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IMPACT ANALYSIS OF TREE PLANTATION PROGRAMMES IN PUNJAB AND FACTORS AFFECTING SURVIVAL OF TREES

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ABSTRACT

In the wake of climate change, awareness about the importance of environmental conservation has led to several plantation programmes throughout the country. However, the survival of these planted trees is a major concern that decides the success or failure of the plantation drives. The current study was carried in Punjab state of India, and aimed at assessing the survival rate of trees according to the species, agro-climatic zone, and plantation sites. The constraints in the survival were also studied using the Rank Based Quotient. The study revealed that the highest rate of survival was observed in the commercial species *viz. Eucalyptus* (86.8%) and Poplar (84.3%). The plantations carried out at farmers' fields and near tubewells resulted in higher survival rate (86.6 and 70.1%, respectively). Among the agroclimatic zones, survival was recorded to be highest in the sub-mountainous undulating zone (87.3%). Abiotic (heat, frost & water) stress, damage by wild and stray animals and poor management due to lack of manpower and inadequate supervision were perceived as the major reasons for failure of the plantation programmes. It is necessary to strengthen post-plantation tree management strategies at the community level for achieving the desired target of any plantation drive.

Keywords: Afforestation, Constraints, Plantation programme, Survival rate

Globally, climate change is a major challenge of the current time that poses a great danger to the environment. Frequent changes in climate affect the life cycle of flora and fauna of any region. Land use change is one of the major reasons responsible for climate change. In many developing countries, deforestation, being done for subsistence and commercial agriculture is a major concern (Hosonuma *et al*., 2012). Destruction of forest cover can increase the ecosystem's vulnerability to severe weather conditions like floods and other natural disasters, as well as human settlement and other natural resources (Wisner *et al*., 2003). The deforestation and land degradation needs to be addressed to combat with global challenges of climate change as well as to mitigate environmental challenges.

India has sub-tropical climatic conditions and area extends from the Himalayan mountains to the tropical rain forests of southern region. In India, the total forest and tree cover is 80.9 million hectares representing 24.62% of the total geographical area. The National Forest Policy of India, 1988 recommended one third of the total land area to be under the forests for a sustainable environmental growth. However, actual forest cover of India is merely 21.76 % (ISFR, 2023), while that of Punjab is 3.67 % (ISFR, 2023). In Punjab, regions lying near the foothills of Himalayas have geographical area of 50,362 square kilometers out of which forest and tree cover is 2985 square kilometers (Anonymous, 2022).

From the past few decades, deforestation, over-exploitation of natural resources and changes in land use pattern has posed a serious threat to the natural forest of the country. Thus, it has become even more important in the recent years to plant more trees due to the erratic changes in the climate. This can be assured through afforestation programmes being organized by various institutions. Trees provide numerous benefits for urban dwellers, including reduced energy usage, improved quality of air, flood management and increased property values. Trees also play the foremost role in mitigating the climate change by acting as a carbon sink. Increasing the area under trees outside forests can act as an effective approach to increase the forest area.

Extensive afforestation initiatives have been initiated for forest cover in various regions of world (Bastin *et al*., 2019; Friggens *et al*., 2020), In Punjab, India, too, the plantation drives are being carrired out at community level every year by NGOs, private

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agencies as well as by Government sector through projects such as PUNCAMPA, Greening Punjab Mission etc. (Anonymous, 2025). Afforestation has gained even more importance in today's era of carbon credit system. Reforestation can attribute to around 50% of the total carbon sequestration (Griscom *et al*., 2017). Worldwide, climatic vulnerability has threatened forest ecosystems and there are several reports of forest fires. There is an urgent need to analyze the factors responsible for success of afforestation programs. The positive results from these plantation campaigns can be harnessed only from studying the tree survival and forest stability. The current study aimed to analyse the performance of the tree plantation programmes conducted by Punjab Agricultural University, Ludhiana over the five years from 2017 to 2021 by calculating the survival of the trees and to determine the possible reasons affecting the survival and thus, the success of such programmes. This study will help in identifying some key factors to be kept in mind while planning future plantation activities.

MATERIALS AND METHODS

Based on topography, rainfall and cropping pattern, Punjab is divided into five agro-climatic zones as given in Table 1 (Gulati *et al*., 2017). The tree plantation programmes from 2017 to 2021 (five years) were conducted through extension setup at different districts, the *Krishi Vigyan Kendras* (18 Nos.), and Farm Advisory Service Centres (10 Nos.) of the Punjab Agricultural University, Ludhiana, India. For plantation drive, zone-wise adaptability (as per recommendations of the university) and demand of the farmers were considered for selection of species of tree plants (Table 2-3). During 2023, a general survey was conducted where 100 farmers from each zone were selected through random sampling technique and were interviewed for enlisting most preferred tree species for planting. During plantation drive, trees were planted at different locations such as adjoining tubewells, at farmers' fields, road sides, village roads (*kacha* paths), periphery of village pond, jungle area, and public places such as schools, common areas in a village (community centre, *Panchayat ghar*) etc. The impact of plantation drive was studied by computing survival rate for different tree species in different zones and locations.

Survival of trees: To study the survival of the trees

Table 1. Agroclimatic zones of Punjab

Zone	Agro-climatic Zone	Districts
I	Sub-mountain undulating zone	Gurdaspur, Hoshiarpur, Pathankot
II	Undulating plain zone	Roopnagar, SBS Nagar, SAS Nagar
III	Central plain zone	Amritsar, Tarn Taran, Kapurthala, Jalandhar, Ludhiana, Fatehgarh Sahib, Sangrur, Patiala
IV	Western plain zone	Ferozepur, Faridkot, Fazilka
V	Western zone	Moga, Bathinda, Mansa, Sri Muktsar Sahib, Barnala

Table 2. List of forestry trees planted in the plantation drive

Common name	Scientific name
Poplar	*Populus deltoides*
Eucalyptus / *Safeda*	*Eucaluptus* sp.
Neem/Indian lilac tree	*Azadirachta indica*
Moringa /*Sohanjana*/ Drumstick tree	*Moringa oleifera*
Dek/ Persian Lilac/ Chinaberry tree	*Melia azedarach*
Tahli/ *Shisham*/ Indian Rosewood	*Dalbergia sissoo*
Sukhchain /*Karanja* /Indian Beech tree	*Pongamia pinnata*
Bamboo /*Baans*	*Dendrocalamus strictus*
Tun /Burma *tun*/ Indian cedar/ *Maha nim*	*Toona ciliata*
Arjun	*Terminalia arjuna*
Bahera	*Terminalia bellirica*
Ornamental Shrubs:	
Rose /*Desi gulab*	*Rosa indica*
Chandni/ Single *chandni*/ Crape jasmine	*Tabernaemontana divaricata*
Kaner /*Peeli Kaner*, Yellow oleander	*Thevetia peruviana*
Cassia / Golden senna	*Senna surattensis*
Palm /Fishltail palm	*Caryota urens*
Miscellaneous Trees:	
Jakranda / *Neeli Gulmohr* /blue jacaranda	*Jacaranda mimosifolia*
Harar	*Terminalia chebula*
Rohida /Honey tree/ *Marwar* teak	*Tecomella undulata*
Molsari /Spanish cherry	*Mimusops elengi*
Pilkan /White fig	*Ficus virens*
Kachnar /Orchid tree	*Bauhinia variegata*
Gulmohar /Flame tree/ Royal Poinciana	*Delonix regia/ Cassia fistula*
Amaltas / Golden shower tree	

Table 3. Zone-wise most planted species

S. No.	Zone	Agro-climatic zone	Most planted species	Number of trees planted
1	I	Sub-mountain undulating zone	Eucalyptus (*Eucalyptus hybrid*)	3600
2	II	Undulating plain zone	Poplar (*Populus deltoides*)	12300
3	III	Central plain zone	Moringa (*Moringa oliefera*)	2040
4	IV	Western plain zone	Neem (*Azadirachta indica*)	2812
5	V	Western zone	Poplar (*Populus deltoides*)	2050

planted under the plantation programmes, the number of plants/trees that survived were recorded by personal visits as well as reporting by the beneficiary farmers of the plantation programmes. For this study, at least two years old plants were considered as 'survived' at the plantation site. This age of tree is selected as the plants of less than two years were considered prone to damage by factors like wild animals, water and heat stress and their survival chances are lower. Accordingly, the survival for the plantations done from 2017 to 2021 was recorded during 2023. The species-wise survival of trees was recorded. In addition to this, the survival of the trees at different types of sites, where the trees were planted, was also recorded. The agroclimatic zone-wise survival rate was also calculated during the study. The survival rate was calculated using the following formula:

$$\text{Survival (\%)} = \frac{\text{No. of trees survived}}{\text{Total no. of trees planted}} \times 100$$

The survival percentage data across all zones was tested for normality and homogeneity of variance using Shapiro-Wilks and Lavene test, respectively. One way ANOVA test was performed to measure the significance of difference between total survival percentage of different trees and at different locations of planting using Fisher protected LSD test at alpha level of 0.05 in IBM SPSS Statistics 22.

Reasons for poor survival: The reasons for failure of the plantations were assessed to increase the effectiveness of the future plantation programmes. For this purpose, the possible reasons for poor survival were asked from the beneficiaries/farmers in the survey proforma. Based on this, a proforma containing the technical and fundamental reasons was prepared and distributed among twenty farmers from each zone (total hundred farmers) for ranking of the reasons so that the most significant reason was given rank 1. The frequency of farmers for each reason under a particular rank was recorded.

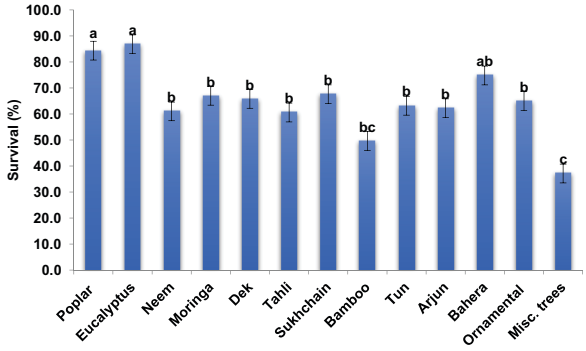

Fig. 1. Overall survival (%) of different tree species
Bars with different letters are significantly different from each other

The quantification of this data was done by calculating Rank Based Quotient (RBQ) as given by Sabarathanam (1988):

$$\text{RBQ} = \frac{\sum fi\,(n+1-ith)}{N \times n} \times 100$$

where, fi= number of farmers reporting a particular reason under i^{th} rank,

N = number of farmers

n= number of reasons identified

RESULTS AND DISCUSSION

In these plantation drives, the type of forestry trees that were planted and the place where they were planted was purely according to choice of the farmers (Table 2). According to the survey, the most preferred species included Poplar, *Eucalyptus,* Moringa, Neem and Dek. *Eucalyptus,* neem and moringa were the most planted species in the plantation programmes in sub-mountain undulating zone, western plain zone and central plain zone, respectively. Poplar was the most planted tree species in undulating plain zone and the western zone in the plantation programmes. These findings suggested that tree species with highest preference should be selected for distribution among the farmers of that particular zone. This will ensure the higher chances

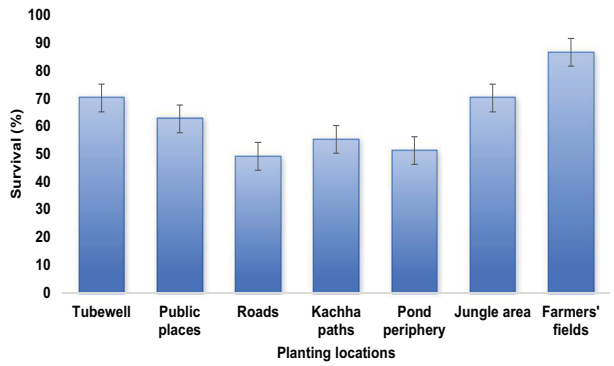

Fig. 2. Overall survival (%) of forestry trees at different planting locations. The differences are non-significant

of the survival of tree species and thus, the success of the plantation programmes.

Survival of different trees species: The type of tree species has significant influence on the survival of different tree species *(p=0.026)*. The highest survival was recorded in *Eucalyptus* (86.8%), followed by poplar (84.3%) and the lowest survival rate was observed in other miscellaneous trees like *Jakranda, Harar, Rohida, Molsari, Pilkan, Kachnar, Gulmohar, Amaltas*, etc. which included medicinal trees, and other slow growing trees. The study revealed that the characteristics of trees influenced the survival and growth of planted trees. Eucalyptus is a fast-growing tree, which can survive under a wide range of temperature and rainfall, thus resulting in higher survival. Similar findings were confirmed by Melkamu *et al.* (2020). In addition to this, Poplar, which is the major agroforestry tree species of Punjab, had higher survival, which can be attributed to the proper after-planting care and management of the trees in the fields.

The survival percent of all the different species of trees planted under the plantation programmes is given in Figure 1. Apart from *Eucalyptus* and poplar

Table 4. Zone-wise survival of different tree species

Forest Tree	Sub-mountain undulating zone		Undulating Plain Zone		Central Plain Zone		Western Plain Zone		Western Zone	
	Total No.	Survival (%)	Total No.	Survival (%)	Total No.	Survival (%)	Total No.	Survival (%)	Total No.	Survival (%)
Poplar	-	-	12300	88 .0	800	60.0	500	93	2050	66.6
Eucalyptus	3600	90	1290	82.7	1025	83.5	150	82	-	-
Neem	-	-	160	65.0	1012	63.8	2812	60.1	319	61.5
Moringa	80	56.3	714	61.2	2040	67.0	400	75.5	345	68.4
Dek	80	60.0	200	60	1430	72.8	1183	61.8	280	65.7
Tahli	25	76	275	64	1070	68.9	794	47.9	135	60.7
Sukhchain	-	-	40	75	670	67.8	200	72	205	60.9
Bamboo	25	100	-	-	7	28.6	617	43.9	100	75.0
Tun	-	-	-	-	640	63.1	-	-	-	-
Arjun	-	-	125	52.8	315	59.7	90	85.6	-	-
Bahera	35	80	-	-	50	50	100	85	-	-
Ornamental Shrubs: Rose, *Chandni*, *Kaner*, Cassia, Palm, etc.	-	-	-	-	1057	70.6	-	-	235	23.8
Misc Trees: Jakranda, *Harar*, *Rohida*, *Molsari*, *Pilkan*, *Kachnar*, *Gulmohar*, *amaltas* etc.	105	87.6	2	50.0	937	62.9	70	92	242	78.0
Total Forest trees*	**3950**	**87.3**	**15106**	**84.8**	**11053**	**68.1**	**6916**	**62.6**	**3911**	**64.1**

*The survival (%) of different tree species was non-significantly affected by agro-climatic zones

which fall under the category of the agroforestry tree species, other forest trees such *viz. Bahera, Sukhchain, Moringa* and *Dek* had higher survival in the range of 65.8% to 74.8%. This can be attributed to the psychological preferences of farmers for these traditional trees. Farmers tend to care more for such trees in social forestry.

Survival in different agroclimatic zones: The tree survival was not statistically different in different agro-climatic zones (*p=0.345*). Among the agroclimatic zones, the survival of trees in sub-mountainous undulating zone (87.3%) was found to be highest followed by survival in undulating plain zone (84.8%). The weather in these zones is cooler with good amount of rainfall that helped in the better survival of the plants. The least survival was recorded in the western plain zone (62.6%). The soils of this zone were water logged, saline and alkali in nature (Gill *et al*., 2016). Moreover, the climate in this zone is of semi-arid nature. Therefore, survival of trees planted in such plantation drives was less as compared to their zones. This can be attributed to the suitable environmental conditions and soil fertility status. Jiang *et al.* (2021) also presented the relationships between environmental factors and growth of tree species.

The survival of forest trees species under different agroclimatic zones is given in Table 4, from which it can be inferred that trees such as *Eucalyptus*, bamboo, *bahera, tahli, jakranda, harar, rohida, molsari, pilkan, kachnar, gulmohar* and *amaltas* can be planted in the sub mountain undulating zone for better survival. In the undulating plain zone, poplar, *Eucalyptus, sukhchain, neem, tahli* can be taken up for plantation drives. *Eucalyptus, dek*, ornamental shrubs like rose, *chandni, kaner, Cassia,* palm, etc., *tahli, sukhchain,* moringa, neem are suitable for planting in the central plain zone. Poplar, *Eucalyptus, arjun, bahera, jakranda, harar, rohida, molsari, pilkan, kachnar, gulmohar, amaltas,* moringa and *sukhchain* can be successfully grown in western plain zone.

Location-wise survival of trees: The trees were planted at different locations such as farmers' fields, near tubewells, roadsides, *kacha paths*, pond periphery, jungle area and public places such as schools, common village areas etc. The place of planting the forestry tree has non-significant effect on the survival percentage *(p=0.068)*. However, the highest survival was observed in the trees planted in the farmers' fields in most of the agroclimatic zones, which can be attributed to better care and maintenance in the fields (Table 5, Fig. 2). The survival of plants was also higher in the plants planted near tubewells which may be due to high water availability leading to better survival during high temperatures in summer season. Lowest survival was observed in the trees planted along roads and *kacha paths*. The poor survival rate on roadsides could be due to

Table 5. Location-wise survival of forestry trees in different agro-climatic zones

Location	Sub nountain undulating zone		Undulating plain zone		Central plain		Western plain zone		West zone		Total	
	Total no. of plants	Survival (%)	Total no. of plants	Survival (%)	Total no. of plants	Survival (%)	Total no. of plants	Survival (%)	Total no. of plants	Survival (%)	Total no. of plants	Survival (%)*
Tubewell	160	80.0	500	80.0	2785	64.5	1222	70.1	1050	78.8	**5717**	**70.1**
Public places	45	75.5	1150	59.3	1320	49.4	2780	67.1	960	70.8	**6255**	**62.6**
Roads	95	65.2	85	61.1	550	32.7	335	61.1	165	63.6	**1230**	**49.1**
Kacha paths	25	64.0	521	47.9	582	30.0	80	71.2	985	72.4	**2193**	**55.2**
Pond periphery	-	-	-	-	500	44.0	80	95.0	5	80.0	**585**	**51.2**
Jungle (or *Jhiri*)	65	70.7	-	-	200	70.0	-	-	-	-	**265**	**70.1**
In private land such as crop fields, houses etc.	3600	90.0	12825	89.6	1980	69.8	189	79.3	-	-	**18594**	**86.6**

*The survival (%) of different tree species was non-significantly affected by planting locations

Table 6. Ranking of technical and fundamental constraints/reasons for poor survival

Sr. No.	Constraints/Reasons	RBQ*	Rank
Technical			
1	Heat stress, water stress, frost damage, overwatering, etc.	79.50	I
2	Damage by wild/stray animals	75.83	II
3	Damage during uprooting and transportation, especially in non-containerized plants – fruit plants	54.17	III
4	Insect and disease attack e.g. virus in papaya, termite attack in trees, etc.	52.00	IV
5	Damage due to regular fire incidents for straw burning/weed control	48.17	V
6	Failure to apply known planting and management techniques	40.33	VI
Fundamental			
1	Lack of manpower at village level for post planting care and management	74.8	I
2	Inadequate supervision of plantations	70.2	II
3	Less preference by farmers for some species due to less financial benefits	64.4	III
4	Wide time gap between procurement of plants and planting.	50.0	IV
5	Delay in planting: plantation done after the monsoon season or after the onset of summer has less chance of survival and requires more care.	40.6	V

*Rank based quotient

poor after care and management, damage by stray animals, etc. The difference in the survival rates at different sites can be due to the factors such as ease in management, water availability and interest of the local community. In some other studies, due to inadequate or improper post-planting maintenance, the majority of trees failed to survive after the tree planting season in the studied areas (Murekezi *et al*., 2013).

Reason for poor survival: It was observed that among the technical reasons, effect of environment such as heat stress, water stress, frost damage, overwatering, etc. was the main reason for poor survival of the plantation with RBQ of 79.50, followed by damage by wild or stray animals with RBQ of 75.83 (Table 6). As a result of climate change, heat stress and drought have become the most important limiting factors to tree survival. Heat stress greatly affected various morphological, biochemical and physiological changes in the plants (Wahid *et al*., 2007). Stray animals are another big problem for establishment of trees in public places. More damage by stray animals might have happened as some animals, particularly goats, are being allowed to roam freely during dry season (Mlamba, 2018). Among the fundamental reasons, lack of manpower for care and management of the plantations emerged as the main reason for failure with RBQ of 79.50. Other reasons responsible for the success of plantation drive are preferences or choice of farmer, wide time gap and delay in planting (Table 6). Human interest and empathy for nature are prominent determinants for proper maintenance of tree plantation done in community places.

CONCLUSION

Tree planting is recognized as one of the most environmentally sustainable activities, as it tends to make a significant contribution to their surroundings by giving oxygen, improving air quality, sustaining ecosystems, maintaining soil and mitigating climate change. It can be concluded that for success of any plantation programme, proper after-planting care and management is necessary. In addition to this, selection of location for planting the trees should be carefully planned in advance such that the place should be near to water source for irrigation of the trees especially during the summer season. Apart from this, trees with fast growth and high market value should be preferred for agroforestry in crop fields and shade, ornamental and medicinal trees should be preferred for plantation near tubewells. Proper fencing around the newly planted trees for protection against stray animal attack and manpower for the management should be made available for successful plantation programme. It can thus be concluded that apart from extensive plantation activities, equal focus on management of the trees planted is a must for making any future plantation programme a success.

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Conflicts of interest

Authors declare that they have no conflicts of interest.

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