

## **Insights from communities' awareness and participation in greening semi-arid lands for effective environmental conservation**

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# Insights from communities' awareness and participation in greening semi-arid lands for effective environmental conservation

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## Abstract

**Background and Research Aims:** Tree planting holds significant potential for environmental protection in the era of climate change and variability. It is particularly crucial in semi-arid areas where tree density is extremely low, necessitating the engagement of local communities. However, information about local people's awareness and their willingness to participate in greening practices is rarely considered. We assessed the levels of community awareness, the extent of participation, and the factors influencing their willingness to green the Dodoma semi-arid area between 2018 and 2022.

**Methods:** We collected data from 145 respondents using a household questionnaire survey, focus group discussions, and in-depth interviews. Quantitative data were analyzed using SPSS version 26, while template analysis was applied to the qualitative data.

**Results:** We found the overwhelming majority of respondents (n= 136) are aware of the importance of tree planting, and 89.7% of respondents participated in greening practices. Income level, education level, environmental awareness, perceived benefits of tree planting, and social influence were significant predictors of communities' willingness to plant trees.

**Conclusion:** Despite the greater awareness and active participation of tree planting found among local actors in the study area, efforts must be directed towards suitable selection of adaptive, affordable and improved tree species for sustainable and feasible socio-ecological benefits of afforestation in semi-arid areas.

**Implications for conservation:** The study underscores the potential of community awareness and participation in tree planting for environmental conservation and the sustainable supply of forest products, which are vital for local livelihood development. We advocate for the consideration of socioeconomic and ecological factors when engaging local actors in greening urban semi-arid lands through technical and financial empowerment.

## Keywords

Climate change, exotic species, semi-arid land, tree planting campaign, water scarcity

## Introduction

The interrelationship between people and forests has increasingly become a significant subject of public discourse (Scheid et al., 2018). The focus of forestry has shifted from being solely for industrial raw material provision to becoming an essential resource for local livelihood development (Miller et al., 2017). Global tree planting initiatives on farms and in backyards aim to meet local needs, including providing fuel

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wood, poles, fodder, and timber (Galabuzi et al., 2021). For decades, there has been a global emphasis on more livelihood-oriented forestry in sub-Saharan Africa (Bremen and Kessler, 1997; Aalbaek, 2004). However, the expected livelihood outcomes from forestry can only be achieved if local people, as key stakeholders, understand the importance of their active involvement in tree planting (Pataki et al., 2021). A better understanding and active participation of local communities in tree planting programs foster a sense of ownership and stewardship over the planted forests, which help prevent deforestation and environmental degradation (Roman et al., 2015).

Tree planting is especially crucial in semi-arid parts of the world, where the fuel wood crisis is severe due to drier conditions (Scheid et al., 2018). It is also particularly important in these regions where ecological degradation threatens local livelihoods (Raja et al., 2017). The participation of local communities, in collaboration with officials from both governmental and non-governmental organizations, in tree planting projects is becoming increasingly popular (Kalinitchenko et al., 2021). However, the knowledge and principles of local participation in afforestation initiatives, along with the lessons learned, are less documented, particularly in greening semi-arid areas. To consolidate the significant knowledge gained in this area, it is important to undertake systematic research evaluating what local communities understand and how they participate in tree planting programs.

Tree planting in Tanzania, particularly in semi-arid regions, is highly encouraged at all levels, including individuals, local communities, and governmental and non-governmental institutions. Afforestation initiatives in these areas are carried out in household backyards, non-residential areas, around public buildings, farm fields, and open spaces (Gayo, 2023). The motives for tree planting among local people include improving environmental management and better access to forest products such as fuelwood, timber, fruits, nuts, and medicines (Mwambusi et al., 2021). However, inadequate awareness of the importance of tree planting is reported to limit their active participation in the greening movement of many degraded landscapes (Gwedla et al., 2022).

Despite the ongoing tree planting initiatives in different parts of the country, the level of local people's awareness and participation in greening programs is less documented in the scientific literature. Related empirical studies have focused on investigating farmers' access to tree germplasm (Aalbaek, 2004), factors influencing tree mortality in urban areas (Kalinitchenko et al., 2021), willingness to participate in tree planting initiatives (Gwedla et al., 2022), and the level of street tree vandalism in the Eastern Cape, South Africa (Richardson and Shackleton, 2014). Other studies have assessed the benefits of tree planting (Pataki et al., 2021), perceptions of ornamental plant species among users (Rahnama et al., 2019), and the use of tree species diversity to

meet various plant needs among local people (Scheid et al., 2018).

Tree planting practices in Dodoma's semi-arid district have been ongoing since 1976. These practices have been promoted through various campaigns aimed at increasing local communities' awareness and participation (Gayo, 2023). However, there is limited information about the local people's awareness and involvement as key actors in greening the district (Luswaga, 2023). Furthermore, empirical evidence on community participation in tree planting practices in the city is inadequately documented in the scientific literature. Therefore, this study aimed to address this research gap by assessing the level of local awareness regarding the importance of tree planting in the study area, investigating the extent of their participation, and identifying factors influencing their willingness to green the district. The findings of this study aim to highlight the importance of involving and engaging well-informed and knowledgeable communities in tree planting efforts globally, and particularly in Dodoma district. Locals with a better understanding can potentially act not only as laborers but as custodians of environmental protection and prevent deforestation (Gwedla and Shackleton, 2019).

## Methods

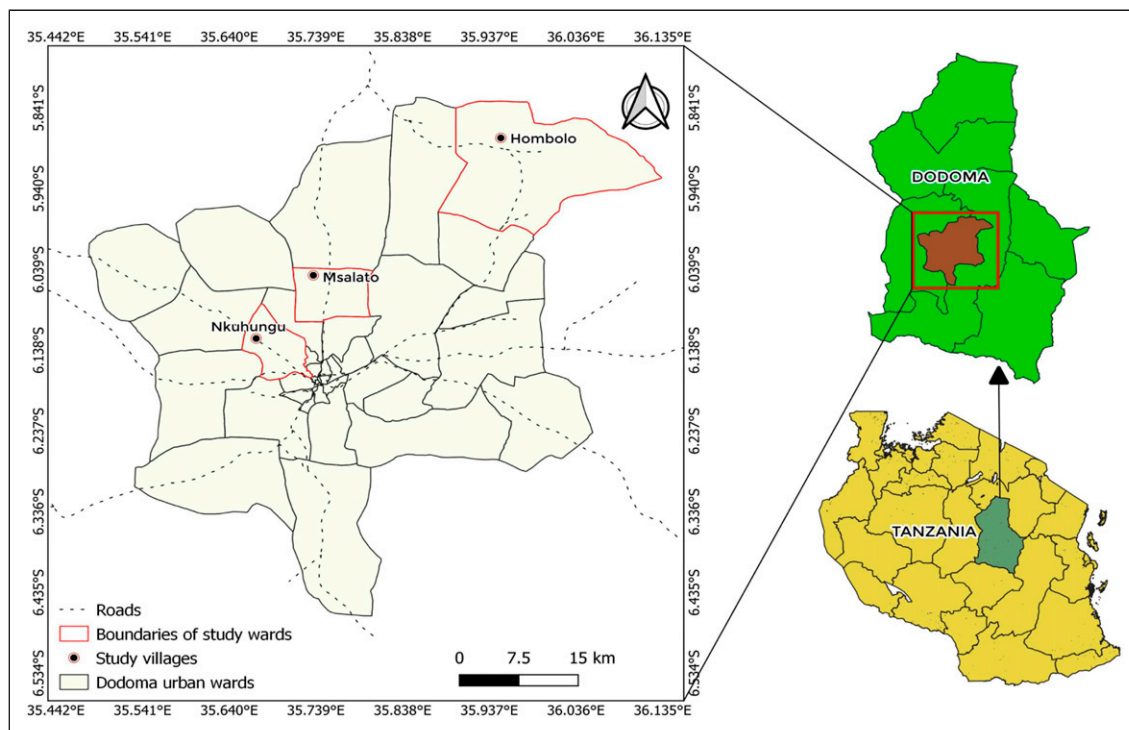
### Study area description

Dodoma District is a semi-arid region located at 6°11'29"S, 35°82'80"E (Figure 1). The annual rainfall ranges from 550 to 600 mm, occurring between December and April, with temperatures varying from 13°C to 30.6°C (Gayo, 2021). The district features low, dry vegetation, primarily consisting of shrubs and thickets (Gayo, 2022). In 2022, the human population was estimated at 765,179 (URT, 2022). The local economy is primarily based on crop production, agropastoralism, and pet businesses. The main staple and food crops are maize, cassava, millet, groundnuts, and bambara nuts, while grapes and sunflowers are the primary cash crops grown in the district. Major livestock include cattle, sheep, and goats (Gayo, 2023).

### Data collection

A combination of retrospective and cross-sectional study designs was used to assess awareness and participation of local communities in tree planting in the district. The retrospective assessment involved gathering secondary data from conservation agencies, predominantly the Tanzania Forest Services Agency (TFS), collected during the period of intensified Dodoma greening campaigns from 2018 to 2022.

A cross-sectional design was employed to collect primary data from the villages of Hombolo, Msalato, and Nkuhungu, chosen due to their demonstrated relatively high number of planted trees (Gayo, 2023). The study utilized the formula by



**Figure 1.** Map showing the study area.

Naing et al. (2006) to determine the sample size for a finite population, as follows:  $n = \frac{N^2 P(1-P)}{[d^2(N-1) + Z^2 P(1-P)]}$ , such that “n” represents the sample size for the household questionnaire survey (HQS), N is the estimated population size that is approximately 2400 households across the three study villages, Z is 1.96, representing the Z-score value for a specified level of confidence, P is 0.5, indicating the proportion of the total surveyed population used for determining the maximum sample size under a normal distribution, and d is 0.08, representing the precision at a 92% confidence level.

The sample size obtained ( $n = 145$ ) was allocated across the study villages based on their populations. Specifically, 60, 47, and 38 household respondents participated in HQS from Nkuhungu, Msalato, and Hombolo respectively. Households in these villages were selected through systematic sampling using intervals of 16, 19, and 21 in Nkuhungu, Msalato, and Hombolo villages respectively. Respondents in their households were administered a set of closed and open-ended questions in the form of questionnaire sheets to assess their awareness and level of participation in tree planting activities. Specifically, awareness was assessed by querying respondents about the following: when tree planting campaigns were intensified, where tree planting practices are mainly carried out, who the major actors of tree planting in the district are, why tree planting is considered vital in their area, and what kinds and species of trees are commonly planted in the study area.

To enhance data reliability, the study triangulated Household Questionnaires (HQS) with other methods,

including focus group discussions (FGD), key informant interviews (KII), and participant observation. A minimum of two FGDs for each study village, comprising 5 to 8 individuals per group from elders, adult men, women, and youth, was conducted to collect qualitative data in the form of descriptions about the themes under study. FGDs enabled participants to discuss and expand upon information provided by colleagues, as well as to clarify points for a better understanding of the issues discussed. Regarding KII, individuals with exceptional knowledge and experience in the study themes were consulted. This included one district forest officer, one forest officer from the Tanzania Forest Services Agency (TFS), and three village executive officers, who participated in in-depth interviews using a checklist.

### Data analysis

Descriptive statistics on demographic factors of respondents, community awareness of tree planting, participation in greening programs, and the number of trees planted in the district from 2018 to 2022 were summarized and analyzed in Microsoft Excel. Since the quantitative data exhibited non-parametric characteristics ( $Kurtosis > 3$ ), the chi-squared statistical test ( $\chi^2$ ) was conducted to assess variations in responses across study villages at a significance level of  $p = 0.05$  using IBM Statistical Package for Social Sciences (SPSS) version 25. Factors influencing communities’ willingness to contribute to greening the district were determined using a generalized linear mixed model (GLMM) in R

software with the “lme4” version 1.1-29 package, utilizing a binomial family due to the binomial nature of responses (yes or no).

We formulated the research questions as follows: “What are the factors influencing community willingness to plant trees in the study area, and how do they interact with demographic variables?” In our Generalized Linear Mixed Model (GLMM), the willingness to plant trees (measured on a Likert scale or as a binary variable indicating willingness/non-willingness) was designated as the response variable. The fixed effects were categorized as follows: Socio-demographic and economic status (including age, sex, income level, education level, and occupation type); Environmental awareness (attitudes towards environmental conservation and previous involvement in environmental activities); Perceived Benefits of Tree Planting (perception of improved air quality, enhanced aesthetics, and community health benefits); Access to Green Spaces (proximity to existing parks or green areas, and availability of green infrastructure in the neighborhood); and Social Influence (influence of neighbors, friends, or family members, and participation in community organizations or events related to tree planting).

We utilized neighborhood or community-level random effects to address the clustering of responses within specific geographical areas, capturing unobserved heterogeneity and spatial autocorrelation in willingness to plant trees. The predictor factors were presented along with their estimated coefficients, standard errors, and p-values in tabular form. Additionally, in the random effects section, we provided the variance estimate and standard deviation for the neighborhood or community-level random effects, capturing the variability in willingness to plant trees across different geographical areas.

Qualitative data from FGDs and KIIs were analyzed using the template technique as suggested by Bengtsson (2016). This technique was chosen due to its ability to manage large datasets with different variables across a wide range of projects (Brooks & King, 2014). Following the steps recommended by Brooks and King (2014), we first read the interview transcripts to familiarize ourselves with the raw data. Next, we conducted preliminary coding of the raw data to identify study themes. We then defined the initial coding template to illustrate the relationships between these study themes. Subsequently, we applied the initial template to the available dataset, modifying it where necessary to accommodate new themes and redefining or removing existing themes that did not align with the new data. We iteratively tested various versions of the template, repeating this process until we developed a comprehensive template capable of accommodating all the dataset aspects pertinent to the study questions. Finally, we applied the finalized template to interpret all the datasets and generate the study findings, which were presented as quotes.

## Results

### *Socio-demographic characteristics of respondents*

Table 1 shows that more males were involved in this study ( $\chi^2 = 8.90$ ,  $df=2$ ,  $p=0.03$ ) and the majority of respondents were aged below 45 years ( $\chi^2 = 17.21$ ,  $df=6$ ,  $p=0.02$ ). Furthermore, we observed a high level of literacy in the study area, with a large number of respondents having secondary or college education. Regarding employment, many respondents were informally employed (Table 1).

### *Community awareness on tree planting potentials*

The level of awareness among respondents regarding tree planting and the importance of this practice in the study area is demonstrated in Table 2. The majority of the respondents were aware of the ongoing tree planting exercise ( $\chi^2 = 7.10$ ,  $df=1$ ,  $p=0.02$ ). They cited the period when tree planting campaigns started in late 2017 and intensified in early 2018 to the time of data collection ( $\chi^2 = 19.07$ ,  $df=2$ ,  $p=0.003$ ). Greening initiatives are largely executed in residential areas, places with institutional buildings and open spaces ( $\chi^2 = 103.07$ ,  $df=4$ ,  $p=0.458$ ) while the key actors involved in tree planting activities included local communities, pupils and students in schools and colleges, religious institutions and staffs in government institutions (refer to Table 2). Exotic trees were predominantly planted for economic purposes, as illustrated in Table 2.

Through in-depth interviews, it was also demonstrated that communities receive socio-ecological benefits from tree planting. For instance, the Msalato village executive officer stated that,

“Increased tree planting has supported the availability of fuelwood for energy use in homes, provided cooling shade, and helped to break the wind during the dry season”.

A similar argument was presented in Hombolo village by one of the discussants during the FGD, stating that,

“The trees we planted enhance property values and provide resources such as timber, fruits, and nuts, thereby supporting the economies and livelihoods of many households in our village”.

Similarly, during the Focused Group Discussion (FGD) in Nkukungu village, one participant reported that,

“Planted trees contribute to the creation of aesthetically pleasing landscapes, thereby enhancing urban environments that are attractive to both residents and visitors”.

Although few respondents mentioned the ecological importance of tree planting, it was revealed through a key informant interview that the planted trees were able to reduce the negative effects of semiarid characteristics. One of the TFS officers asserted that:

**Table 1.** Socio-demographic characteristics of the households' respondents.

Variables	Categories	Study villages			Total (n=145)	$\chi^2$ -test	df	p-value
		Nkuhangu (n=60)	Msalato (n=47)	Hombolo (n=38)				
Gender	Male	38	34	23	95	8.90	2	0.03
	Female	22	13	15	50			
Age	26-45	39	27	18	84	17.21	6	0.02
	46-60	10	14	12	36			
	> 60	11	6	8	25			
Education	Primary	25	21	19	65	14.06	3	<0.001
	Secondary	19	11	10	40			
	College	16	15	9	40			
Employment	IE	47	30	28	105	18.46	6	<0.01
	FE	13	17	10	40			

Where: IE=Informal Employment, FE=Formal Employment,  $\chi^2$ = Chi square, df=Degree of freedom, p-value=Probability value.

**Table 2.** Awareness of respondents on the importance of tree planting in the study villages.

Variables	Categories	Study villages			Total (n=145)	$\chi^2$ -test	df	p-value
		Nkuhangu (n=60)	Msalato (n=47)	Hombolo (n=38)				
Do you know the ongoing tree planting exercise?	Yes	58	43	35	136	7.10	1	0.02
	No	2	4	3	9			
When tree planting campaigns started and intensified in the district?	1980' and 2010'	40	37	25	102	19.07	2	0.003
	2000' and 2020'	11	10	11	32			
	Don't know	5	2	4	11			
Where tree planting is largely practiced?	Residential areas	8	17	10	35	103.07	4	0.458
	Open spaces	3	2	4	9			
	Places with governmental institutions	10	4	6	20			
	All sites mentioned above	34	20	15	69			
	Don't know	3	5	4	12			
Who are the major actors of tree planting in the area?	NGOs	5	4	3	12	122.6	4	0.305
	Government institutions	8	7	5	20			
	Community groups	15	8	9	32			
	Individuals	34	20	15	69			
	Don't know	5	4	3	12			
Do you think tree planting is important?	Yes	52	43	31	126	12.81	1	0.03
	No	8	4	7	19			
Why tree planting?	Economic	42	37	25	104	20.56	2	<0.001
	Social	3	2	4	9			
	Ecological	15	8	9	32			
Which main product do you get from tree planting?	Fruits	17	11	8	36	118.09	5	<0.01
	Fuel wood	13	10	11	34			
	Timber	9	7	6	22			
	Windbreaker	15	11	7	33			
	Control soil erosion	2	3	3	8			
	Demarcating plot boundaries	4	5	4	13			
	Don't know	15	8	9	32			
What kind/species of trees commonly planted in the study area?	Exotic	42	34	25	101	17	2	0.0328
	Native	3	5	4	12			
	Don't know	15	8	9	32			

Where:  $\chi^2$ = Chi square, df=Degree of freedom, p-value=Probability value.

“In areas where many trees have been planted, excessive wind, extreme solar heating, and increased dryness of the landscape are significantly reduced, even during the dry season”.

Ecological benefits were also mentioned during the FGD in Nkuhungu village, where two of the discussants noted that:

“Tree planting has been integrated with crop farming to enhance pollination, reduce soil erosion, and provide shade during crop harvesting”.

“The increased tree cover resulting from tree planting in our village plays a critical role in adapting to climate change by providing buffer zones against extreme weather events, especially heat waves”.

Regarding the social benefits of tree planting, participants in the Focused Group Discussion (FGD) in Hombolo reported planting trees for various purposes, including demarcating farm or plot ownerships, for medicinal uses, and for enhancing urban green spaces. This enables people to learn about nature and provides spaces for social interaction, relaxation, and exercise to minimize body stress and anxiety. Through participant observation, the study revealed the existence of several community initiatives engaging in nursery production and tree planting in residential plots, alongside efforts to promote the regeneration of natural trees in farm fields.

### *Participation of communities in tree planting*

Table 3 illustrates the participation of respondents and various institutions in tree planting across the study sites. Most of the respondents participated in greening the study area by planting approximately 1 to 50 trees (refer to Table 3). They also expressed willingness to plant more trees in the future ( $\chi^2 = 10.17$ ,  $df=2$ ,  $p<0.003$ ). Individuals, schools/colleges, groups of women and youth, along with TFS, were identified as the primary contributors to tree planting ( $\chi^2 = 108.03$ ,  $df=5$ ,  $p<0.01$ ), as illustrated in Table 3.

The secondary data collected by TFS-Dodoma between 2018 and 2022, indicating the participation of various groups in tree planting, is summarized in Table 4. A total of 3,305,983 trees were planted across the green belt, open areas, and residential zones. The green belt spans 9 km and includes the Dodoma bus terminal, Job Ndugai market, areas along the Dar es Salaam Road, and the Mahomanyika area. Open areas comprised Mzakwe, Nzuguni, and Njedengwa valleys, while residential zones encompassed government institutions and human settlements. Youths aged 15–35 years and women were the most active, planting approximately 2,353,128 trees, equivalent to 71.2% of all planted trees (refer to Table 4).

Figure 2 illustrates the annual number of trees planted from 2018 to 2022. In 2020, a relatively small number of trees (450,000) were planted, whereas in 2022, a significantly larger number (950,000) were planted.

### *Factors influencing communities' willingness in greening Dodoma district*

The results regarding factors influencing the willingness of communities to plant trees are presented in Table 5. Income and education levels, environmental awareness, perceived benefits of tree planting, and social influence were identified as significant predictors of local communities' willingness to engage in tree planting in the study area (see Table 5).

Other results emerged from Key Informant Interviews (KII) and Focus Group Discussions (FGD). For instance, during an in-depth interview, a key informant from Hombolo village stated that:

“The high prices of seedlings discourage communities from planting trees, particularly since higher-value trees are only purchased when they offer clear socioeconomic benefits”.

Another participant in the focus group discussion (FGD) in Msalato village mentioned that:

“It is much better to plant trees with economic return like fruits, timber and fuel wood rather than planting a mere shade trees.”

Similarly, two discussants of the FGD in Nkuhungu village argued that,

“Nkuhungu is a densely populated area where space for planting trees is among the key limiting factors, primarily due to high land prices, competing land uses, and existing infrastructure such as buildings, roads, and utilities.”

“The cost of purchasing, planting, and maintaining trees has prohibited the majority of people, particularly those in low-income households with limited financial resources”.

## **Discussion**

### *Socio-demographic characteristics of respondents*

Assessment of socio-demographic characteristics of respondents in social surveys is essential as they offer critical context for understanding and interpreting survey results. We assessed socio-demographic factors such as age, gender, education and occupation thereby affecting how they respond to survey questions. We found involvement of more males in this study that could have occurred by chance, as males tended to be responsible for addressing all matters related to the socioeconomic status of households. We utilized systematic random sampling in each study village to select respondents; however, there was a higher proportion of respondents under the age of 45, with the majority having attained secondary or college education. This presents an opportunity for local development and environmental conservation if the study population actively participates in tree planting practices (Lockwood and Berland, 2019). Furthermore, since most respondents are employed in the informal sector, this could ensure ample time for local individuals to

**Table 3.** Communities' participation in tree planting between 2018 and 2022.

Variables	Categories	Study villages				$\chi^2$ -test	df	p-value
		Nkukungu (n=60)	Msalato (n=47)	Hombolo (n=38)	Total (n=145)			
Did you plant trees?	Yes	56	41	33	130	9.05	2	0.01
	No	4	6	5	15			
How many trees did you plant for last 5 years?	1-10	27	25	12	64	12.81	2	0.03
	11-50	23	14	15	52			
	>50	6	2	6	14			
Do you expect to plant more in future?	Yes	57	39	33	129	10.17	2	<0.003
	No	3	8	5	16			
Who was highly involved in tree planting?	Individuals	17	14	11	42	108.03	5	<0.01
	Groups of women and youth	11	7	8	26			
	TFS	12	7	6	25			
	Religious institutions	4	5	4	13			
	Government ministries	2	3	3	8			
	Schools/ colleges	14	11	7	32			

Source; Field data, 2023. Where;  $\chi^2$ = Chi square, df=Degree of freedom.

**Table 4.** Tree planting participation of various individuals, groups and institutions in Dodoma District.

Institutions/places planted trees	Planted trees	Seedlings died	Survival rate (%)	Area planted (ha)	Reason for tree death
Individuals	42,337	2,160	94.9	7	Water lodged
Dodoma wards/streets	478,775	62,071	87	2	Poor management
Various social groups of youths and women	2,353,128	104,575	95.6	12	Water lodged
Primary &Secondary schools	110,056	4,891	96	23	
Dodoma TFS	50,954	2,264	95.6	37	Water lodged
Religious Institutions	9820	1,768	82	1	Poor management
Defense and Security Institutions	111,460	16,719	85	33	Water lodged
Government Ministries	23,142	4860	79	2.5	Poor management
Other Private institutions	14,496	3914	73	2	Poor management
Dodoma City Council and Regional Commissioner Office	49,100	7856	84	11	Poor management
Higher learning Institutions	55,510	10,659	81	49	Poor management
Politicians Dodoma	7,205	1297	82	0.5	Poor management
<b>Total</b>	<b>3,305,983</b>	<b>223,034</b>	<b>93.3</b>	<b>180</b>	

Source: TFS-Central Zonal office, 2023.

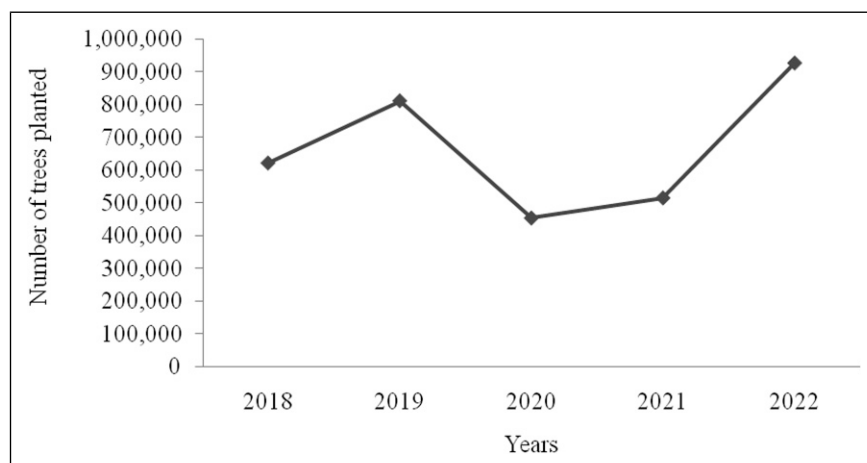
fully engage in tree planting initiatives, thereby promoting afforestation practices in the district.

### Community awareness on tree planting potentials

The study community was assessed whether is familiar with the ongoing tree planting exercise in their areas. We found that a large proportion of respondents acknowledged understanding the existence of tree planting initiatives in their villages, likely due to awareness generated through multiple channels, such as community posters, participation in tree planting exercises, and coverage in local news. This finding is

supported by Conway (2016), who noted that respondents frequently mentioned community centers and local news as primary sources of information on environmental conservation initiatives. Similarly, Galabuzi et al. (2021) observed that posters displayed in community centers played a crucial role in increasing awareness among residents. Moreover, the majority of respondents were aware of the time periods when afforestation programs were initiated (1980s) and intensified (2010s), which could coincide with increased awareness of environmental issues in the study area. However, despite this widespread awareness, there remains a notable gap in direct involvement or comprehensive information among certain





**Figure 2.** Number of trees planted in Dodoma district from 2018 to 2022 as collected by TFS-Dodoma.

**Table 5.** Factors influencing communities' willingness in greening initiatives.

Variable	Coefficient	Standard Error	p-value
<b>Fixed Effects</b>			
<b>Socio-demographic and economic aspects</b>			
-Age of respondent	0.197	0.073	0.094
-Sex of respondent	0.456	0.021	0.133
- Income level	0.302	0.068	<b>&lt;0.001</b>
- Education level	0.151	0.042	<b>&lt;0.01</b>
- Occupation type	-0.087	0.055	0.12
<b>Environmental Awareness</b>			
- Attitudes towards environmental conservation	0.217	0.038	<b>&lt;0.001</b>
- Previous involvement in environmental activities	0.134	0.045	<b>0.013</b>
<b>Perceived Benefits of Tree Planting</b>			
- Perception of improved air quality	0.189	0.052	<b>0.031</b>
- Perception of enhanced aesthetics	0.127	0.036	<b>&lt;0.01</b>
- Perception of community health benefits	0.105	0.048	<b>0.033</b>
<b>Access to Green Spaces</b>			
- Proximity to existing parks or green areas	0.263	0.063	0.337
- Availability of green infrastructure in the neighborhood	0.178	0.049	0.741
<b>Social Influence</b>			
- Influence of neighbors, friends, or family members	0.201	0.041	<b>&lt;0.001</b>
- Participation in community organizations or events related to tree planting	0.155	0.047	<b>0.015</b>
<b>Random Effects</b>			
<b>Neighborhood/Community</b>			
- Variance Estimate	0.089		
- Standard Deviation	0.299		

The 95% CI for the treatment effect was [0.56, 1.14], the model fit was assessed using Akaike Information Criterion (AIC = 345.67) and Logit link function (LogLik = - 87.5).

segments of the population. [Gayo \(2023\)](#) highlighted that some respondents in the study area expressed uncertainty or lack of engagement due to limited personal involvement or inadequate access to detailed information. This suggests that while awareness strategies may effectively reach certain demographics, further efforts are needed to facilitate more inclusive participation and communication strategies.

However, existing literature supports the findings that respondents are adept at identifying areas targeted by greening campaigns, particularly residential areas, open spaces, and locations with government institutions ([Kirkpatrick et al., 2012](#); [Gwedla and Schackleton, 2019](#)). [Kulindwa \(2016\)](#) similarly observed this trend among respondents, noting their keen awareness of greening initiatives

deployed in these specific locales. Furthermore, [Kuruneri-Chitepo & Shackleton \(2011\)](#) noted that residential areas and open spaces were often prioritized in greening campaigns due to their potential for community engagement and environmental impact. Contrary to expectations, although respondents recognized key actors in tree planting efforts such as NGOs, government institutions, community groups, and individuals recent studies have emphasized the significant role played by private enterprises in such initiatives ([Ouedraogo et al., 2014](#); [Oduro et al., 2018](#)). [Rahnema et al. \(2019\)](#) found that private companies increasingly engage in tree planting activities as part of corporate social responsibility (CSR) initiatives, often collaborating with government bodies and NGOs. Similarly, [Roman et al. \(2015\)](#) highlighted the emergence of public-private partnerships (PPPs) as a driving force behind successful tree planting campaigns, emphasizing the need to recognize the diverse array of actors involved in environmental conservation efforts.

The higher proportion of respondents who understand the importance of tree planting could be associated with increased provisioning of education on environmental conservation, climate change, and variability, particularly to the general public and local communities. The increased campaigns and initiatives on tree planting in the study district could have created better awareness and knowledge among most urban dwellers ([Gayo, 2023](#); [Luswaga, 2023](#)). Similar findings have been reported in other empirical studies, which suggest that afforestation theories and frameworks indicate intrinsic factors such as knowledge, perception, and attitudes of individuals influencing the adoption of tree planting behavior ([Meijer et al., 2015](#)).

Dodoma semi-arid district is characterized by a shortage of annual rainfall, prolonged drought, and limited natural vegetation ([Gayo, 2021](#)). The increased human population and infrastructure development in the district have exacerbated the loss of natural vegetation, resulting in high demand for firewood and timber, among other resources ([Gayo, 2022](#)). Tree planting efforts for economic gain could have been an alternative livelihood strategy enabling participating households to accrue income through selling tree products, as perceived by respondents in the present study. These findings are corroborated by [Miller et al. \(2017\)](#), who found that economic benefits from tree planting practices among urban inhabitants in Sub-Saharan Africa contributed to an average of 17% of the total household annual gross income. The observed higher awareness of the ecological importance of tree planting among local people in the study area is similarly reported by [Etshekape et al. \(2018\)](#), who found that local people in Kinshasa, Democratic Republic of Congo, were highly motivated to plant trees for sequestering atmospheric carbon, reducing flood damage and soil erosion, supporting soil formation and rehabilitation, as well as for photosynthesis and nutrient cycling. Although some aspects such as the contribution of tree planting to mitigating soil erosion were only reported by a few respondents, this finding may

indicate the extent to which some members of the study community are aware of the potential of greening practices to safeguard ecological integrity.

Regarding the social benefits of tree planting, we found that planted trees serve multiple purposes, including demarcating farm or plot ownerships, providing medicinal benefits, and enhancing urban green spaces. Trees also enable people to learn about nature, offer spaces for social interaction, relaxation, and exercise, thereby minimizing body stress and anxiety. These findings are supported by [Pataki et al. \(2021\)](#), who observed that tree planting improves urban green spaces, aiding in the recovery of mental well-being and contributing to the reduction of social crimes in Chicago.

The existence of several initiatives among communities engaging in nursery production and tree planting in their residential plots, along with the promotion of natural tree regeneration in farm fields, likely reflects existing knowledge among Dodoma inhabitants regarding the importance of tree planting. This observed awareness of the potential of tree planting in the study area may be attributed to people being partially informed about ongoing forest depletion and associated adverse environmental changes, which lead to reduced crop yields and food insecurity. The majority of respondents acknowledged planting many exotic trees in different parts of the district, possibly as an alternative means of securing forest ecosystem services and enhancing the availability of forest products for improved food production and reduced income poverty. Awareness of tree planting is also noted in various parts of the world. For instance, [FAO \(2015\)](#) estimated that 1.2 billion people in the developing world plant trees for food production and to alleviate income poverty. Similarly, [Davoren et al. \(2016\)](#) documented a wide range of plant diversity patterns in the backyards of urban dwellers in northern South Africa, including trees for fruits, organic fertilizers, animal fodder, and firewood supply.

### *Participation of communities in tree planting*

Local involvement ensures that tree planting initiatives are more sustainable, as communities take ownership and responsibility for maintaining and protecting the trees over time ([Galabuzi et al., 2021](#)). Without their engagement, many projects fail due to neglect or lack of support ([Nketia et al., 2021](#)). We also assessed community participation in tree planting across study sites and found the higher participation of Dodoma communities in tree planting that could present opportunities for environmentalists in their conservation efforts. It is anticipated that increased tree planting in the district will mitigate the adverse climatic effects of its semi-arid nature. Similar findings were reported by [Bremen and Kessler \(1997\)](#), showing that active participation of local people in planting trees resulted in increased ecosystem values, including improved nutrient cycling, water availability, higher crop yields, and increased production of livestock fodder in the Sahel region. However, caution must

be exercised in selecting tree species for greening the district, as evidence suggests that the traditional approach of afforestation as a primary tool for ecosystem restoration is not always environmentally friendly (Asgarzadeh et al., 2014). Empirical studies indicate that when trees not adapted to the local environment are planted, they can sometimes contribute to environmental degradation (Bhadouria et al., 2016).

The observed higher participation of the Dodoma community in afforestation initiatives could be attributed to the tree-planting campaigns spearheaded by the Tanzanian Vice President's office since 2019, aimed at greening Dodoma. Such phenomena may indicate that local people in the study area are highly motivated to participate in environmental campaigns, especially when they are well-organized by leaders (Ouedraogo et al., 2014). The significant number of trees planted by youth and women in the study area may be due to their active involvement in local livelihood development and environmental protection, including tree planting (Galabuzi et al., 2021). Tree planting, seen as offering job and income opportunities among many urban dwellers in the study area, likely explains the high participation of youths and women in greening the Dodoma district. The study identified individuals engaged in self-employment through tree planting-related projects, such as developing nurseries and gardens. The involvement of women and youths in greening projects is also supported by previous studies. For example, in Nasarawa State, Nigeria, seventy percent of women planted various tree species in their households' compounds and street gardens between 2004 and 2008 (Labaris, 2009). Similarly, in the Ashanti region of Ghana, youth facilitated the establishment of 1,313 hectares of forests between 2018 and 2019 under an afforestation program (Nketia et al., 2021).

Poor tree management (URT, 2017), periodic droughts in semi-arid zones (Xie et al., 2016), and extreme waterlogging during the wet season (Shemsanga et al., 2017) may have been the major factors resulting in seedling death experienced in the study area. These findings are consistent with other studies on the ecology of tree-seedling growth in dry tropical environments. For example, Bhadouria et al. (2016) asserted that proper management in terms of water, nutrients, and light supply, as well as control of weeds and herbivory, is critical for effective tree-seedling growth in dry tropical areas. Moreover, Cao et al. (2010) reported that anthropogenic, hydrological, climatic, landscape, and pedological factors are essential in selecting suitable afforestation sites for proper tree growth in arid and semi-arid regions of China. It might be imperative for responsible individuals and authorities to ensure the best tree management practices to increase seedling survival rates in the district.

The highest survival rate of seedlings recorded in trees managed by primary and secondary schools is likely attributed to the intensive and regular monitoring conducted by these institutions. Proper growth of seedlings and young trees necessitates regular watering and protection against

disturbances (Mwambusi et al., 2021). Despite numerous trees being planted in the district, the total planted area was only 180 hectares, largely due to trees being planted in single lines along paths such as walkways, roads, plot boundaries, and around houses rather than in woodlots. With respect to annual tree planting, there were few trees planted in 2020 and 2021 (Fig. 2), possibly due to the COVID-19 pandemic limiting people's movement and participation in certain socioeconomic and environmental activities (Kideghesho et al., 2021).

### *Factors influencing communities' willingness in greening Dodoma district*

Empirical studies reported various factors influencing willingness of local people to participate in tree planting practices to include environmental benefits, biodiversity conservation, economic advantages, social and health benefits, erosion control and soil fertility to mention a few (Etshekape et al., 2018; Lockwood and Berland, 2019; Farrell et al., 2022; Gwedla et al., 2022). In the present study several factors were tested using Generalized Linear Mixed Model to assess their influence on local people willingness to green Dodoma district and find that income and education levels, environmental awareness, perceived benefits as well as social influence as the major predictors. Regarding income level, the positive coefficient implies that higher income levels are linked with a greater willingness to plant trees. This suggests that individuals with higher disposable income may have more resources to invest in tree planting activities or may place a higher value on environmental initiatives. Previous studies have also noted a positive association between higher socioeconomic status and pro-environmental behaviors (Gregorio and Herbohn, 2010; Kallio et al., 2011; Mwambusi et al., 2021). Similarly, research by Gwedla et al. (2022) in Eastern Cape, South Africa, demonstrated that individuals with higher income levels were more likely to engage in tree planting activities. However, some studies have reported mixed findings regarding the relationship between income status and environmental behaviors. For instance, studies by Gregorio and Herbohn (2010) and Mwambusi et al. (2021) found that while income was negatively associated with certain pro-environmental behaviors, suggesting that the relationship may be complex and context-dependent.

Regarding the education level of respondents, individuals with higher levels of education demonstrate a stronger inclination towards tree planting. This finding underscores the role of education in shaping environmental attitudes and behaviors, as those with more education likely possess a better understanding of the benefits of tree planting and environmental conservation. This discovery aligns with other related studies indicating that educated individuals tend to support conservation efforts in their respective areas (Oduro et al., 2018; Ngongolo and Kilonzo, 2022). For example,

Lockwood and Berland (2019) observed in Central Indianapolis that households with higher education levels had greater tree density and taxonomic diversity in their residential plots.

In the context of environmental awareness, we have found that positive attitudes towards environmental conservation significantly influence respondents' willingness to plant trees. This highlights the importance of fostering environmental awareness and promoting a culture of conservation within communities. Consistent with our findings, previous research has demonstrated that attitudes towards environmental conservation strongly predict pro-environmental behaviors (Roloff et al., 2010; Meijer et al., 2015; Gayo, 2023). For example, studies by Asgarzadeh et al. (2014) in Tehran, Iran, and Ngongolo and Kilonzo (2022) in Dodoma, Tanzania, found that individuals with more pro-environmental attitudes were more likely to engage in tree planting and other conservation activities. Additionally, previous involvement in environmental activities positively impacts the willingness to plant trees. This suggests that individuals who have participated in environmental initiatives in the past are more likely to continue engaging in similar activities, indicating a cumulative effect of environmental engagement on behavior. However, contrasting findings have been reported in some studies. For instance, Farrell et al. (2022) found that past engagement in tree planting does not always predict actual behavior, suggesting that other factors may also influence behavior.

We also found that positive perceptions of the benefits associated with tree planting, such as improved air quality, enhanced aesthetics, and community health benefits, contribute significantly to a greater willingness to plant trees. This underscores the importance of emphasizing the multiple benefits of tree planting in community outreach and education efforts. Our results align with previous studies that have highlighted the significance of perceived benefits in motivating pro-environmental behaviors (Oduro et al., 2018; Etshekape et al., 2018; Gayo, 2023). For example, research by Breman and Kessler (1997) and Pataki et al. (2021) found that perceived personal benefits, such as improved aesthetics and health, were strong predictors of support for tree planting initiatives in the Sahel and other semi-arid regions. However, some studies have reported mixed findings regarding the role of perceived benefits (Conway, 2016; Davoren et al., 2016). For instance, a study by Etshekape et al. (2018) found that while perceived benefits were important in urban and peri-urban areas of Kinshasa, they were not always the primary drivers of tree planting behavior, suggesting that other factors may also influence decision-making.

Social influence from neighbors, friends, or family members can motivate individuals to engage in greening initiatives. Our study found that positive influence from social networks significantly impacts the willingness of local people to plant trees. This emphasizes the importance of social connections and peer influence in promoting environmental

behaviors within communities. Our findings align with previous research highlighting the role of social networks in shaping environmental behaviors (Oduro et al., 2018; Gwedla and Shackleton, 2019). For example, studies by Gwedla et al. (2022) found that social norms and peer influence were strong predictors of willingness to participate in tree planting initiatives in low-cost housing areas of the Eastern Cape, South Africa. However, contrary to our findings, some studies have reported mixed results regarding the role of social influence. For instance, research by Conway (2016) found that while social norms were important, they were not always sufficient to motivate tree planting habits, suggesting that other factors may also play a role.

Participation in community organizations or events related to tree planting positively influences the willingness to plant trees in the study area. This suggests that community-based initiatives and collective action play a crucial role in fostering tree planting activities and promoting environmental stewardship at the local level. Our findings are supported by Etshekape et al. (2018), who noted that active involvement in community-based tree planting projects led to increased willingness among residents to plant trees and engage in environmental stewardship efforts. Similarly, Pataki et al. (2021) concluded that participation in community events related to tree planting positively influenced individuals' attitudes and behaviors towards environmental conservation, highlighting the importance of collective action in promoting pro-environmental activities.

However, a study by Meijer et al. (2015) found that while community participation had some impact on individuals' awareness of environmental issues, it did not necessarily translate into increased willingness to engage in tree planting activities, especially in areas with low socio-economic status. Additionally, Farrell et al. (2022), during a meta-analysis of various community-based environmental initiatives, including tree planting projects, found mixed results regarding the influence of community participation on individuals' willingness to adopt environmentally friendly behaviors. This suggests that factors such as socio-economic status, cultural norms, and project design could mediate the relationship between community involvement and pro-environmental actions.

## Implications for Conservation

Since 2018, efforts to green Dodoma, a semi-arid district in Tanzania, have intensified. An assessment of community awareness and participation in tree planting practices from 2018 to 2022 demonstrated that local people are aware of the importance of greening semi-arid lands and appreciate the ongoing tree planting initiatives. The high level of awareness among respondents regarding greening initiatives can be linked to increased knowledge about environmental stressors, climate change, and variability (Ngongolo and Kilonzo, 2022). The community acknowledged their participation in

tree planting campaigns and expressed a commitment to plant more trees in the near future. This positive perception among respondents presents an opportunity for environmentalists and conservationists to engage local communities in efforts to combat environmental degradation (Richardson and Shackleton, 2014).

However, to promote sustainable tree planting, a number of socioeconomic factors need to be considered, as they have been shown to increase respondents' willingness to participate in tree planting initiatives. Income and education levels, environmental awareness, perceived benefits of tree planting, and social influence all determine people's willingness to participate in tree planting in the study area (Davoren et al., 2016; Conway, 2016; Etshekape et al., 2018; Gwedla and Shackleton, 2019). Regarding environmental conservation, it is imperative to intensify conservation education for youth and illiterate people as a way of transforming them into future stewards of tree planting (Galabuzi et al., 2021). In the context of semi-arid regions, it is crucial to subsidize ecologically suitable tree species and ensure an adequate water supply for ongoing tree planting practices to support sustainable environmental and biodiversity conservation (Farrell et al., 2022). Therefore, increasing the number of boreholes and wells/ponds for watering trees, providing affordable, improved, and adaptive seeds to semi-arid areas, and continuing to provide extension services will ensure that afforestation efforts are comprehensive and sustainable (Namwata et al., 2015).

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