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Contribution of CAMPA (Compensatory Afforestation Fund Management and Planning Authority) scheme to Green Cover in Punjab, India

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Abstract

Since 2000, a multiple afforestation programs have been launched by India including the National Afforestation Programme (NAP), the National Mission for a Green India (GIM), the Forest Fire Prevention and Management Scheme (FFPM) and Compensatory Afforestation Fund Management and Planning Authority (CAMPA) etc. The primary objectives of these programs are sustainable development and management of forest resources and increase and improve forest and tree cover. Among these, the CAMPA Act endeavours to uphold ecological integrity while facilitating sustainable development practices. It also signifies a proactive approach to addressing the complex issue of forest land diversion. This synthesis focuses on evaluation of green cover contributed by Compensatory Afforestation Fund Management and Planning Authority during eight years i.e., from 2014-2022 in Punjab, India. It also aimed to study the impact of sampling on evaluation of survival percentage of plantations. The study indicates that Punjab region rapid greening trend has been aided by afforestation initiatives, and it emphasizes the significance of human intervention in promoting regional vegetation growth in the context of climate change.

Keywords: Afforestation, CAMPA scheme, green cover, plantation, survival percentage *etc.*

Introduction

The forest ecosystem and climate change are closely associated (Marshet and Fekadu, 2019). Forests act as carbon sinks as they sequester atmospheric CO_2 and aid in climate change mitigation. The planting of saplings, trees to increase forest cover to protect and conserve environment from the harmful effects of pollution and human development is one way to address this issue. Various afforestation and reforestation schemes such as Compensatory Afforestation Fund Management and Planning Authority (CAMPA), Compensatory Afforestation (CA), Additional CA, Net Present Value (NPV) etc. are designed to increase the green cover of the country/state. Conversion of native grasslands to forest plantations modifies primary production, ecosystem structure (Vassallo *et al.*, 2013), the quantity and quality of litter inputs, root turnover (including exudates), and microclimatic conditions such as moisture and temperature (Chen *et al.*, 2016). Afforestation emerges as a key strategy for restoring and revitalizing urban ecosystems (Dominy *et al.*, 2010), involving the transformation of non-vegetated spaces into forested areas through tree planting (Buendia *et al.*, 2016). This practice plays a crucial role in addressing environmental degradation by enhancing urban greenery, enriching soil fertility, expanding habitats for urban wildlife, and regulating local climates. Internationally, more than 40 nations have allocated a minimum of 15% of their governmental funds towards initiatives such as national forest conservation, afforestation, reforestation, and plantation efforts (Jin *et al.*, 2021; Rosenbaum and Lindsay, 2001). Plantations are being carried out since 2014 in Punjab, India along with several other Indian states under CAMPA scheme on a regular basis and thus it becomes imperative to keep a record of changes being brought by afforestation. This synthesis focuses on the evaluation of green cover contributed by young plantations during eight years (2014– 2022) under

CAMPA/CA/Additional CA in sixteen forest divisions of Punjab, India. The CAMPA, expanded as Compensatory Afforestation Fund Management and Planning Authority Act, is a pivotal piece of Indian legislation designed to establish a robust institutional framework, both centrally and across individual states and union territories. Its primary aim is to facilitate the swift and transparent utilization of funds released in exchange for forest land diverted for non-forestry purposes, thereby mitigating the adverse effects of such diversions. Enacted by the Government of India, the CAMPA Act signifies a proactive approach to addressing the complex issue of forest land diversion. It mandates the creation of a committee tasked with overseeing matters related to the diversion of forest lands for non-forestry purposes, calculating the Net Present Value of the forests being diverted, and ensuring the efficient utilization of funds received under the CAMPA project by respective states. This legislative framework, outlined in an order issued by the Ministry of Environment, Forests, and Climate Change in 2004, underscores the government's commitment to balancing developmental needs with environmental conservation. By establishing mechanisms for compensatory afforestation and prudent fund management, the CAMPA Act endeavours to uphold ecological integrity while facilitating sustainable development practices. Rapid urban development such as building constructions, roads, railways, irrigation canals, agricultural lands, factories and certain other technologies leads to forest destruction, trees displacement, rising temperature, global warming and eventually climate change. Urban ecosystems and human well-being may be impacted by the disappearance of urban trees, forests, and vegetation (Ahn *et al.,* 2015; Jin *et al.,* 2020). Therefore, in a semi-arid region such as Punjab where urbanization, industrial development and low vegetational area are frequent to be seen; compensatory afforestation comes to play a massive role. In this synthesis we intended to assemble and compare divisional afforestation progress during eight years i.e., 2014 – 2022 through the assessment of survival percentage of plantations. The species elected for plantation include heat resistant which are mostly native to Punjab region. These were *Acacia catechu, Acacia nilotica, Ailanthus excels, Albizia lebbek, Albizia procera, Alstonia scholaris, Azadirachta indica, Bauhinia variegata, Butea monosperma, Callistemon viminalis, Cassia fistula, Casuarina equisetifolia, Chukrasia tabularis, Cordia myxa, Dalbergia sissoo, Dendrocalamus strictus, Euclyptus spp., Ficus benghalensis, Ficus religiosa, Grevillea robusta, Holoptelea integrifolia, Jatropha curcas, Kigelia pinnata, Mangifera indica, Melia composita, Moringa oleifera, Morus alba, Nerium oleander, Parkinsonia aculeata, Phyllanthus emblica, Pithecellobium dulce, Pongamia pinnata, Tectona grandis, Terminalia arjuna, Thevetia peruviana, Toona ciliata* and *Zyziphus mauritiana* etc. We have explored the survival percentage of overall tree species in forest divisions; however, the individuality of species survival is beyond the scope of this synthesis. We also attempted to study the impact of sampling on evaluation of survival percentage of plantations..

Materials and Methods

Study area

Punjab, the northwestern state of India is located between 29° 30' N to 32° 32' N latitude and 73° 55' E to 76° 50' E longitude. It has geographical area of 50,362 sq. km, which is 1.54 % of country's total geographical area. The state is situated at an average elevation of 300 m above sea level. Most of the land in Punjab is fertile alluvial plain, irrigated by rivers and canals; except the south-east region having semi-arid and desert conditions. The southern part of the state borders with arid areas of Thar Desert of Rajasthan. The state forms a part of Indo-Gangetic alluvial plain and is composed of sediments of Shiwalik hills and Himalayas brought down and laid by the rivers of Indus system. The tall vegetation is comprised mainly by *Acacia nilotica, Acacia catechu, Azadirachta indica, Bauhina variegata, Holoptelia integrifolia, Melia composita, Morus alba* and *Pongamia pinnataetc*. The small vegetation is dominated by herbs and shrubs such as *Achyranthes aspera, Argemone mexicana, Cannabis sativa, Calotropis procera, Parthenium hysterophorus, Ricinus communis* and *Saccharum spontaneum* etc. The state is comprised of sixteen forest divisions namely Amritsar, Bathinda, Dasuya, Ferozepur, Garhshankar, Gurdaspur, Hoshiarpur, Jalandhar, Ludhiana, Mansa, Shri Muktsar Sahib, Pathankot, Patiala, Rupnagar, Sangrur and SAS Nagar (Mohali). The forest composition in the state are Northern Dry Mixed Deciduous Forests having small crown which include *Acacia catechu, Anogiessus latifolia, Dalbergia sissoo, Acacia nilotica*; Dry Deciduous Scrub Forests which include *Carissa opaca, Adhatoda vasica, Lantana camara* and *Dodonia viscosa*; Dry Tropical Riverain Forests which include *Terminalia arjuna, Syzygiun cumini, Holoptelea integrifolia, Tamarix diocia, Bombax ceiba* and *Butea*

monosperma; Khair-Sissoo dominated by *Dalbergia sissoo*; Butea forests distributed in the locality where badly drained clayey soils or very dry clayey soils are found at the foot of hills. The common species in these regions are *Butea monosperma, Ficus religiosa, Acacia nilotica, Ziziphus species*. Amongst grasses *Vetiveria zizanioides, Eranithus munga, Eleusine species, Bothriochlo apertusa, Hetropogon contortus* and *Apluda mutica* are common. Hoshiarpur, Pathankot and Ropar Forest Divisions are seen distributed with Dry Bamboo Brakes which is dominated by *Dendrocalamus strictus*. Shiwaliks Chir pine Forests is also seen distributed with the scattered lower deciduous tree storey more numerous in depression and cool aspects of Shiwalik hills. *Pinus roxburghii* is dominant species of this region (Champion and Seth, 1968).

Methods

The main objective of the study was to compare survival percentages during eight years (2014 – 2022) of plantations carried out by Punjab Forest Division under different plantation schemes in sixteen forest divisions. The data of five years plantations from 2014 – 2018 were pooled from Forest Research Institute, Dehradun PUNCAMPA publications. Whereas, data for three years plantations i.e., 2019 – 2022 was collected during February – December, 2023. However, the methodology followed pertaining to survival assessment was consistent for all eight years plantations.

The sampling was carried out by selecting sample plots in each division to carry out the assessment of plantations. The division was considered as a unit and representation of size of plots and category of plantations was also taken in consideration. Random samplings along with convenient sampling have been preferred for selection of sample plots. The total selected plantation site was traversed and area was verified by GPS. The geo-coordinates of the monitored sites were marked by GPS and mapped using ArcGIS (Fig. 1 (a,b,c)). About ninety-five percent of the sites for plantations 2019-22 sampling and about 50% sites for plantations 2014-2018 were selected for survival assessment of the total plantation sites and 10% of the plantation's area of each sample site was selected for data collection. However, more than 10% area was also selected for large area plantations depending on the sample size. In each patch, up to size of 5 ha, five sample plots of 0.1 ha were laid, in patch of 10 ha ten plots of 0.1 ha were laid, in case of patch with area 15 ha 15 samples plots, and for 20 ha size patch a total of 20 sample plots were laid for survival assessment. Within the plantation patches plots of 0.10-hectare size 31.62m x 31.62m were laid in rectangular or square shape as per field convenience to assess survival and growth parameters of plants as per format. Most of the plantation sites were roadside and few were off - road. Therefore, sampling was strategized separately according to the location of study sites. On roadside plantation, an area of plantation site was randomly chosen for assessment. For only one side plantation either right or left side to the road, a plot of 5 × 90 m2 was drawn and data was collected. For both side plantations, plots 5 × 45 m2 were drawn at intervals. The sample plots proportionately allocated into each division so as to cover the scheme and its components. Selected plantation area or site was examined for area accuracy with the help of GPS by way of traversing around the boundary of the plantation. Survival rate was estimated by counting number of surviving plants to the total number of plants planted falling within plots. The data obtained was analyzed using SPSS 16.0 and MS Excel 2021. We evaluated weighted averages for survival percentage of each division to omit out the impact of area and to standardize and equalize the comparison. The details of number of sites and area covered in each division during eight years are given in Tab. 1.

Results and Discussion

A total of 3020 plantation sites were visited to evaluate the survival percentage of plantations during eight years. The maximum sites were covered for the year 2019-20 plantations which constitutes to the 21% of total sites followed by 2020-21 and 2021-22 plantation sites constituting 19%(each) of total sites. The minimum sites were visited for 2014-15, 2015-16 and 2018-19 plantations with 5%, 6% and 9% respectively of total sites (Fig. 2(a)). Total area covered was 24740.55 hectares. Maximum area was covered for 2019-20 plantations i.e., 24% of total area followed by 2021-22 plantations viz., 23% and 18% for 2019-20 plantations. Minimum area was covered for 2014-15, 2015-16 and 2017-18 plantations (Fig 2(b)).

Plantations were recorded with a survival percentage of range 67 – 77% during eight years in sixteen forest divisions. Maximum survival percentage was observed for year 2017 – 18 plantation (77%) and minimum for 2014 – 15 plantations (67.92%). ISFR 2019 has also reported a gain of 12 sq. km (0.65%) in total forest cover with respect to its previous assessment report of 2017. Our study has revealed that plantation survival was minimum for year 2014 – 15

plantations and during the same year, total forest was evaluated least i.e., 1771 sq. km (ISFR, 2015) in the state of Punjab. Among sixteen divisions, maximum average survival percentage was recorded for Shri Muktsar Sahib Forest Division (79.81%) and Ferozepur Forest Division (76.87%). Mansa Forest Division was recorded with minimum average survival percentage during eight years (67.64%). Forest Survey of India, 2021 has reported Ferozepur (20.98 sqkm; 1.03% of geographic area) and Muktsar (1.62 sqkm; 0.77% of geographic area) forest divisions with a gain of maximum change with respect to 2019 assessment. The common outcomes of these observations reflect the influence of afforestation schemes being brought in forest divisions of Punjab for green and sustainable development. Afforestation stands out as a highly impactful method of enhancing green spaces within urban areas, offering significant mitigation against a range of environmental challenges (Jin *et al.*, 2021). Validation from spatial analysis of ISFR, 2021, it has been observed that afforestation increased the overall forest in Punjab, surpassing the initial target. After afforestation, the entire freshly planted green area surpassed the intended target by 66 sq. km of trees. During 2015 – 2021, Punjab has gained 0 to 11 sq. km of very dense forest and from 1771 to 1847 sq. km of total forest. Moderate dense forest has fluctuating records during 2015 – 2021 (Tab. 3). This signifies the role of afforestation programs being played in compensatory green mission and climate change. We have assessed plantations using traditional field survey method by laying plots and visual interpretations. Spatial analysis is an alternative and much advance approach for plantation monitoring and evaluation. However, as the plantations assessed to carry out the present study were one, two- and three-years young; therefore, spatial analysis could be doubted as equally impactful as traditional method. Plantation monitoring using a digital camera and integrated sensors has been carried by Putra et al., 2020. The study highlighted the future research potential related to the use of image information for plantation management, especially in areas with high-density trees, agroforestry, and narrow plantation areas (Putra *et al.*, 2020). New afforestation plantations are less dense, distantly apart as plantations are done conveniently and are not very tall. Nevertheless, spatial analysis could not be overlooked for plantation monitoring and evaluation.

We have placed sixteen forest divisions under four groups on the basis of their plantation survival performance. Although, each forest division has survival percentage above 60%, however, five divisions i.e., Garhshankar Forest Division, Hoshiarpur Forest Division, Jalandhar Forest Division, Ludhiana Forest Division, Mansa Forest Division (Group I) has comparatively lower survival percentage of below 69%. Therefore, plantation management needed to be more focused in these forest divisions in the near future. Maximum green cover contribution has been made by Muktsar Sahib, Ferozepur and Sangrur Forest Divisions (Group IV) with an average survival percentage of 75 and above during eight years. Pathankot, Patiala and Rupnagar forest divisions has also shown considerable plantation survival performance of range 72% - 74% (Group III).Amritsar, Bathinda, Dasuya, Gurdaspur and SAS Nagar Forest Division have been placed in Group II with average survival percentage of 70 – 72%.

Eight years assessment of plantations

In 2014-2015 plantations, among sixteen forest divisions Muktsar Forest Division was recorded with maximum average survival percentage of 79.21% followed by Amritsar (74%) and Sangrur Forest division (73%). Minimum average survival percentages were recorded for Dasuya (61.02%), SAS Nagar (62%) and Jalandhar (62.21%) forest divisions. In 2015-16 plantations, Patiala Forest division was recorded with survival percentage of 80% and Muktsar sahib was seen with average survival percentage of 76.57%. Seven forest divisions were observed with an average survival percentage of more than 70% (Tab. 2) for 2015-16 plantations. Four forest divisions i.e., Bathinda, Garhshankar, Jalandhar and SAS Nagar were recorded with an average survival percentage of less than 65%. In 2016-17 plantations, Ferozepur (81.89%), Muktsar (81.59%), Patiala (80.3%), Dasuya (80.23%) had maximum plantation survival percentage and Jalandhar (59.45%), Mansa (61%) were recorded with minimum survival percentages. In the year 2017-18, Ferozepur attained maximum average survival percentage (87.33%) of plantations. Plantations in Sangrur Forest divisions (86.62%) were also seen performing extremely good this year. For year 2018-19, minimum average survival percentage was 69% and all forest divisions were recorded with average survival percentage of more than 70%. In 2019-20 plantations, the survival percentage of plantations was recorded in the range of 66 – 77% with maximum survival percentage in Muktsar Sahib Forest Division (76.15%) and minimum in Patiala Forest Division. Muktsar Sahib also led 2020-21 plantations and 2021-22 plantations. In eight years of plantation assessment,

2017-18 and 2018-19 plantations contributed to maximum green cover in the state of Punjab. We observed that Shri Muktsar Sahib Forest Division consistently performed virtuous through eight years falling in the range of 74 – 88% of plantation survival as shown through Box & Whisker diagram (Fig. 3). Muktsar Sahib has also been seen improving total forest by 1.62 sq. km (ISFR, 2021) and our results also depicts that the forest division is expected to be increasing in the near future assessment for forest cover. Descriptive statistical analysis of sixteen forest divisions of Punjab revealed that the survival percentage of plantations during eight years were most dispersed for Ferozepur, Sangrur and SAS Nagar Forest Divisions (Fig.2) and least dispersion was seen for Gurdaspur, Amritsar and Ludhiana. A wide dispersion in survival percentage of plantations indicates variations in environment and climate of specific area and least dispersion reflects high uniformity in observations and the consistency of climate in that locality which might have helped in maintaining uniformity. We have recorded an outlier for Mansa Forest Division due to its lowest survival percentage estimation (61%) for the year 2016-17. This could be attributed to extreme heat and drought climate of Mansa. Despite minor fluctuations, Mansa division exhibited a relatively Tab. survival percentage trend without any drastic increases or decreases.

Garhshankar Forest Division maintained relatively consistent survival percentages with minor fluctuations throughout the eight years. Survival percentages of plantations in Ludhiana Forest Division remained Tab., fluctuating around a similar range without significant variations over the period. The survival percentage in Patiala Forest Division showed consistent levels over the years with fluctuations but no clear trend of significant increase or decrease. These divisions demonstrated more Tab. survival percentage trends compared to others, indicating a consistent performance in terms of forest survival rates over the eight-year period. In Gurdaspur Forest Division, the survival percentage started at 69.3% and showed a clear increasing trend, reaching 73.69% by 2021-2022.Sangrur Forest Division plantations survival percentage showed an overall increasing trend from 67.7% to 86.62% over the eight-year period. These divisions exhibited consistent and significant increases in survival percentages from the beginning to the end of the analyzed period. We have evaluated average survival percentage, standard deviation and z – scores for every forest division (Tab. 5). These scores indicate dispersion of survival percentages of plantations more appropriately. The z – scores were found in the range of -2.37 to 1.73 indicating dispersion and data without any distinct outliers.

We tested the relatedness between number of sites, area covered and survival percentage using Pearson's correlations to assess the impact of sampling on survival estimation. The survival percentage was not seen relating with any of these two factors (Fig. 4). This shows that the survival estimation did not get affected by a smaller number of sites and area covered for 2014-2018 plantations and also, increased sampling for 2019 – 22 plantations did not improve or deprive survival percentage estimation.

Future Prospects of the Study

This study lays the underpinning to further comprehend the role of afforestation in greening and climate change. Spatial analysis of landscape transition detection could be carried out to highlight areas that have recorded maximum green cover in a semi-arid region like Punjab. Furthermore, thorough assessment of ecosystem services and other costs or benefits could be conducted; however, we sturdily demand to identify the spatial-temporal changes during afforestation before implementation. This shall also comprehend major issues with managing planted sites and the expenditures associated with replacing lost land. Also, survival percentage estimation at species level could be carried out which shall highlight adaptability of tree species better suited to studied region. Contribution of afforestation schemes to green cover statistics in various other regions of the country shall also be studied.

Conclusions

This study forms a robust database of afforestation implementation for eight years plantations in sixteen forest divisions of Punjab. It attributes the significant increase in green cover in the Punjab state to Shri Muktsar Sahib and Ferozepur Forest divisions along with Sangrur, Pathankot, Patiala and Rupnagar forest divisions. However, plantations could be improved in Garhshankar Forest Division, Hoshiarpur Forest Division, Jalandhar Forest Division, Ludhiana Forest Division and Mansa Forest Division. We felt primary challenges for the assessment of new afforestation which are: i) lack of spatial distribution evaluation ii) overstatement of outcomes in afforestation and iii) extensive field surveys. Therefore, we also put forth an urge for spatial analysis of implementation of afforestation programs which shall assist in designing further afforestation and

reforestation schemes and proper utilization of funds. The explicit survey of literature reveals no study on new afforestation assessment in India. Hence, the study is first of its kind to form a database on afforestation assessment and act as a base for afforestation assessment studies using spatial analysis in the near future.

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Reference

Ahn R., Burke T.F., McGahan A.M. (2015) Innovating for Healthy Urbanization; *Springer: Boston, MA, USA*. ISBN 9781489975973. doi: 10. 1007/978-1-4899-7597-3

Buendia C., Batalla R.J., Sabater S., Palau A., Marcé R. (2016) Runoff Trends Driven by Climate and Afforestation in a Pyrenean Basin. *Land Degradation and Development* 27: 823–838. doi: 10.1002/ldr.2384

Chen L.F., He Z. B., Zhu Xi, Du J, Yang J. J., Li J. (2016) Impacts of afforestation on plant diversity, soil properties, and soil organic carbon storage in a semi-arid grassland of northwestern China. *Catena* 147: 300-30 https://doi.org/10.1016/j.catena.2016.07.009

Dominy S.W.J., Gilsenan R., Mckenney D.W., Allen D.J., Hatton T., Koven A., Cary J., Yemshanov D., Sidders D. (2010) A retrospective and lessons learned from Natural Resources Canada's Forest 2020 afforestation initiative. *For. Chron.*86, 339–347 doi: 10.5558/tfc86339-3

ISFR (2015) India State of Forest Report, Forest Survey of India. (Ministry of Environment & Forests), Dehradun, India.

ISFR (2017) India State of Forest Report, Forest Survey of India. (Ministry of Environment & Forests), Dehradun, India.

ISFR (2019) India State of Forest Report, Forest Survey of India. (Ministry of Environment & Forests), Dehradun, India.

ISFR, (2021) India State of Forest Report, Forest Survey of India. (Ministry of Environment & Forests), Dehradun, India.

Jin J., Gergel S.E., Lu Y., Coops N.C., Wang C. (2020) - Asian Cities are Greening While Some North American Cities are Browning: Long-Term Green space Patterns in 16 Cities of the Pan-Pacific Region. *Ecosystems* 23, 383–399. doi: 10.1007/s10021-019-00409-2

Jin J., Sheppard S.R.J., Jia B., Wang C. (2021) Planning to Practice: Impacts of Large-Scale and Rapid Urban Afforestation on Green space Patterns in the Beijing Plain Area. *Forests* 12: 316. https:// doi.org/10.3390/f12030316

Marshet N G., Fekadu H H. (2019) Review on Effect of Climate Change on Forest Ecosystem. *Int. J Environ Sci. Nat Res.* 17(**4**): 555968. doi:10.19080/IJESNR.2019.17.555968

Putra B. T. W., Soni P., Marhaenanto B., Harsono S. S. Fountas S. (2020) Using information from images for plantation monitoring: A review of solutions for smallholders. Information Processing in Agriculture, 7(**1**): 109-119. http://dx.doi.org/10.1016/j.inpa.2019.04.005

Rosenbaum K.L., Lindsay J.M. (2001) An Overview of National Forest Funds: Current Approaches and Future Opportunities. Food and Agriculture Organization of the United Nations: Rome, Italy.

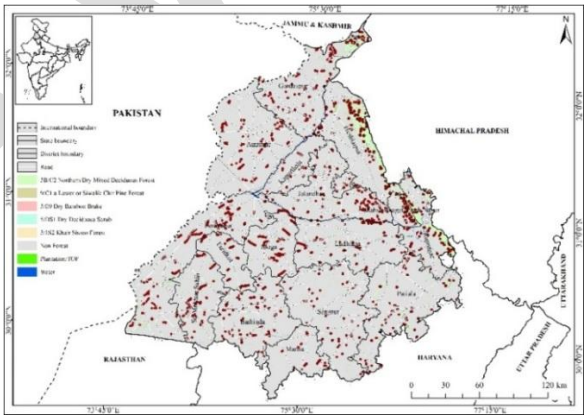


Fig. 1. a) Location plots of 2019-20 plantations

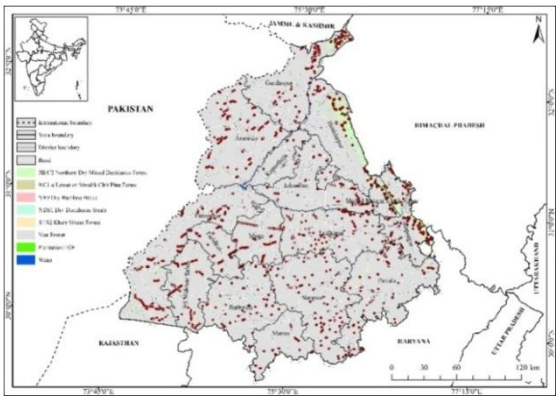
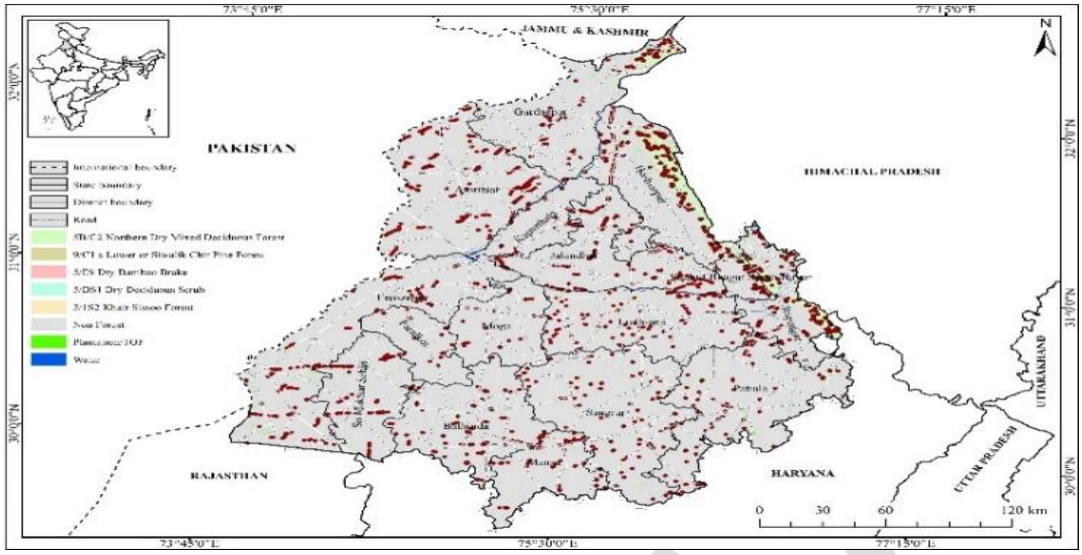


Fig.1. b) Location plots of 2020-21 plantations



b) Location plots of 2021-22 plantations

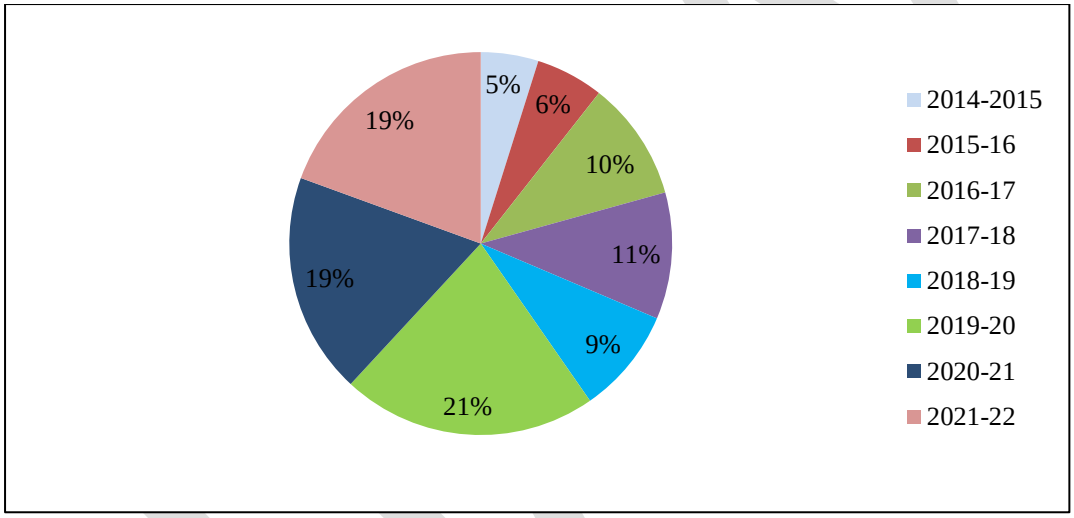
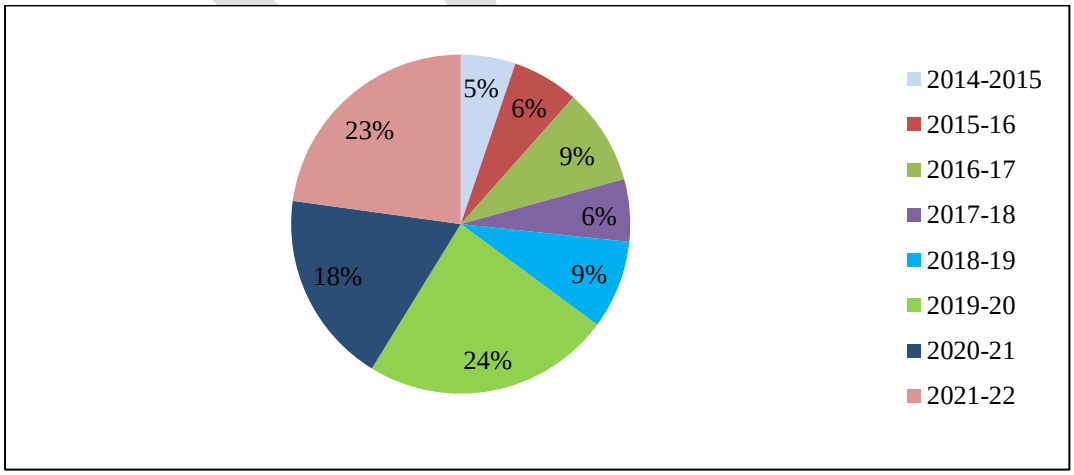


Fig. 2: a) the site proportion visited for survival estimation during eight years



b) Area proportion covered for survival estimation during eight years in sixteen forest divisions of Punjab state

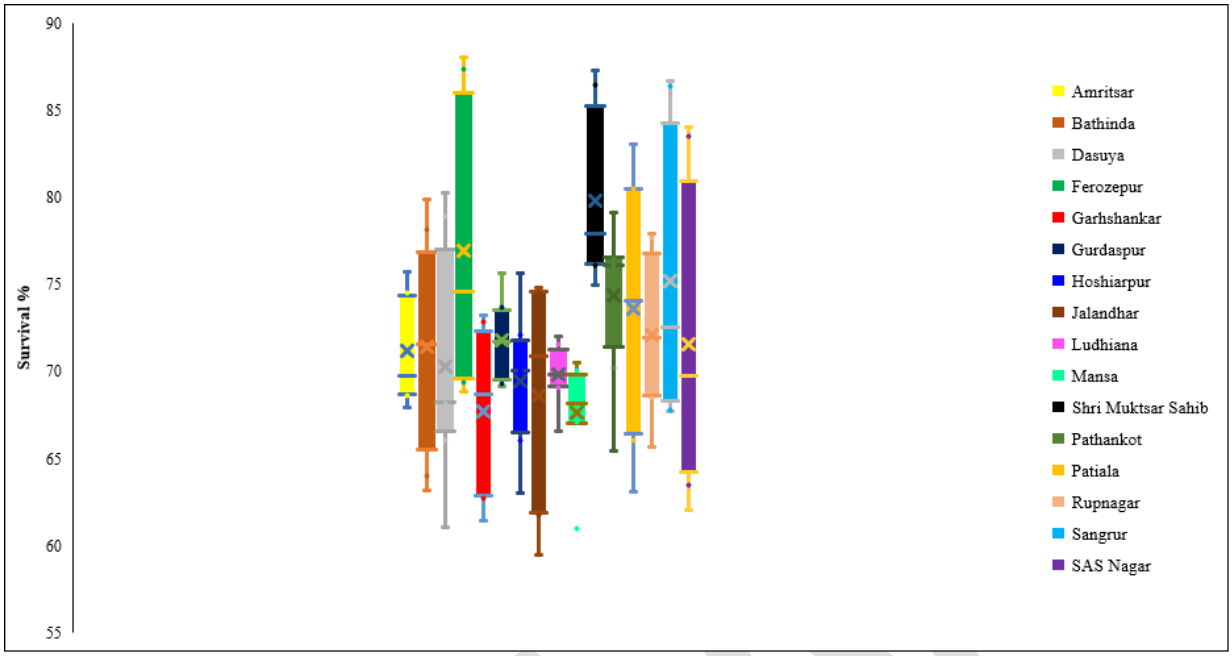


Fig. 3: Distribution of survival percentage for eight years in sixteen forest divisions of Punjab state

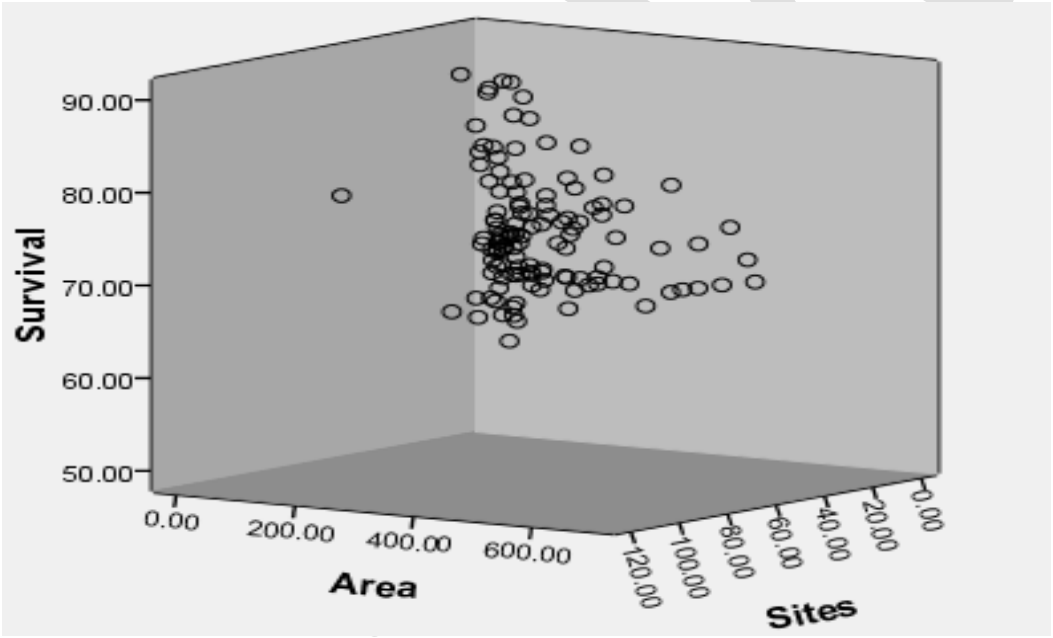


Fig. 4: Relatedness between plantation sites, plantation area and survival percentage

Table 1: Details of no. of sites and area covered for eight years (2014-2022) in sixteen forest divisions of Punjab state of India

Sr. no.	Name of Forest Division	2014-2015		2015-16		2016-17		2017-18		2018-19		2019-20		2020-21		2021-22	
		No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)	No. of Sites	Area Covered (Ha)
1	Amritsar Forest Division	9	76	16	127	30	183	17	125.57	21	147.49	29	282.842	34	218	40	263
2	Bathinda Forest Division	6	130	4	30	11	66	9	38	14	52	56	308.64	36	198.78	44	233.92
3	Dasuya Forest Division	7	71.46	6	80	14	112	11	70.32	18	119.69	34	386	31	320	35	479.83
4	Ferozepur Forest Division	19	139	12	126	25	266	19	40	14	104.68	49	419.4	49	304.19	44	384
5	Garhshankar Forest Division	11	106	9	87	31	74	19	111.39	15	194.78	67	415	36	464	47	491.4
6	Gurdaspur Forest Division	10	77.04	11	68.9	17	70.25	10	71	13	78	28	301.4	29	201.22	25	265.1
7	Hoshiarpur Forest Division	6	46	15	86	6	40	14	74.09	20	208	41	627	21	310.25	39	576.5
8	Jalandhar Forest Division	15	95	16	123	15	106	26	130.29	18	87.86	46	207.99	35	208.74	32	273.92
9	Ludhiana Forest Division	5	49	6	80	13	102	9	84.18	10	140	51	402	55	362.88	63	436.3
10	Mansa Forest Division	3	41	6	55	5	12.2	10	64.4	10	39.03	14	99.67	31	160	19	133.34
11	Shri Muktsar Sahib Forest Division	10	35	16	76.03	20	189	12	82.39	22	157.65	38	261.721	27	216.92	29	319.255
12	Pathankot Forest Division	5	86	8	61	20	109	14	105.83	13	208.08	29	357.2	28	315.39	26	310
13	Patiala Forest Division	6	13	12	66	49	518	112	218.74	24	86.03	50	348.446	50	359.13	47	288.83
14	Rupnagar Forest Division	15	84	11	192	11	107	15	89.91	19	220.12	43	622.22	30	397.3	35	506.15
15	Sangrur Forest Division	9	149	12	201	29	189	16	75.6	19	84.94	48	296.559	43	258.57	28	179.35
16	SAS Nagar Forest Division	11	97	13	109	9	120	10	92.4	20	160.536	28	518	29	258.57	34	502.75
Total		**147**	**1294.5**	**173**	**1567.93**	**305**	**2263.45**	**323**	**1474.11**	**270**	**2088.886**	**651**	**5854.088**	**564**	**4553.94**	**587**	**5643.645**

Table 2: Average survival percentage of plantations for eight years (2014-2022) in sixteen forest divisions of Punjab state

Sr.no.	Name of Forest Division	2014-2015	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	Amritsar Forest Division	74	70.2	68.61	75.72	74.5	67.91	69.2	69.01
2	Bathinda Forest Division	64	63.14	72.05	79.89	78.12	70.07	71.07	73.06
3	Dasuya Forest Division	61.02	66	80.23	78.87	71.4	68.18	68.33	68.13
4	Ferozepur Forest Division	76	73.17	81.89	88.04	87.33	69.34	68.8	70.42
5	Garhshankar Forest Division	61.4	62.7	63.2	69.62	72.82	70.61	67.8	73.24
6	Gurdaspur Forest Division	69.3	73	70.45	70.2	69.11	75.62	72.99	73.69
7	Hoshiarpur Forest Division	63	70	66	67.96	70.87	70.1	72.08	75.6
8	Jalandhar Forest Division	62.21	61.73	59.45	72.32	69.37	74.6	74.82	74.51
9	Ludhiana Forest Division	69.26	71.55	66.54	70.37	72.02	69.07	69.86	69.71
10	Mansa Forest Division	70	67.02	61	67.06	69.31	70.5	67.38	68.89
11	Shri Muktsar Sahib Forest Division	79.21	76.57	81.59	87.23	86.42	76.1	76.4	74.96
12	Pathankot Forest Division	70.2	75	65.45	76.55	76.44	76.15	76.06	79.08
13	Patiala Forest Division	63.12	80	80.3	80.47	83.02	66.04	68.06	67.59
14	Rupnagar Forest Division	69	71.22	74.14	77.67	77.89	72.56	65.64	68.44
15	Sangrur Forest Division	73	72	78	86.62	86.33	69.89	67.7	67.77
16	SAS Nagar Forest Division	62	63.46	66.41	83.5	84.03	68.52	71.02	73.15

Table 3: Data matrix of change in forest cover in Punjab since 2015 to 2021

Year	Geographic Area	Very Dense Forest (VDF)	Moderate Dense Forest (MDF)	Outside Forest	Total Forest	% of Geographic Area	Change in Forest Cover w.r.t. Previous Year	Change % w.r.t. Previous Year	Scrub
2015	50,362	0	735	1036	1771	3.52	-	-	-
2017	50,362	8	806	1023	1837	3.67	66	0.13	33
2019	50,362	8	801	1040	1849	3.67	12	0.65	33
2021	50,362	11	793	1043	1847	3.67	-2	-0.11	34

Table 4: Classification of forest divisions as per survival percentage estimation

	Average Survival Percentage (2014-15 to 2021-22)	Forest Divisions
Group I	67 - 69%	Garhshankar Forest Division Hoshiarpur Forest Division Jalandhar Forest Division Ludhiana Forest Division Mansa Forest Division
Group II	70 - 72%	Dasuya Forest Division Amritsar Forest Division Bathinda Forest Division Gurdaspur Forest Division SAS Forest Division
Group III	73 - 75%	Pathankot Forest Division Patiala Forest Division Rupnagar Forest Division
Group IV	75 - 80%	Ferozepur Forest Division Muktsar Sahib Forest Division Sangrur Forest Division

Table 5: Mean ± SD of weighted average survival percentage and z- scores for sixteen forest divisions of eight years plantations of Punjab state

Sr.no.	Name of Forest Division	Mean ± SD	Z - scores							
			2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	Amritsar Forest Division	71.14±2.88	0.99	-0.33	-0.88	1.59	1.16	-1.12	-0.67	-0.74
2	Bathinda Forest Division	71.43±5.54	-1.34	-1.50	0.11	1.53	1.21	-0.24	-0.06	0.30
3	Dasuya Forest Division	70.27±6.03	-1.53	-0.71	1.65	1.43	0.19	-0.35	-0.32	-0.35
4	Ferozepur Forest Division	76.87±7.39	-0.12	-0.50	0.68	1.51	1.41	-1.02	-1.09	-0.87
5	Garhshankar Forest Division	67.67±4.39	-1.43	-1.13	-1.02	0.44	1.17	0.67	0.03	1.27
6	Gurdaspur Forest Division	71.80±2.20	-1.13	0.55	-0.61	-0.72	-1.22	1.73	0.54	0.86
7	Hoshiarpur Forest Division	69.45±3.59	-1.80	0.15	-0.96	-0.42	0.40	0.18	0.73	1.71
8	Jalandhar Forest Division	68.63±6.08	-1.06	-1.13	-1.51	0.61	0.12	0.98	1.02	0.97
9	Ludhiana Forest Division	69.80±1.57	-0.34	1.11	-2.07	0.36	1.41	-0.46	0.04	-0.06
10	Mansa Forest Division	67.65±2.81	0.84	-0.22	-2.37	-0.21	0.59	1.02	-0.09	0.44

11	Shri Muktsar Sahib Forest Division	79.81±4.50	-0.13	-0.72	0.40	1.65	1.47	-0.83	-0.76	-1.08
12	Pathankot Forest Division	74.37±4.10	-1.02	0.15	-2.17	0.53	0.51	0.43	0.41	1.15
13	Patiala Forest Division	73.58±7.55	-1.39	0.85	0.89	0.91	1.25	-1.00	-0.73	-0.79
14	Rupnagar Forest Division	72.07±4.10	-0.75	-0.21	0.50	1.37	1.42	0.12	-1.57	-0.89
15	Sangrur Forest Division	75.16±7.22	-0.30	-0.44	0.39	1.59	1.55	-0.73	-1.03	-1.02
16	SAS Nagar Forest Division	71.51±7.86	-1.21	-1.02	-0.65	1.53	1.59	-0.38	-0.06	0.21

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