IMPACT ASSESSMENT OF SLOPE STABILIZATION MEASURES ON VEGETATION ATTRIBUTES IN KALAM FOREST DIVISION

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ABSTRACT

The purpose of this study was to evaluate the various vegetation attributes regarding slope stabilization measures carried out in Kalam Forest Division, Khyber Pakhtunkhwa. In Billion Tree Afforestation Project certain targets were given to the Khyber Pakhtunkhwa Forest Department for bad land stabilization. In Kalam Forest Division, total four sites were treated with bad land stabilization techniques in Asrait, Niam, Kullaly, and Dabargai localities respectively. In all these areas, the techniques adopted include Check Dams, Diversion Channels, Vegetated Soft Gabions, Plantations, and Protection Walls etc. The data were collected using two stage sampling technique. In the first stage, circular sample plots having an area of 0.1 ha, with the sampling intensity of 5% were laid out. The vegetation parameters were studied in square quadrats with area of 1 meter square. During data collection, the vegetation density, cover (%), relative density and species composition were determined. Secondary data regarding rehabilitation of degraded slopes were also collected. Results revealed that slope stabilization measures have significant positive effect on vegetation parameters. The statistics show that the cover percent at Asrait, Niam, Kullaly and Dabargai sites was 55.5%. 51.4%, 41.4%, and 24.3% respectively. At Asrait site, 62.53% were planted species and 37.46% were indigenous; at Niam site, the planted species were 37.98% and 62% were indigenous; in Kullaly site, 63.4% were planted species and 36.57% were indigenous; in Dabargai site 91.25% were planted species and 8.93% were indigenous. Physical inspection of sites depicted that the techniques adopted to rehabilitate degraded slopes are very effective and no land slide occurred after rehabilitation of degraded slopes.

Keywords: Degraded slopes, Land stabilization measures, Afforestation, Species composition

INTRODUCTION

Diverse engineering measures are the trending path to prevent soil erosion and land slides. Bio-engineering is the highest applicable technique in the slightly and moderate degraded slopes. Implication of soil bioengineering to some extent ensures the use of plant material, elimination of environmental problems, reducing rapid landslides, eroding slopes. Plants are the main component of implicating bioengineering in preventing soil erosion and landslides. Bioengineering has prioritized perennial plant cover, crop cover planting, mulching to prevent landslides and providing assurance for growth of agriculture plants. Earth walls are the innovative initiatives of bioengineering that determined the reduction of soil erosion by using slopes. Controlling runoff is an

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extra advantage of bioengineering technology that can prevent the erosive force of soil. Considering all the consequences, bioengineering can be defined as a biological system that helps to create products or control or modify the products according to the requirements of biological structures including agriculture, medical, construction and many other fields. Bioengineering accelerates the natural way of preventing landslides and soil erosion by prioritizing the plant vegetation (Suresh and Dwivedi, 2022).

Degradation of mountain ecosystem is a global concern and Himalayan constitutes a threatened ecosystem. This degradation is the result of human interventions into the use of various elements of human resources. The mountains of the Himalayas which make vital contribution to agricultural production are threatened by cultivation of marginal lands due to expanding population which is accompanied by excessive livestock grazing, deforestation. Thus, the entire mountainous environment in our region is undergoing a process of continuous degradation (Storey, 2002). Intensive management interventions like fencing, planting of suitable plant species, repair & raising the level of existing check dams & spillways and construction of new structures have resulted into a decrease in runoff of 46% and reduction in sediment load of 77% (Shah, 2008).

Bioengineering uses plants to protect soil surfaces and stream banks, and to strengthen shallow soil. It can control erosion and prevent or stabilize shallow slope movements where the depth to failure is no more than 0.5 meter (m). If the depth to the sliding surface of a slope failure is greater than 0.5 m, then bioengineering should only be applied in conjunction with other slope stabilization techniques, typically, retaining walls. Bioengineering techniques often provide the most cost-effective methods of surface protection for soil slopes, which is achieved through a surface cover of vegetation that armors the surface against erosion (Salter *et.al.,* 2020)

For successful stabilization of landslides, the engineering; soil bio-engineering and biological measures should be integrated for successful results. This study aimed at determining the detailed evaluation of those structures which have been applied to increase the stability of slopes in order to reduce the landslides and other related threats in Kalam, Khyber Pakhtunkhwa.

MATERIAL AND METHODS

The study was conducted in Kalam Forest Division, Khyber Pakhtunkhwa. The secondary data like detail of structures (Check dams, Soft gabions, Brushwood layering, Diversion channels and close space planting), Maps of Watersheds and slopes treated and Pictures of slopes: pictures before work and during work were collected from the office of concerned Divisional Forest Officer.

For the collection of primary data such as cover percent, density, type of species, soil samples, aspect, GPS coordinates and for taking pictures, each individual site was visited. Two Stage Random Sampling Method was adopted for the selection of sample plots. At first stage, 10 percent sites, by number of total rehabilitated sites, were selected randomly. In second stage, each rehabilitated site was sampled with the sampling intensity of 5%. Quadrats were used to collect data.

Secondly, in order to collect data about vegetation attributes, simple random sampling procedure was adopted. Data about vegetation attributes like density and cover percent were collected of plants, forbs and grasses. For this purpose, a transect line of 16.9 m length was stretched randomly and counted the number of plants, forbs and grasses which fall inside the transect line placed. The number of each species separately in each sample plot was noted. By repeating this procedure, a number of sample plots were taken in the whole slope. The number of sample plots taken varied according to the size of slope.

After collection of field data on structured proforma, the data were compiled and analyzed. Different formulae were used for calculation of various attributes like density, cover percent and species composition etc. Data were analyzed statistically to conclude the results.

RESULTS AND DISCUSSION

The slope stabilization works in Kalam Forest Division were carried out in four different sites namely Niam, Asrait, Kullaly and Dabargai. Results of vegetation attributes are presented below:

Plant Density on Treated Slopes

Plant density at four sites is presented below in table 1.

Table 1. Showing Plant Density on Treated Slopes in Kalam Forest Division

Location	Number of Plants per Sample Plot	Number of Plants per hectare
Asrait	171	1712
Kullaly	169	1692
Niam	160	1607
Dabargai	120	1199

Results reveal that plant density was maximum at Asrait site followed by Kullaly, Niam and Dabargai respectively. The reason for low density was firstly that these techniques were adopted in years 2016 and 2017 in Billion Tree

Afforestation Project. Due to this reason, the vegetation was not of much density. Secondly, drought conditions contributed to lower plant densities.

Cover % on Treated Slopes

Cover% is the estimate of the area a plant species covers in a quadrat while total cover% is the sum of percentages of all species in a quadrate. Cover % of different species of each location was calculated separately within one Sub-Division and three Ranges and then total cover% of all species of each location. *Robinia pseudocacia* had the highest cover % in all locations in Kalam Forest Division except Asrait in which *Robinia pseudocacia* had cover of 8% whereas *Ailanthus altissima* had cover of 9%. The reason for highest cover % of *Robinia pseudocacia* is its fast growth rate and best soil binding capacity.

By taking into consideration the total cover% of each location, Asrait site in Behrain (North) Sub-Division has the highest total cover of 55.5 % and other sites namely Niam, Kullaly, and Dabargai have total cover of 51.4%, 41.4% and 24.3% respectively. The reason for difference in the cover% is due to different date of construction of these sites, because all of them were applied in 2016 and 2017 respectively.

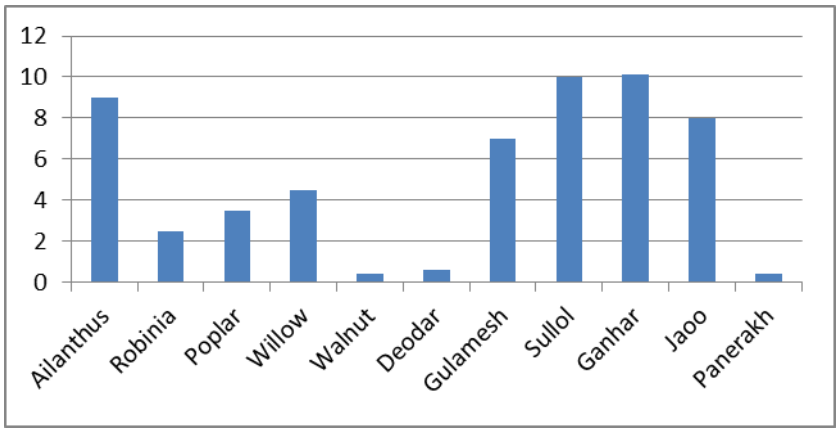

Fig. 1. Cover % of different species at Asrait site

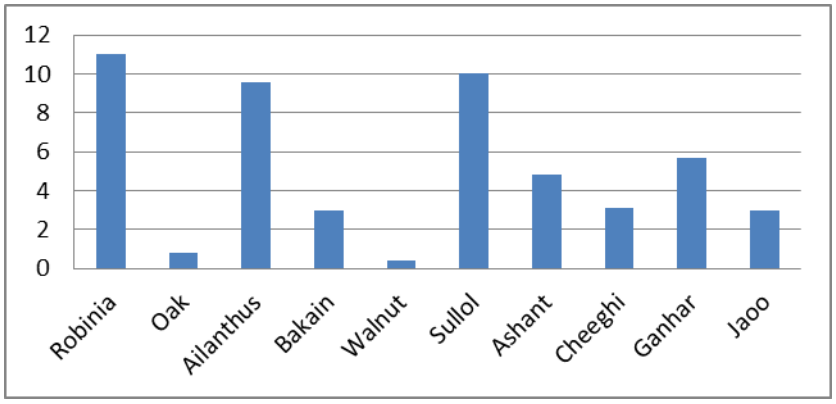

Fig. 2. Cover % of different species at Niam site

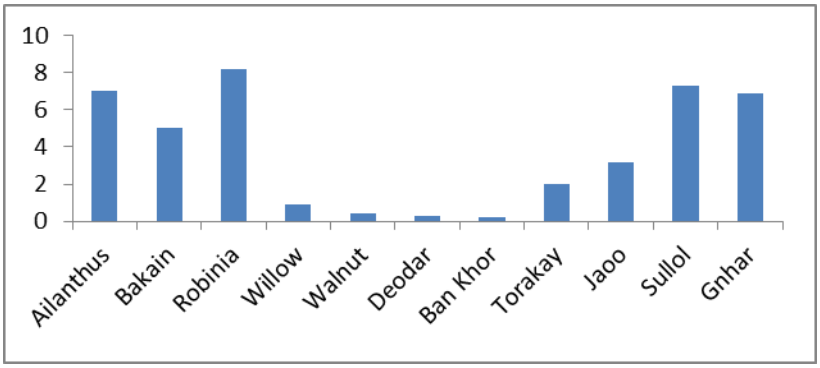

Fig. 3. Cover % of different species at Kullaly site

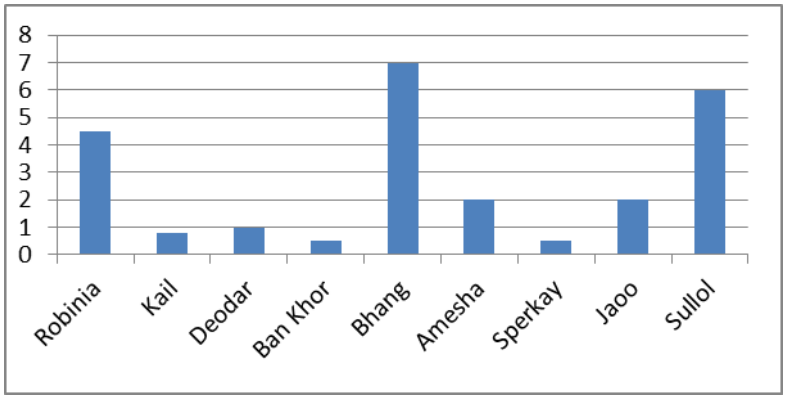

Fig. 4. Cover % of different species at Dabargai site

Species composition

Species composition refers to the contribution of each plant species to the total vegetation. Species composition is generally expressed as a percent, so that all species components add up to 100%. The species composition on land stabilization techniques in Kalam Forest Division was calculated by the formula given in previous chapter, is shown in below pie charts. According to results *Ailanthus altissima* and *Robinia pseudocacia* have the highest species composition in the planted species as compared to other planted species because of its hardness and high success rate compare to other species and that's why they were planted more than other native species. The percent of *Robinia pseudocacia* was 17%, 7%, 11%, and 45% at Asrait, Niam, Kullaly and Dabargai respectively.

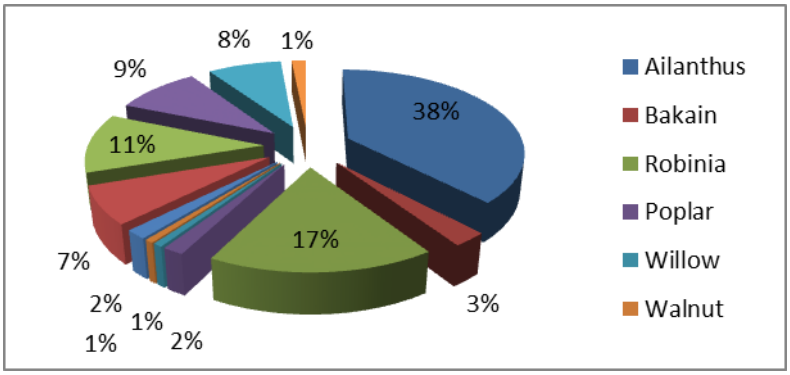

Fig. 5. Species composition at Asrait site

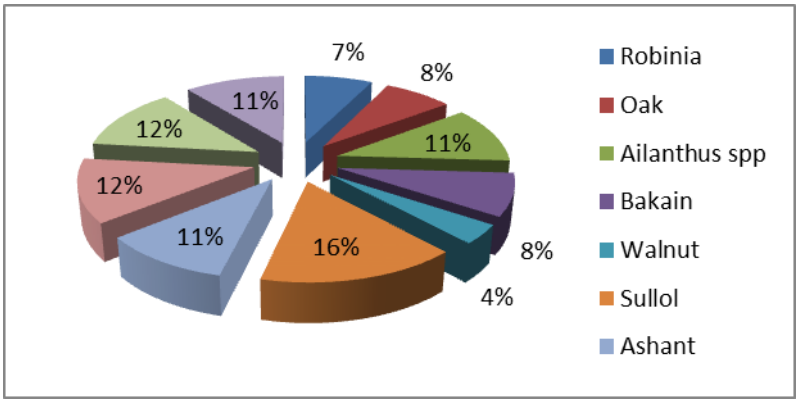

Fig. 6. Species composition at Niam site

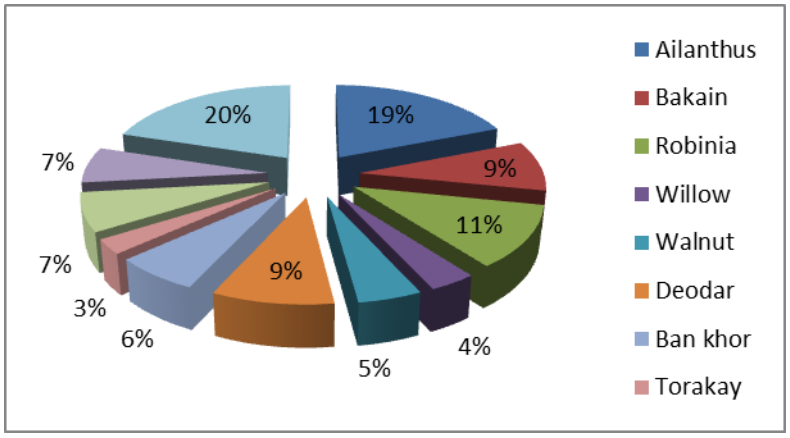

Fig. 7. Species composition at Kullaly site

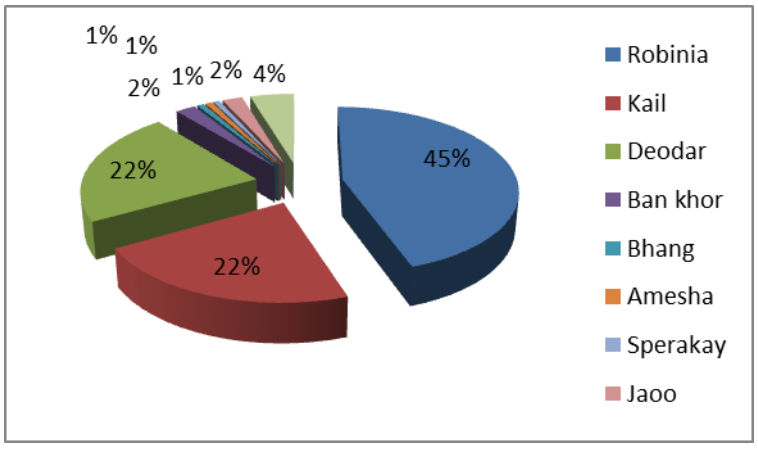

Fig. 8. Species composition at Dabargai site

Comparison of Natural Growth and Planted Species

The results show that in Dabargai, the percent of plants planted was highest and was about 91.25% and that of indigenous plants were about 8.93%. In Asrait, the planted plants were 62.53% and indigenous were 37.46%. In Niam, the planted plants were 37.98% and that of indigenous plants were about 62%. In Kullaly, 63.4% were planted and 36.57% were indigenous.

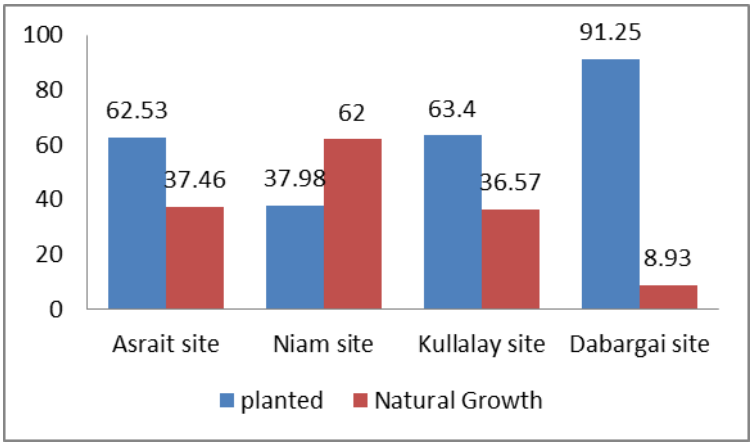

Fig. 9. Showing Comparison of Natural Growth and Planted plants

CONCLUSION

It is concluded from the study that slope stabilization techniques adopted on rehabilitation of degraded slopes were quite effective to control. Physical verification of sites indicates that the techniques adopted to rehabilitate degraded slopes are environment friendly and no land slide has occurred after rehabilitation of degraded slopes.

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