Seedling Survival Levels Under Plantation Establishment For Livelihood Improvement Scheme And Implications For Conservation Of Mt. Elgon Natural Forest Ecosystem, Kenya

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ABSTRACT

Plantation Establishment for Livelihood Improvement Scheme (PELIS) is an incentive system anchored in the Kenya's Forest Management and Conservation Act of 2016. It allows local communities to use forestlands for food crop production while supporting forest establishment phase. Mixed tree-crop farming may benefit or harm planted trees. Forest plantations are being established using PELIS to protect Mt Elgon natural forest as a critical conservation area in East Africa. We assessed the success of this afforestation system, using tree seedling survival as an indicator in three Stations around Mt Elgon: Saboti, Kimothon and Kaberwa. The main plantation tree species are three exotics: *Cupressus lusitanica*, *Pinus patula*, and *Eucalyptus grandis.* Data on tree survival counts were collected in stands aged 1, 2 and 3 years; across 750 plots (0.04 ha each) and all species types. Field observations and structured interviews revealed PELIS-related causes of seedling mortality. Student's t and ANOVA tests were carried out to ascertain observed differences. Forest stocking level is below standard (< 75%) for each species and age class. The non-adherence to guidelines is the root-cause of failed forest establishment. PELIS will serve its intended purpose of supporting sustainable participatory forest management if actors follow guidelines and monitoring systems are in place.

Keywords: Seedling survival rate, PFM, CFA, PELIS management, stocking status.

1. INTRODUCTION

Forest resources play important ecological, social, cultural and economic functions (FAO, 2018). However, the global forest cover has been declining at a rate of 0.14% annually between 2000 and 2010 (Kimutai *et al.*, 2016). In Kenya, the annual deforestation rate has been 0.11% over the same period (Mwangi *et al.*, 2018); and the forest cover stands at 7.4% (KEFRI, 2018), which is below the minimum 10% mark recommended by the United Nations (UNSPF, 2017). The main drivers of deforestation in Kenya include agricultural expansion to meet the ever increasing food demand; high poverty levels and weak forest governance resulting in flawed enforcement of forest laws and policies (Kimutai *et al*., 2016; Mwangi *et al*., 2018).

To mitigate the effects of deforestation and forest cover decline in Kenya, there has been a paradigm shift in governance regimes from a highly centralized to decentralized forest governance, reflecting aspirations to sustainable forest management (Kairu *et al*., 2017). These efforts led to the enactment of the Forest Act of 2005 which legalised the devolution of rights to local forest-dependent communities through Participatory Forest Management (PFM). PFM seeks to enhance co-management of protected forests between the agency in charge of forests, Kenya Forest Service (KFS) and local communities. While elements of decentralized forest management in Kenya begun in 1997 at a pilot stage in Arubuko-Sokoke forest following demands from neighbouring communities (Matiku *et al*., 2013), it was until 2005 when the legal framework was introduced. The Forest Act (2005) requires forest adjacent communities to register Community Forest Associations (CFAs) and participate in joint management with KFS for identified forest areas. The Act confers user and access rights to CFAs to graze their livestock, develop eco-tourism projects and practise bee-keeping in designated forest areas but they also assume responsibilities of carrying out some conservation and protection activities (Ongugo *et al*., 2008; Agevi *et al*., 2014). The Forest Act of 2005 was recently revised into the Forest Conservation and Management Act No. 34 of 2016 which retained PFM as a pillar to the conservation of forest resources in Kenya.

One of the user rights set up under PFM is the Plantation Establishment for Livelihood Improvement Scheme (PELIS). This scheme allows communities living near forests to legally use degraded or clear-cut forestland for crop production while also establishing tree seedlings for reforestation through their CFAs (Kagombe & Gitonga, 2005). The scheme was initiated with the twin objective of increasing plantation forest cover and improving the livelihood of the landless and poor rural communities (Matiku *et al*., 2013). CFA members are assigned parcels of land in deforested state forests upon payment of a prescribed fee. They grow their food crops as they also establish commercial forest plantations. By 2019, there were over 325 registered CFAs participating in PELIS across the country (Kimutai et al, 2016). Through the PELIS system, there has been an improvement in the socio-economic wellbeing of rural communities demonstrated by poverty and conflict reductions (Kinyili, 2014; Kimutai et al., 2016). For example, Forest Adjacent Communities participating in PELIS in Malava forest (Western Kenya) confirmed that income from PELIS had improved their overall household income where they earned between USD 45 and 143 from their plots' crop yield annually (Agevi *et al*., 2016). While PELIS has a potential to improve livelihoods of local communities (Kinyili, 2014; Agevi *et al*., 2016; Kimutai et al., 2016), assessment of its impact on forest condition has received limited attention to date. This paper presents findings of a study that assessed tree seedling survival levels and associated determining factors under the PELIS management in *Cupressus lusitanica*, *Pinus patula* and *Eucalyptus grandis* commercial plantations around Mt. Elgon in western Kenya.

Forest cover and the status of forest condition are influenced by seedling survival defined as the total number of live seedlings after the forest regeneration or plantation establishment period, typically six months in the tropics. The total number of live seedlings impacts the density and stocking (Evans & Turnbull, 2010) and other structural forest components throughout the plantation life cycle (Grossnickle, 2012). As a guide, if more than 1250 trees per hectare are planted, up to 20% mortality is acceptable, but with a lower stocking only up to 10% is allowed and only 5% of deaths may be tolerated at 625 trees per ha i.e. 4 m x 4 m initial spacing (Evans & Turnbull, 2010). The seedling survival level also determines the likely net return at the end of the rotation period. Therefore, under commercial forestry, seedling survival level is a critical component at the centre of interactions between the Kenya Forest Service and participants in PELIS.

2. MATERIALS AND METHODS

2.1 STUDY AREA AND STUDY SITES

This study was carried out in Mount Elgon forest ecosystem, which is located along longitude 01° 07′ 06″ N and latitude 34° 31′ 30″ E, about 100 km northeast of Lake Victoria (KEFRI, 2018). The study sites were three forest stations; Saboti, Kimothon and Kaberwa (Figure 1). The sites were purposively selected to represent the biophysical characteristics around Mt. Elgon ecosystem (Table 1). In addition, the sites have active CFAs enforcing the Forest Management and Conservation Act of 2016.

Table 1. Biophysical characteristics of the study sites within the Mt. Elgon ecosystem, Kenya

Biophysical attribute	Study sites		
	Saboti Forest Station	Kimothon Forest Station	Kaberwa Forest Station
Altitude range (m)	1350-2000	1850-2000	1350-2000
Mean annual rainfall (mm)	1300-1800	1300-1800	1300-1800
Driest months (rainfall)	Dec-March	Dec-March	Dec-March
Wettest months (rainfall)	April- June	April-June	April-June
Soil type	reddish brown	reddish brown	grey brown
Year of CFA's establishment	2005	2005	2005

Source: Hamilton et al., (2016)

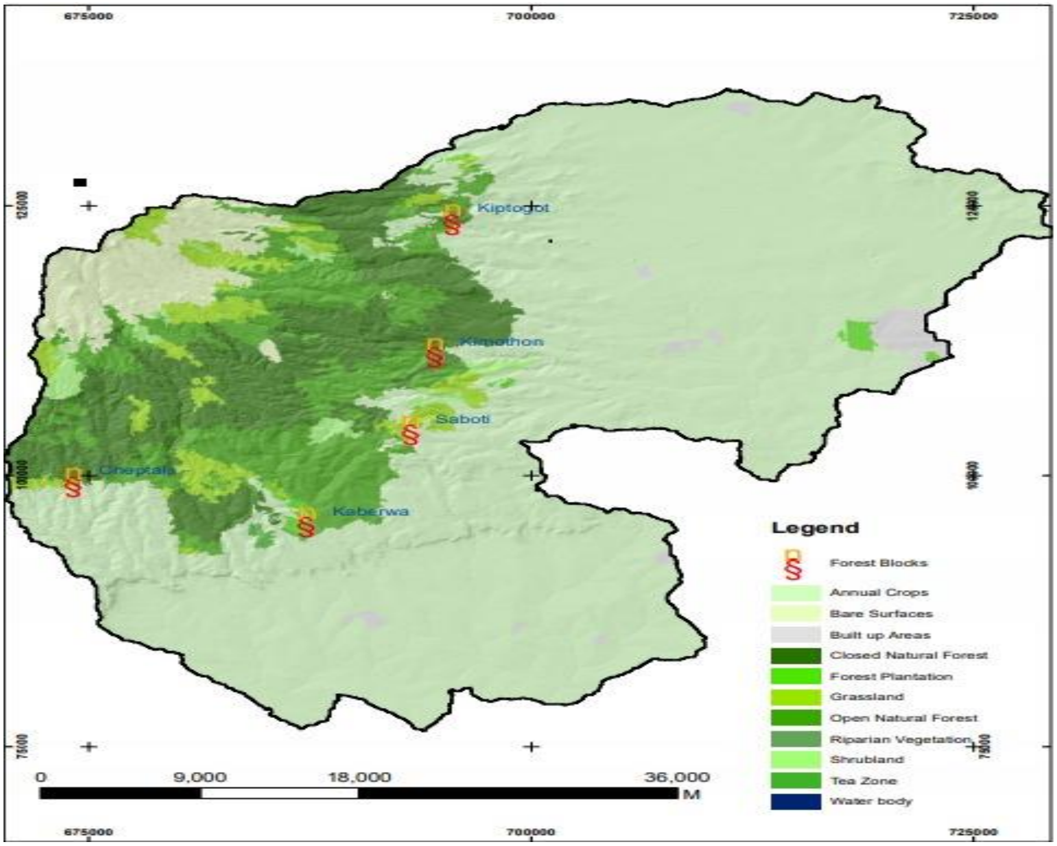

Figure1: Map of the study area in relation to Mt. Elgon Ecosystem (Adapted from Kiprop et al., 2017).

2.2 DATA COLLECTION

Data on initial plantation establishment such as year established, location of compartments and sub-compartment and initial stocking and spacing were obtained from Compartment Registers at respective sites. The assessment of seedling survival, inter seedling spacing, and factors causing seedling mortality (also referred to as determinants of seedling survival) was done within 0.04 ha circular plots distributed in all study sites.

The number of sample plots for each site (represented by a Sub-compartment) was determined as described by Cochran, (1977) and Skidmore *et al*., (2014) formulae as follows (Equation 1):

$$n = \frac{1}{\frac{1}{N} + \left[\frac{E}{tCV}\right]^2} \quad \text{(Equation 1)}$$

Where; *n* = total number of plots to be established and assessed; *t* = Student-t value of a 95% confidence level; *E%* = allowable sample error in percentage (±10%); *CV%* = the highest coefficient of variation (30%); *N* = total number of plots in a sub-compartment (hectarage of sub-compartment /0.04ha).

Table 2: Distribution of sampling plots across tree species, age groups and sub-compartments

Tree plantation species	Age (years)	No. of sample plots per sub-compartment		
		Saboti	Kimothon	Kaberwa
		(281.2ha)	(186.8ha)	(119.6 ha)
Cupressus lusitanica	1	65	60	33
	2	65	29	N/A
	3	61	34	33
Pinus patula	1	66	30	33
	2	63	26	33
	3	32	32	N/A
Eucalyptus grandis	1	26	29	N/A
	2	N/A	N/A	N/A
	3	N/A	N/A	N/A
Total		378	240	132

Circular plots (0.04 ha) were established by measuring the radius of 11 m. Different consecutive plots were established at an equidistance of 30.5 m while ensuring that each set of plots cuts across the sub-compartment (Klein *et al*., 2015). Seedling survival was determined by recording the number of live seedlings in each plot. The cumulative number of live seedlings was used to determine the survival percentage for each species per site, the density per hectare and stocking status. Average inter seedling spacing was assessed by measuring the intra- and inter-row distances between seedlings in each plot using linear tape. Determinants of seedling survival were assessed based on available evidence of possible causes of seedling mortality, and presence of signs and marks associated with a known disturbance external factor in each plot. Twenty-four Focus Group Discussions (FGDs) with an average of 12 participants each in the PELIS management across all sites were carried out in November-December 2018 to identify cultural operations and other management practices carried out and challenges faced during implementation of PELIS.

2.3 DATA ANALYSIS

The seedling density was obtained as a proportion of the average number of live seedlings in a plot to the plot size (Equation 2).

$$\text{Seedling density per ha} = \frac{\text{Number of Live seedlings per 0.04 ha plot}}{\text{0.04 ha}} \quad \text{……………. (Equation 2)}$$

To estimate seedling survival percentage (Equation 3), the average number of live seedlings per hectare was compared with the standard density for commercial plantations in the Sawn Timber Working Cycle for each type of species (Table 3) as recommended by Forest Department (1996). These standards were followed in establishing the plantations used in this study sites (Camirand, 2002).

$$\text{Seedling survival (\%)} = \frac{\text{average live seedlings per hectare}}{\text{Standard no.of seedlings per hectare}} \text{ x 100} \quad \text{…………… (Equation 3)}$$

Table 3: Standard stockings for sawn timber working cycle in Kenya

Species	Common name	Standard density/ha	Average Inter-Seedling Spacing	Plot density/ (0.04ha)
Cupressus lusitanica	Cypress	1600	2.5 m x 2.5 m	64
Eucalyptus grandis	Blue gum	1320	2.75 m x 2.75 m	53
Pinus patula	Pine	1111	3 m x 3 m	44

Source: Forest Department, (1996)

The stocking status was assessed based on the seedling survival percentages as follows: poorly stocked (1-30%), understocked (30-74%) and satisfactorily stocked above 75% (Coleman et al., 2012; Goelz, 1997)

Each Forest Station (as represented by Sub-compartments) formed a block and species types were treatments; the design was simulated to a Randomized Block Design (RBD) and independent t-tests, analysis of variances by both one- way and two-way ANOVA performed on the survival rates among species and sites. The analysis was for seedlings in each age category separately and with $\alpha = 0.05$.

The types and frequency of agents of seedling mortality for different tree species in different forests under PELIS in Mt Elgon, Kenya were obtained from focused group discussions and field observations in the plots visited. They were summarized and analysed using descriptive statistics. The frequency of an agent of seedling mortality was defined as the percentage of plots where the agent was detected over the total number of plots assessed in the forest.

3. RESULTS AND DISCUSSION

3.1 SPECIES SURVIVAL ANALYSIS AND IMPLICATIONS TO THE CONSERVATION OF MT. ELGON FOREST ECOSYSTEM

Survival levels, summarized in Table 4, are presented based on sites, species and ages. Survival levels are important in attainment of ecological and financial benefits from forests (Moon et al, 2019).

Table 4: Average survival of tree species seedlings (%) in different study sites, Mt. Elgon

Station	Ages	Survival %	*Density ha^{-1}*	Survival %	*Density ha^{-1}*	Survival %	*Density ha^{-1}*
		C. lusitanica		*P. patula*		*E. grandis*	
Saboti	1	41.1	657	47.3	526	13.6	180
	2	30.5	488	15.8	176	N/A	N/A
	3	28.9	462	30.4	338	N/A	N/A
	Average	**33.5**	536	**31.2**	347	**13.6**	180
	Overall Stocking	under stocked		Understocked		poorly stocked	
Kimothon	1	10.2	163	6.8	76	5.7	75
	2	18.8	301	20.3	226	N/A	N/A
	3	14.3	229	51.8	575	N/A	N/A
	Average	**14.4**	230	**26.3**	292	**5.7**	75
	Overall Stocking	poorly stocked		poorly stocked		poorly stocked	
Kaberwa	1	28.1	450	76.5	850	N/A	N/A
	2	N/A	N/A	20.3	226	N/A	N/A
	3	48.4	774	N/A	N/A	N/A	N/A
	Average	**38.3**	613	**48.4**	538	N/A	N/A
	Overall Stocking	under stocked		under stocked		N/A	N/A

Key: *Understocked = survival rates 30 -74%; Poorly stocked refers to survival rate < 30%*

The survival levels (Table 4), indicate the average survival percentages with all being below 50%; far much below 75% survival rate recommended for a well-stocked forest. The survival results are below that of Nyandarua County (79%) and the National average in Kenya (67%) as recorded by KFS in the 2012/2013 planting season (Kisyula *et al*., 2018). Generally, these survival levels indicate lower stand densities thus plantations with survival percentage less 30% should be written off while plantations with survival percentage 30-74% should undergo beating up (Coleman et al., 2012).

All plantations around the Mt. Elgon forest ecosystem were established using the PELIS system. It was found that all stakeholders across the study sites were aware of the guidelines and requirements for participating in the PELIS system in accordance with the Forest Management and Conservation Act of 2016. However, only two out of the three selected stations (Saboti and Kimothon) had complied with the signing of management plans with KFS. Kaberwa Station did not have an approved management plan; therefore, not fully compliant.

3.1.1 SURVIVAL LEVELS IN SABOTI FOREST STATION

Overall, the mean species survival levels for Saboti Station (Table 4) were highest in *C. lusitanica* (33.5%), intermediate in *P. patula* (31.2%), and lowest in *E. grandis* (13.6%) stands. However, the species survival levels for 1 year and 3-year-old stands (Table 4) were higher for *P. patula* (47.3% and 30.4%) than for *C. lusitanica* (41.1% and 28.9%) stands.

A t-test analysis of survival rates among sites for age 2 of *C. lusitanica* found the mean survival rate of Saboti Station to be significantly higher (19.5%) than Kimothon Station (12.0%), (p=0.001). However, a t –test about the survival means for age 3 found the mean survival rate of Kimothon Station to be significantly higher

(24.05%) than Saboti Station (13.4%), (p=0.001). The results are an indicator of inability to control the effects of external influences across the sites, species and age groups.

A One-Way analysis of variance of the species survival means for age 1 were found to be significantly different (p= 0.005) among the three species. Tukey's post hoc test revealed that the survival rate was significantly lowest for *E. grandis*. However, there was no significant difference in survival rates between C. *lusitanica* and *P. patula* and *E. grandis*. In addition, a two independent samples t-test analysis for survival rate indicated that at age 2 *C. lusitanica* had significantly higher survival rate (19.52%) than *P. patula* (6.92%) (p = 0.001). Similar trend was observed in stands aged 3 years old with 19.14% survival rate for *C. lusitanica* and 13.40% survival for *P. patula* (p= 0.009).

High mortalities were recorded in *E. grandis* compared to other species due to attacks from underground moles and rats. Additionally, the Forest Manager pointed out that termites attacked the *E.grandis* especially during the dry seasons. Delays or absence of weed clearing in some plots increased the spread of rodents which affected *P. patula* and *E. grandis*. The survival levels of *C.lusitanica* and *P.patula* were low across the ages with most stands being under stocked, the survival means for age 2 and 3 were also found to be statistically significant, this could be attributed to differences in the intensity of attacks from external influences since most the plantation were not fenced. Also, the state of the physical conditions of the saplings prior to the exposure to the external influences determined its survival as seedlings adjust differently after planting. The regimes in beating up (replacement of the death seedlings six months after establishment) may not have been done in *C. lusitanica* but done belatedly to *P. patula* in the 3rd year. The delays by CFA scouts and the forest rangers in the carrying out establishment count and subsequent reporting may have resulted to failure in prescribing the required treatments of beating up further affecting the stocking status.

3.1.2 SURVIVAL LEVEL IN KIMOTHON STATION

The mean survival levels for Kimothon Station (Table 4) were highest in *P. patula* (26.3%), followed by *C. lusitanica* (14.3%), and least in *E. grandis* (5.7%). The species survival levels were observed to increase from age 1 to 2 in *C. lusitanica* (10.2%, 18.8%) and ages 1,2 and 3 in *P. patula* (6.8%, 20.3% and 51.8%). This could be attributed to late beating up and the ability of the saplings to withstand the effects of the external influences. The survival of *E. grandis* was poor, however there were few plantation of the species in the area indicating the likelihood to face out the plantations.

An analysis of variance for the survival means for year 1 were found not to be statistically significant (p= 0.271). In addition, a two independent samples t-test analysis for survival rates found no significant difference in the survival means of age 2, (p= 0.148). However, the survival rate of age 3 for *P. patula* was significantly higher (22.57%) than *C. lusitanica* (9.36%), (p =0.001). This could be attributed to more control of the external influences in *P. patula* than *C.lusitanica.* A comparison of survival rates by analysis of variance for age 1 of C. *lusitanica* amongst the sites was found to be statistically significant (p= 0.004). A similar trend was observed in age 1 of *P. patula* (p=0.001). Tukey`s post hoc test revealed significantly least survival level at Kimothon Station in relation to Kaberwa and Saboti Stations. Also A t- test about the survival means of *E. grandis* of age 1 found the mean survival rate of Kimothon Station to be significantly lower (3.05%) than Saboti Station (7.55%), p=0.001. The differences can be attributed to lack of adequate cleaning of the plots in Kimothon resulting in competition for site resources between weeds and seedlings. Weeds also provided a breeding ground for rats that attacked the seedlings.

It was found that field assessments for survival count and enforcement was mainly done by the forest rangers and the scouts under CFA who reported to the Forest Manager. However, non-conformity to guidelines of the PELIS system may have resulted to low survival levels. Most farmers in Kimothon Station as was with other stations in Mt. Elgon preferred maize (*Zea mays*) farming which grows fast limiting the accessibility of young saplings to sunlight. Kisyula, 2018 in a study on PELIS in Kericho County, Kenya indicated that different tree-crop combinations affected seedling survival in the PELIS system with maize (*Zea mays*) -*Pinus patula* combination registering the least survival percentage. Other forms of malpractices in the system such as burning debris in non-designated zones, inflicted damages and trampling eventually affected survivals. The average survival levels of both *C.lusitanica* and *P.patula* were thus below the required standards hence most of plantation were due to be written off.

3.1.3 SURVIVAL LEVEL IN KABERWA STATION

The mean survival levels (Table 4) were highest in *P. patula* (48.4%) and intermediate in *C. lusitanica* (33.5%). The survival levels for *P.patula* was observed to drop from age 1(76.5%) to age 2 (20.3%). An independent t-test conducted to compare the survival means found that at age 1, *P. patula* had significantly higher survival rate (33.67%) than *C. lusitanica* (18.0%), (p= 0.001). The differences can be explained as favourable crop and tree combinations in *P.patula* compared to *C. lusitanica* plantations as much of the plantation were under the short crops (beans and cabbages) and possible species-site match. The site conditions affect the success of plantation establishment since some sites may not be suitable for certain species, as a result, soil characteristics with attention to the pH, texture, moisture, and nutrient availability should be considered prior to undertaking establishments. The soil pH may influence growth when at a certain level, particular nutrients become unavailable or toxic to the seedlings (Matonyei *et al*., 2014; Grossnickle, 2005).

Kaberwa Station was found to have established the least plantations, 119.6 hectares. The Forest Manager indicated that they relied exclusively on the funds from KFS to carry out new plantation establishments as opposed to both Saboti and Kimothon who had enhanced mechanisms of engaging their associations. They also had few active CFA participants and did not have the scouts for enforcement.

To address the shortfalls arising from low seedling survivals, Forest Managers in Mt. Elgon should focus on the quality of seedlings produced based on factors such as total size, root-top ratio, the form of roots and crown, stem thickness, and colour of foliage since vigorous, healthy-looking seedlings have a better chance of surviving in the field after being planted than less vigorous seedlings (Struve, 2009). Additionally, participants in PELIS should improve the techniques of seedling handling to minimize physical injuries, minimize pest and disease attacks on seedlings through cultural practices of ensuring clean plots, openness and promptness in reporting new changes in seedlings growth. The survival levels and the stocking status can be used to reference the current forest regenerations in Mt. Elgon to the potential conditions. Low seedling survival levels may be attributed to the weak systems of governance by CFAs in the implementation of PELIS system that form the determinants of seedling survival. Therefore, the current status of seedling survival levels under PELIS in Mt. Elgon may delay afforestation programs and the attainment of envisioned stable forest ecosystems in Kenya.

In summary, the above results in Table 4 across all sites, indicate that the existence of management plans per se did not improve tree survival either; the implementation of the same plans was poor and not monitored.

3.2 DETERMINANTS OF SEEDLING SURVIVAL TOWARDS AFFORESTATION AROUND MT. ELGON FOREST RESERVE

The factors that impacted on the seedling survival (Table 6) were dominated by livestock grazing which accounted for 38.0% of seedling mortality followed by trampling by haulers that accounted for 20.0%. Others include fire (11.6%), inflicted damages (10.7%), moles (5.3%), weed control (5.0%), rats (4.2%), garden ants (3.0%) and wildlife herbivory (2.2%). All the above factors are indicators of poor management of the stands; lack of protection against livestock, haulers and lack of sufficient control and fight of wild fires, rodents such as moles and rats, weeds, ants and wildlife. Frequency of direct damage on trees by farmers (about 11%) was also high.

Table 6. Types and frequency (in percentage) of agents of seedling mortality for different tree species in different forests under PELIS in Mt Elgon, Kenya.

Agents of seedling mortality	Forest Stations								***Total damage weight (%)***
	Saboti			Kimothon			Kaberwa		
	CL	PP	EG	CL	PP	EG	CL	P.P	
Livestock effect	13.3	6.7	4.7	4.0	2.7	2.0	2.4	2.3	**38.0**
Hauler trampling	2.3	2.2	4.0	1.3	3.1	3.2	1.3	2.7	**20.0**
Fire		4.0			6.3		1.3		**11.6**
Farmer-inflicted damage	3.3	0.7	2.0	0.7			2.7	1.3	**10.7**
Moles			3.7		1.6				**5.3**
Weed control	2.1					1.6		1.3	**5.0**
Rats debarking		0.9	1.2			2.1			**4.2**
Garden ants	3.0								**3.0**
Wildlife herbivory							1.5	0.8	**2.2**

Key: CL = Cupressus lusitanica; PP = Pinus patula; EG = Eucalyptus grandis. Frequency as a measure of damage weight = % of plots affected

Livestock grazing influenced seedling survival through browsing and trampling. Although grazing rights are provided for in the Forest Conservation and Management Act (2016), it restricts such activities in zoned areas only. Apart from affecting plant life forms, grazing induced stress, inflicted wounds and caused mortalities

(Kikoti *et al*., 2015; Ratovonamana *et al*., 2013). Therefore, the results indicate that improved livestock management systems in the area and close monitoring of plots under PELIS would significantly safeguard the benefits of farmers while maintaining high survival of trees under the PELIS system.

Inflicted damages by uprooting, cutting, and moving trucks through plantations resulted to loss of seedlings. Farmers covered young seedlings with field debris, limiting access to sunlight, or even carried out excessive pruning. These practices of nonconformity to set rules of operations is a pointer to weak or absence of strong pillars of governance that increases conflicts which impairs actualization of forest based programmes (Kallio, 2013).

Cultural practices of weed control by burning field debris resulted in fire spillage that burnt seedlings. Delays in weed clearing led to competition for site resources; light, water and nutrients occasioning chlorosis, retarded growth, susceptibility to disease infusion and deaths of seedlings (Vasic *et al*., 2012). The use of chemicals to control weeds may have affected non-target plants that causes great changes in survival, health, or the reproduction that eventually alter species richness and stand densities (Chhabra *et al*., 2013).

The rats and moles affected young *E. grandis* and *P. patula*. The rats caused debarking while moles destroyed the roots. Bushy and uncleaned plantations are known to create breeding grounds for rodents (Ostfeld *et al*., 1997). Garden ants (*Lasius niger*) attacked young stems of *C. lusitanica* during the dry season sacking the sap from the tissues; this affected the flow of water and nutrients across the plant resulting in yellowing and browning of the foliage on the affected twig; this eventually caused partial damage to the twigs or death of the entire plant.

Results in Table 6 reveal laxity in the laid down guidelines governing people who participated in PELIS. Procedures and practices were flawed from allocation of PELIS plots, annual renewal of membership, intercrop selection (short perennial crops that do not outcompete tree seedlings and saplings e.g., for light and/or water and nutrients), weeding practices, disposal of field debris, movement for machinery and livestock, pruning operations, and zoning for grazing and riparian conservation.

4. CONCLUSION

Plantation Establishment for Livelihood Improvement Scheme (PELIS) is the main model through which forest plantations are currently established in Kenya. The system has helped establish some plantations and improved the livelihoods of local communities through crop farming. Generally, the initial seedling survival levels in the study area are low; hence most of the plantations need immediate gaping to raise the stock density to acceptable standard while others have to be written off and plan for re-planting afresh. Indicators of poor management and inadequate supervision are evident. Grazing, inflicted damages, uncontrolled burning of field debris, pests were observed to influence survival. The survival levels are an indicator of the possible failure of the PELIS program in the study area. Therefore, the PELIS system in Mt. Elgon to succeed, it should be strengthened by setting good management practice and supervision protocols, and allow only CFA members whose plots register high survivals to continue. Under current state of PELIS in the study area, Mt Elgon natural forest ecosystem remains exposed to future threats due to failed buffer plantations.

ACKNOWLEDGEMENT

The authors are highly indebted to Volkswagen Stiftung Foundation-Germany for funding this project. Special appreciations are also extended to Jomo Kenyatta University of Agriculture and Technology (JKUAT) and the University of Kabianga, Kericho for motivation and directorial support during field activities. Appreciations are also extended to Kenya Forest Service (KFS) station managers and Community Forest Association (CFA) heads in the study area for helping us in mapping study sites and conducting household heads.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

FUNDING

This work was supported by Volkswagen Foundation under the programme on Livelihood Reforms and Structural Transformation in Africa

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