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Original Article

Tree Species Preference and Economic Analysis of Tree Nurseries in Dryland; A Case Study of KEFRI Turkana Nursery 2020-2022

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ABSTRACT

Tree nursery establishment is a major component in the realisation of the global efforts to climate change adaptation and mitigation. The desire to plant trees is a function deeply influenced by preferences in both social and ecological aspects. This paper was aimed at evaluating the community's tree species offtake preference in Turkana and identifying the optimal seedlings offtake season for planting in the drylands. In this study, data collection involved the meticulous acquisition of information directly from the nursery tree seedlings' offtake records. The process involved systematic retrieval of the quantities of tree species sold over a three-year period from January 2020 to December 2022. A comprehensive dataset of 590 samples was assembled, enabling a detailed analysis of tree species preferences and their economic implications within the dryland context. The data was fed into SPSS version 27 for analysis. Seasonality indices were calculated, and descriptive statistics were conducted. Excel version 2016 was used to construct pivot tables, line charts and bar graphs. The results showed that Azadirachta indica (neem tree) stands out with a 40.1% preference rate among the top ten species, attributed to its multifaceted benefits. Conversely, Terminalia mantaly (umbrella tree) holds a more modest 2.69% preference. Exotic species dominate the top ten preferred list at 71.44%, while indigenous species make up 28.56%. The seasonality index conducted indicated April, September, October, and November having the highest indices, suggesting a propensity for heightened demand and increased seedlings offtake from the Turkana KEFRI nursery. The study's recommendations emphasise the need to initiate seedling production activities well in advance to align with the optimal seedling demand season, thus enhancing the overall effectiveness of tree planting efforts.

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INTRODUCTION

The conservation and restoration of tree species in dryland areas play a vital role in maintaining ecological balance and promoting sustainable development. According to FAO (2010), dryland occupies 40% of the total land mass and about 5-15% of the global terrestrial carbon sequestration; thus, it plays a considerable role in mitigating the impacts of climate change. Tree nurseries serve as important institutions for the propagation and distribution of tree species, contributing to ecosystem restoration efforts. Understanding the tree species preferences and conducting an economic analysis of tree nurseries in dryland regions are crucial for effective conservation strategies and informed decision-making. Dryland areas are characterised by low and unpredictable rainfall, high evaporation rates, and limited water availability, posing significant challenges to tree growth and survival. However, the strategic selection of tree species that are well-adapted to these arid conditions can contribute to ecosystem resilience, soil stabilisation, and the provision of various ecological services.

The selection of tree species in dryland areas is influenced by various factors, including environmental conditions, soil characteristics, water availability, and the specific ecological requirements of different species. Identifying the preferred tree species in these regions is essential to ensure the successful establishment and growth of trees, as well as their ability to provide desired ecological and socioeconomic benefits. Furthermore, conducting an economic analysis of tree nurseries provides insights into the financial viability, cost-effectiveness, and profitability of tree propagation and distribution activities (Jamnadass, 2011). This analysis includes evaluating the most preferred tree seedling species, as well as assessing the potential returns from tree seedling sales and associated products or services.

Understanding the economic aspects of tree nurseries helps in optimising resource allocation, improving business models, and enhancing the overall sustainability of tree propagation initiatives (Jamnadass, 2011). This study aims to investigate the tree species preferences and conduct the economic viability of tree nurseries in dryland areas. By examining the species preferences, researchers and conservationists can identify the most suitable tree species for restoration efforts and prioritise their propagation and distribution. The identification of these preferred species is often based on their ability to tolerate drought, resist pests and diseases, enhance soil fertility, provide shade, and offer other valuable ecosystem services. The findings of this study will contribute to the knowledge base on tree species preferences and economic aspects of tree nurseries in dryland regions. The insights gained from this research will assist in the development of targeted conservation and restoration programs, policy frameworks, and sustainable business models for tree propagation and distribution. By aligning tree species preferences with economic viability, stakeholders can make informed decisions regarding resource allocation, market strategies, and potential collaborations. Ultimately, the effective management of tree species preferences and economic considerations will foster ecological resilience, enhance ecosystem services, and promote socioeconomic development in dryland areas. The combination of suitable tree species

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and economically viable nursery operations will support the restoration of degraded landscapes, contribute to climate change mitigation and adaptation efforts, improve the livelihoods of communities in dryland regions and contribute to the development of informed tree planting strategies and sustainable livelihoods in the drylands of Turkana.

Evaluating the long-term economic sustainability of tree nurseries involves considering factors such as product diversification, value-added processing and potential income-generating activities associated with tree planting. Researchers have examined the economic viability and financial returns of tree nurseries, taking into account factors such as subsidies, incentives, and market fluctuations (Cannell, 1988). The major objective of this study is to assess the tree species preference in Turkana in terms of their offtake from the nursery. The specific objectives are to evaluate the community's tree species preference for planting in the drylands of Turkana, assess the economic viability of tree nurseries in drylands for sustainable livelihoods and finally, identify the optimal planting season to ensure that seedlings are prepared and available for planting in the drylands.

LITERATURE REVIEW

Dryland regions, characterised by low rainfall and high evaporation rates, present unique challenges for tree establishment and growing (Hailu & Mehari, 2021). The success and sustainability of tree nurseries in these arid and semi-arid environments rely on the careful selection of tree species. Additionally, economic analysis is crucial in assessing the viability of tree nurseries and guiding decision-making processes. This literature review aims to provide an overview of research conducted on tree species preference and economic analysis in dryland tree nurseries.

Ecological adaptation is a significant factor influencing tree species preference in dryland areas. Certain tree species exhibit characteristics that make them well-suited for arid and semi-arid conditions, such as drought tolerance, heat resistance, and low water requirements. Researchers have conducted studies to explore the physiological and morphological traits of tree species and their suitability for dryland environments. Moreover, economic value plays a crucial role in determining the preference for specific tree species in dryland nurseries. Market demand for timber, non-timber forest products, and ecological services greatly influence the selection of species. Studies have examined the economic benefits associated with particular tree species, including their potential contribution to local livelihoods (Reed et al., 2017). These are significant aspects that influence the offtake of these species for planting and influencing the behavioural change of communities living in the drylands towards tree growing and restoration. Another significant aspect towards tree planting is looking at the environmental considerations, especially while selecting tree species for dryland nurseries. Over the years, the impacts of tree species' invasiveness have significantly become eminent as an agent of degradation in most of the drylands. Invasive species such as *Prosopis juliflora*, *Calotropis procera*, and *Cuscutta spp* have significant impacts, both positive and negative, in the drylands. These species play complex roles, and their impacts can significantly vary depending on their interactions with other plants and organisms (Thomas et al., 2016). Most of these invasive species have thus taken control of the degradation of indigenous vegetation in most of the drylands.

. Researchers have examined the ecological suitability and environmental compatibility of tree species in relation to dryland ecosystems (Thomas et al., 2016). Economic analysis of tree nurseries involves assessing the costs and benefits associated with their establishment and management. Tree nursery establishment, especially in the dryland, plays very significant in enhancing the pool stock of seedlings necessary for restoration in the drylands. Further, it acts as a sustainable livelihood option that can be adopted in the drylands to help address the food security situation in these areas. According to Keefe et al. (2012), conducting a cost-benefit analysis helps

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determine the economic feasibility of these tree nurseries by quantifying the costs of land preparation, seedling production, irrigation, labour, and infrastructure. Simultaneously, the benefits derived from tree nurseries, such as revenue from seedling sales, carbon sequestration, and ecosystem services, are evaluated and compared. Moreover, Market analysis is crucial for tree nurseries to align their production with market demand. Studying market dynamics helps understand consumer preferences, the supply chain, and pricing strategies for tree seedlings. By analysing market studies, insights can be gained into the economic viability of different tree species (Keefe et al., 2012).

METHODOLOGY

This study employed a longitudinal research design, which involved the collection and analysis of data from the KEFRI Turkana Nursery seedlings sales list from January 2020 to December 2022. A sample size of 590 was selected using a systematic random sampling method. The targeted population for this study consisted of all individuals or entities who bought seedlings from the KEFRI Turkana Nursery between January 2020 and December 2022. These included Local farmers and landowners, non-governmental organisations (NGOs) or government agencies involved in reforestation and afforestation projects in the Turkana region and any other relevant stakeholders, community members, Community Based Organisations, institutions, or organisations involved in tree planting initiatives in the area.

Study Area

This study was conducted at the KEFRI Turkana Nursery. The station is in Lodwar town, Turkana Central Ward, Turkana County. The KEFRI Turkana Nursery is 0.5 acres located at the coordinates of latitude 3.112803^{0}N, 35.599461^{0}E. Turkana County (3.1155° N, 35.6041° E) is an arid and semi-arid county in the north-western part of Kenya (Climate Data, 2022). It is characterised by dry and hot climate conditions most of the time. The nighttime minimum temperature ranges between 24.2 and 26.0 °C, and the daytime maximum temperature oscillates between 35 and 36.0 °C (Rotich & Ojwang, 2021). The rainfall pattern and distribution are erratic and unreliable, both temporal and spatial. Turkana County has three main rainfall seasons (long rains occur on March-April-May, June-July-August, which occurs in Turkana West, Turkana South, Loima and some parts of Turkana East sub-counties. This is influenced by inter-tropical convergence zone (ITCZ) rainfall-bearing systems as well as Congo Airmass (CAM) (King et al., 2021). The short rains occur in October-November-December. The soils in Turkana County are mainly sand with alluvial deposits in areas close to the rivers (CIDP, 2018). The vegetation comprises densely populated *Prosopis juliflora* and scattered *Acacia tortilis* along the riverine. Other tree species in the area include *Salvadora persica, Acacia mellifera, Acacia senegal, Acacia reficiens, Acacia nubica, Terminalia brownii and Zyziphus Mauritania* (Kaudo et al., 2022). Annual grass species include *Aristida mustabilis,* while perennial grasses are mainly *Cenchrus ciliaris*. The forbs in the area include *Indigofera spinosa* (Morgan, 1981). The population of Turkana County is 926,976, and the main economic activity of communities living in Turkana County is pastoralism (KNBS, 2019). Agro-pastoralism is also practised in areas that receive moderately high rainfall and irrigated farming along the river Turkwel.

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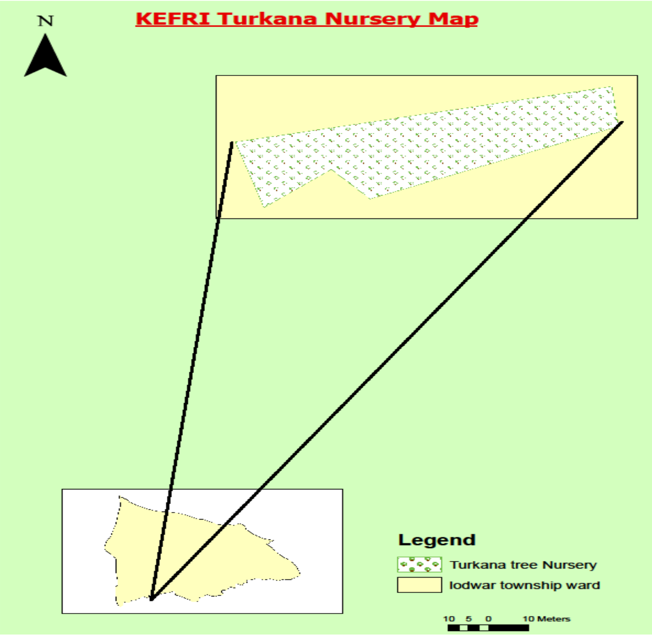
Figure 1: Map of the Turkana Nursery



Data Collection and Analysis

The data on seedlings sales, species bought, and quantities were obtained from the Turkana Forestry Research Institute Nursery seedlings sales book. The gathered data provided a comprehensive record of seedling sales covering the period from January 2020 to December 2022. This timeframe gained notable importance because Turkana County experienced devastating floods in October 2019, which led to a heightened necessity to strengthen ground coverage and establish safeguarding landscapes. Furthermore, the emergence of the COVID-19 pandemic added another layer of influence, as it prompted a greater emphasis on environmental resilience and the creation of green spaces. The data were then fed into both SPSS Version 26 software and Microsoft Excel for analysis. Analysis of variance (ANOVA) was used to check the mean difference between the seedlings purchased, various tree species, and the time of the year they were purchased. Moreover, Microsoft Excel was used to conduct descriptive analysis. SPSS was used to compute the seasonality index of seedlings offtake to identify peak and off-peak seasons for seedlings preparation.

RESULTS AND DISCUSSION

Seedlings Offtake Preferences

Table 1 provides a compelling glimpse into the intricate dynamics of tree species preferences across a span of three years. A striking revelation emerges as *Azadirachta indica* (neem tree) commands the spotlight with an impressive 40.1% preference rate among the top ten species. This ascendancy could be ascribed to the multifaceted benefits associated with the neem tree, spanning its medicinal properties, pest-repellent attributes, and its remarkable versatility in traditional practices. Notably, *Terminalia mantaly* (umbrella tree) wraps up the list with a more modest 2.69% preference, indicating its niche popularity within the spectrum of choices. Delving deeper, an intriguing pattern surfaces as seven out of the top ten preferred species fall under the exotic category, occupying 71.44% of the top ten most preferred trees, while three hail from indigenous origins. This data was in tandem with a study conducted by Nath et al. (2016), which indicated that exotic species of *Grevillea robustus* were planted 5.4 times more often than native species. Moreover, more individuals will plant trees if they better understand the benefits of doing so, and specifically the goods and services they are likely to realise when they plant a certain tree (Kaudo et al., 2022). This was strongly attributed to their realised economic values and faster growth. Additionally, the presence of tree fruits, including mangoes, papaws, and lemons, in the ranking

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further diversifies the preferences. *Cordia sinensis*, an indigenous species, garnered significant attention, securing a notable 27.17% preference rating within the top ten indigenous choices.

Meanwhile, *Acacia eliator* occupies the tenth slot in the indigenous list, contributing to the intricate tapestry of preferences. Within the exotic tree category, neem once again asserts its dominance, accounting for a substantial 52.06% preference. In an intriguing twist, *P. acueleta* (Jerusalem thorn) finds its place at the tenth spot, hinting at the complexity of preferences that encompass both the familiar and the unfamiliar.

Looking at the extent of tree fruit preference, mangoes reign supreme with an impressive 56.35% preference, underscoring their enduring popularity. This nuanced interplay of preferences reflects a blend of cultural heritage, ecological context, and practical utility, encapsulating the intricate relationship between humans and trees. As arboreal choices mirror societal values, needs, and interactions, the study encapsulates a broader narrative of our connection with the natural world, emphasising the importance of sustainable stewardship.

Table 1: Tree seedlings category offtake preferences 2020-2022

Seedlings	Tree seedlings	Seedlings sold	Percentage
Top ten most preferred seedlings	*A. indica* (Neem)	11172	40.10
	M. indica (Mango)	3738	13.42
	C. sinensis (Edome)	1738	6.24
	C. papaya (pawpaw)	1502	5.39
	D. regia (Ekuruchanait)	1036	3.72
	Citrus limon (Lemon)	933	3.35
	Acacia mellifera (ebenyo)	840	3.02
	B. aegyptica (Ebei)	775	2.78
	C. thevetia (Euphorbia)	773	2.77
	T. mantaly (Umbrella)	750	2.69
Top ten indigenous species	*C. sinensis* (Edome)	1738	27.17
	Acacia mellifera (ebenyo)	840	13.13
	B. aegyptica (Ebei)	775	12.12
	T. brownii (Ekuyen)	469	7.33
	Z. mauritiana (Ekalale)	452	7.07
	T. indica (Epeduru)	358	5.60
	D. scabra (Elim)	340	5.31
	D. glabra (Edapal)	312	4.88
	Vachellia tortilis (ewoi)	255	3.99
	A. eliator (Esenyenait)	253	3.95
Top ten exotic trees	*A. indica* (Neem)	11172	52.06
	M. indica (Mango)	3738	17.42
	C. papaya (pawpaw)	1502	7.00
	D. regia (Ekuruchanait)	1036	4.83
	Citrus limon (Lemon)	933	4.35
	C. thevetia (Euphorbia)	773	3.60
	T. mantaly (Umbrella)	750	3.49
	M. oleifera (Moringa)	429	2.00
	P. guajava (Guava)	252	1.17
	P. acueleta (Jerusalem thorn)	214	1.00
Top 5 preferred fruit trees	*M. indica* (Mango)	3738	56.53
	C. papaya (pawpaw)	1502	22.71
	Citrus limon (Lemon)	933	14.11
	T. indica (Epeduru)	358	3.81
	P. guajava (Guava)	252	1.32

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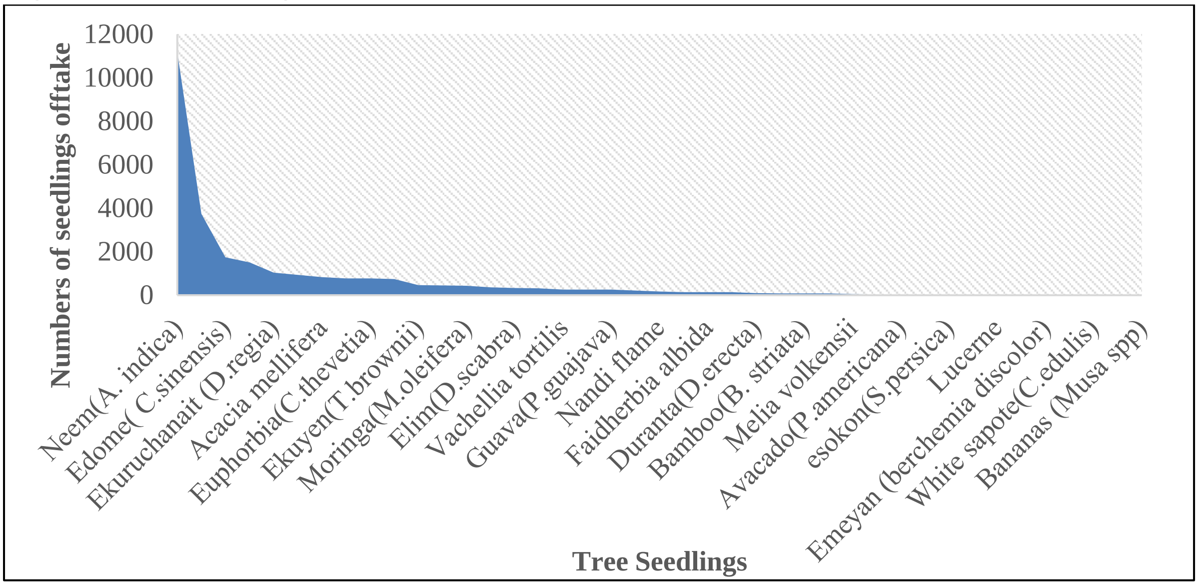
Figure 2: Tree seedlings offtake preference



Tree Nursery Economic Viability Analysis

The viability of a tree nursery hinges on a combination of factors, notably the interplay between production costs and market dynamics. The process of seedling production entails a series of steps, commencing with the acquisition of production inputs such as germination and growth media (comprising soil, manure, and sand), germplasm, potting tubes, labour, and water. This study's scope focuses on assessing the cost of production from the standpoint of these inputs. Notably, day-to-day operational activities such as watering, weeding, and security, which are presumed to be handled by the nursery owner, were excluded from the computation.

According to *Table 2*, the calculated production cost for a single seedling over a three-month period within the nursery amounts to Kes 7.125. Drawing upon the research conducted by Habtemariam Daba (2017), regions characterised by warm and humid climates, coupled with high potential evapotranspiration rates, demand an optimal daily water requirement per seedling, quantified at $0.000056m^3$. This translates to approximately 5 litres of water over three months, equating to a financial outlay of Kes 0.325. Further investigations, as presented by Kaudo et al. (2022), indicate a preference for larger potting tube sizes, specifically 6x9 dimensions, in locales experiencing high evapotranspiration and low rainfall. These tubes exhibit enhanced water retention capabilities and improved aeration. Analysing the costs of forest soil, manure, and sand, which collectively average Kes 1000 per ton based on prevailing market prices, reveals that a single potting tube of the recommended size (6x9), weighing 3.13 kg full of potting soil, costs Kes 3.13 per unit.

To distil these findings, *Table 2* elucidates the calculated cost per seedling for a three-month span. The intricate web of data underscores the intricate relationship between production costs, specific ecological conditions, and the crucial role of appropriate inputs in fostering the viability of tree nurseries. As this analysis reverberates across the realm of sustainable forestry, it underscores the importance of economic and ecological equilibrium.

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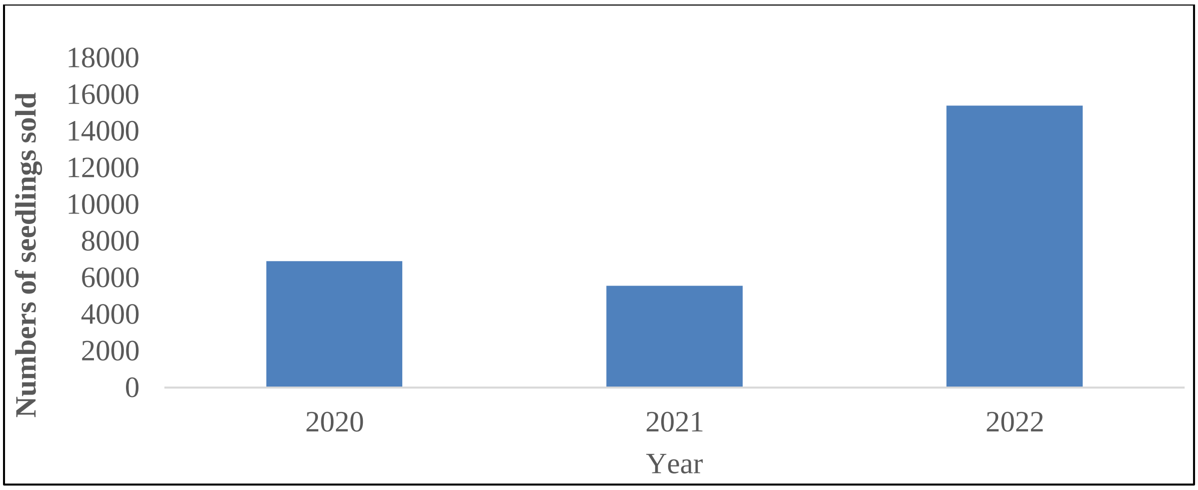
Table 2: Seedlings cost production computation for 3 months

Input	Unit cost/3 months	Total costs (Kes) for 27857 seedlings
Potting tube (6*9) size	2	55,714
Potting	1	27,857
Soil (*Soil mix (5:3:2)*	3.13	87,192.4
Water (*0.000056* m^3*/day)*	0.325	9,053.53
Cost of seeds	0.67	18,664.2
Cost of raising one seedling for 3 months	7.125	19,8481
Gross income		1,392,850
Profit		1,194,369
Projected monthly income		33,176.91

Figure 3: Number of seedlings sold in three years



Seedlings Seasonality Index Offtake Performance

According to the data presented in *Table 4*, a comprehensive analysis of the yearly seedlings seasonality index offtake performance offers valuable insights into the fluctuations and trends observed over the three-year period. The seasonality index serves as a dynamic metric, shedding light on the temporal patterns of seedlings' offtake across the months. The standout performers in this analysis were April, September, October, and November. These months exhibited remarkably high seasonality indices, recording values of 107.63, 112.21, 269.87, and 225.70, respectively. Notably, these figures significantly surpassed the baseline index of 100%, a clear indication of their exceptional performance in seedling offtake. This observation suggests a propensity for heightened demand and increased activities within the nursery sector during these specific periods attributed to the government's massive program on afforestation and achieving the 30% forest cover targets (MoE&F, 2022).

The factors driving this peak could be diverse, encompassing climatic conditions, agricultural cycles, or even specific events that drive seedlings' demand. Consequently, policy dynamics have significantly influenced this increased offtake of seedlings. The mainstreaming of climate change activities within the state and non-state agencies has increased the demand for seedlings for regreening and reforestation activities. On the flip side, February emerged as the month with the lowest seasonality index, closely trailed by January and August, with indices of 26.32, 43.21, and 46.54, respectively. These months experienced subdued seedlings' offtake performance relative to the annual average. This dip in demand could be attributed to factors such as unfavourable weather conditions, less conducive planting seasons, or lower

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agricultural activities. Turkana County receives two rainy seasons: long rainy seasons between April and July and shorter seasons between October and November.

In 2021, the onset of the MAM season was delayed, and the rains started at the end of April and early June (Department, 2021). This indicated a prolonged dry season in the ASALs, thus posing a threat to seedlings offtake. For JJA seasons, the prolonged dry seasons resulted in the deaths of livestock, posing a significant threat to water availability and pastures and a significant decline in seedlings sales and offtake. The dipping in 2021 could also be attributed to the impact of the nationwide lockdown due to COVID-19. According to Das (2021), the COVID-19 shutdown caused production problems, marketing problems, lack of decent prices, higher prices of input, and limited operation of markets. In places where most of the afforestation activities are carried out by developmental partners, corporate and NGO sales dropped to 50% and 40%, respectively (Das, 2021). According to Rahman et al. (2021), the COVID-19 pandemic brought substantial turmoil in all the conservational and socioeconomic aspects of the people depending on forest and forest-dependent natural resources.

Table 3: Optimal Seedlings Offtake Seasonal Index Analysis

Month	Seasonality index
Jan	43.21
Feb	26.32
Mar	74.11
Apr	107.63
May	77.46
Jun	61.23
Jul	70.69
Aug	46.54
Sep	112.21
Oct	269.87
Nov	225.70
Dec	85.04
Baseline Index	**100.00**

Figure 4: 3 Year monthly seedlings offtake seasonality index

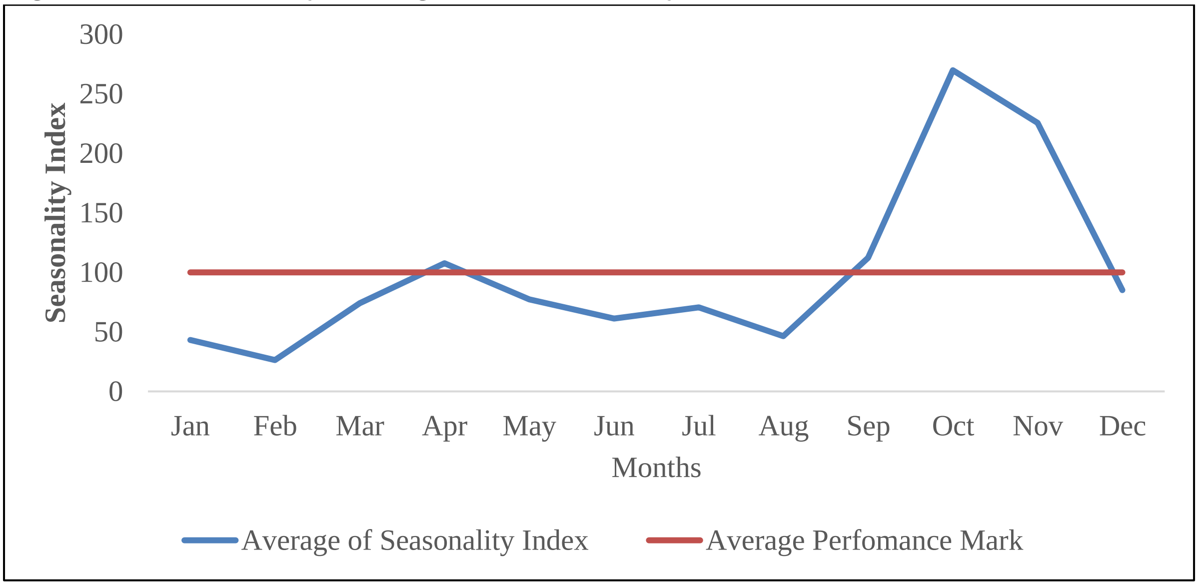

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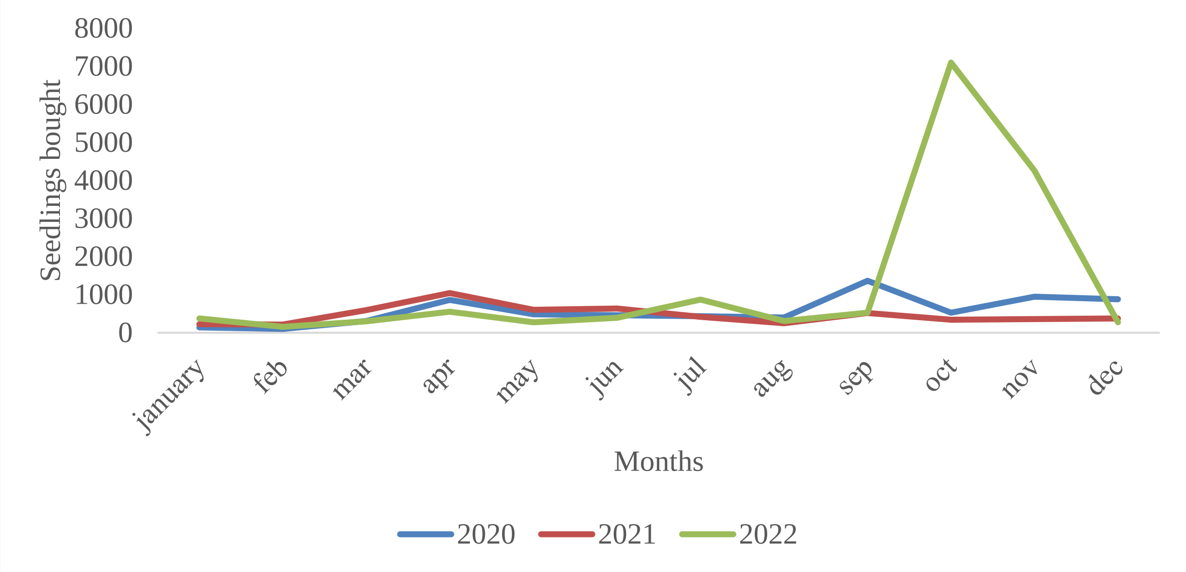
Figure 5: Seedlings offtake in Three years



CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this research, it is apparent that the months of April, September, October, and November exhibit the most pronounced seasonality indices, indicating a notable uptick in the uptake of seedlings. This pattern offers valuable insights for producers of these seedlings, suggesting that aligning their production with these periods of heightened demand would be advantageous. The climatic patterns in the Turkana region exhibit a distinct three-month cycle during which these demands experience a surge, owing to the favourable weather conditions prevalent during these times. This analysis highlights the prevalence of exotic species, constituting 71.44% of the top ten preferred species. In contrast, indigenous species make up 28.56%. This trend raises concerns, considering the pivotal role that indigenous species play in these arid landscapes. They serve as crucial fodder for livestock, a source of sustenance for local communities, and possess adaptations that enable them to thrive in challenging climatic conditions. As a result, there is an urgent necessity to enhance community awareness regarding the vital importance of cultivating and embracing indigenous trees. Moreover, a scrutiny of the economic feasibility of establishing a nursery reveals that operating such a business sustainably in dryland regions is indeed viable, establishing it as a nature-based entrepreneurial endeavour.

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