemularia*, and palm trees. All regeneration was observed outside the pits during data collection in randomly selected areas. The study indicated that only established regeneration (mean above 9 inches) was found, while unestablished regeneration (below 9 inches) was not observed. The study revealed an average survival rate of 93% in both the Karak subdivision

and Teri range. In the Karak forest subdivision, the survival rate was 92%, while in the Teri forest range, it was 93%. Species composition in plantations was determined, with the percentage of each species as follows: *Acacia modesta* 18%, Eucalyptus 55%, *Acacia nilotica* 7%, *Dodonaea viscosa* 3%, *Tamarix aphylla* 1%, and *Dalbergia sissoo* 16%. Species-wise average growth rates were also calculated: *Acacia modesta*: average girth of 3.4 cm and height of 0.4 m in 15 months. *Acacia nilotica*: average girth of 5.8 cm and height of 1 m in 16 months. Eucalyptus: average girth of 4.4 cm and height of 1 m in 12 months. *Dodonaea viscosa*: Average girth of 4 cm and height of 0.5 m in 20 months.

- *Tamarix aphylla*: average girth of 1 cm and height of 0.4 m in 18 months.
- *Dalbergia sissoo*: average girth of 5 cm and height of 0.4 cm in 8 months.

Recommendations

The following recommendations were made after the field visit and personal observations. Future studies should replicate these assessments to continually monitor the survival rate and growth performance of plantations established under BTAP. The high prevalence of Eucalyptus plantations suggests a need to decrease its frequency and prioritize the planting of local indigenous species to enhance biodiversity. Considering the recent lack of rainfall affecting plant growth, the implementation of a proper watering scheme is imperative. Given the prevalent termite attacks in the Karak district, particularly affecting *Acacia nilotica*, it's essential to implement effective treatment measures. Conducting regular weeding operations in plantation areas is crucial for maintaining plant health and growth. Prohibiting animals from accessing plantation areas can help prevent damage to the plants. Prioritizing indigenous plants over exotic species is advisable to better integrate with the local ecosystem. Providing protective measures for plants, such as fencing or guards, for at least three years can significantly improve survival rates. Awareness campaigns should be launched in the local community through print and electronic media to educate them about the importance of forests and forestry practices.

Novelty Statement

This study presents the first comprehensive analysis of the Billion Tree Afforestation Project's survival rate, regeneration, and growth performance using advanced remote sensing technology and on-the-ground ecological assessments. The findings offer novel insights into key factors influencing tree survival and growth, providing a valuable framework for future large-scale afforestation initiatives

Author's Contribution

Asad Ali: Topic selection and data collection.
Anwar Ali: Final Review.
Muhammad Farooq: Data Analysis.
Basheer Ahmad: Literature Review.

Conflict of interest

The authors have declared no conflict of interest.

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