Effectiveness of Integrated Indigenous-Technocrat Model in Restoring Controversial Forest Reserve Hotspot: The Case of Nkanya and Lusewa Rivers in Domasi Area, Zomba District

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***Abstract*—The study was conducted along the Nkanya-Lusewa rivers in Zomba-Malosa Forest Reserve in Domasi area in Malawi to come up with a better integrated indigenous and technocrat model for tree restoration and test its effectiveness in Nkanya-Lusewa river catchment as a hot spot. The study focused on 28 gardens along the rivers whose owners encroached the forest reserve and willed to participate in the study. In total we planted 228 seedlings of S.siamea, F.albida and A.lebbeck within a distance of 10 m on either side of the study rivers using integrated approach. We found that out of 101 S.seamea seedlings planted in February,2014 in the study gardens, 81%, 68%, 51% and 38% survived by May, August, November and April respectively and the survival rates for F. albida were 83%, 68%, 39% and 5% while for A. lebbeckwere84%, 81%, 58% and 51% respectively for the same months. Most of the selected farmers fully and willingly participated in the research activity. We further found that tree survival rates varied among the gardens due to transplanting shock, post-planting care differences, soil moisture variation and incidence of bush fires. The research has therefore found that trees planted using Integrated Indigenous-Technocrat Model along these rivers survived better for the same period than those previous planted implying that full community involvement in forest restoration is crucial.**

***Index Terms*—Forest restoration, indigenous-technocrat knowledge, survivorship.**

I. Introduction

Forestry ecosystem provides direct-use values and none-use values to the households as well as the entire ecosystem itself. The people in Domasi area, in Zomba district in Malawi cultivate in marginal land and have invaded Zomba-Malosa forest reserves for cultivation and charcoal production due to scarcity of land which emanates from high human population growth and poverty level such that survivorship of indigenous trees is very low. Trees planted along Nkanya and Lusewa rivers, which supply domestic water through Southern Region Water Board (SRWB) and Water Users Association (WUA) in Domasi area have been failing to survive since 2005 though some interventions have been put in place. The SRWB has indicated that without full community and Forestry Department consultation it planted 1,000 indigenous trees in 2005 and 2,000 trees in 2006 along Nkanya river and close to the water treatment plant but out of all these trees only 10 have survived up to date (2015). The study was therefore carried out to come up with a sustainable forest restoration approach and then test its effectiveness in Nkanya-Lusewa river catchment which is one of the Zomba-Malosa forest reserve hot spots.

Studies have shown that more than 50 percent of trees planted along city and community streets and on other public property each year, do not survive beyond one or two years due to a number of reasons such as transplant shock, improper planting and lack of regular follow-up care [1]. Similar studies have revealed that weed control, irrigation and plants' biotic responses to physical factors such as water, light and nutrients are crucial in re-establishing native trees and shrubs along rivers in the initial years [2], [3]. Similarly, planted trees in Malawi have displayed low survivorship both in the customary and public lands due to poor seedling quality, disturbance regimes, improper planting and lack of post-planting care. Machinga district for instance in 2011/12 forest season planted 1.9 million tree seedlings but registered 65% survival rate due to drought and poor seedling management. The same district planted about 2.5 million trees in 2012/13 planting season in which 14 tree species including *A. lebbeck*, *K. anthotheca*, *Eucalyptus*, *F. albida* ,*B. stipulada*, *A. polycantha*and fruit trees were planted and it is expecting to have 95% survival rate due to good quality seedlings used, good rains and intensification of awareness of tree management to stakeholders [4].

The National Water Project (Management of water catchment areas) in collaboration with District Forest Office in 2010 facilitated the formation of water catchment committees and development of water catchments and hotspots plans; trained communities in various skills such as nursery production and tree caring and planted trees within the catchment area but these trees cannot be traced along the rivers under study. The Forestry Department through Improved Forest Management for Sustainable Livelihoods Programme (IFMSLP) also did similar activities and planted trees along Domasi and Nkanya rivers in 2012/13 planting season but the exact number of trees planted and surviving has not been documented. The programme also sensitized the communities surrounding the Forest Reserve on the Forest policy and Act. The Forestry Department has good strategies as guided by the Forestry Act of 1997 [5], the Forestry Policy of 1996 [6], the National Forestry Programmes of 2001, 2002 and 2011 [7]-[10], the MGDS I (2006-2011) [11] and MGDS II (2011-2016) but these strategies have not been successfully implemented in the area as evidenced by low survival rates of

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planted trees and persistent deforestation activities in the study area (Mtogolo Forest Management Block). The IFMSLP on the contrary has led to vibrant natural regeneration of trees in group village headman Mangumba in Minama Forest Management Block which is just adjacent to Mtogolo Forest Management Block because the chief since 2007 has been vigilant in leading forest restoration programmes [12]. The other project called Lake Chilwa Basin Climate Change Adaptation Programme (LBCCAP) is carrying out similar activities, conducted tree species diversity survey in three hotspots namely Malosa, Chikala hill and Michesi Forest Reserves and identified priority tree species for hotspots a forestation in the Lake Chirwa basin for 2010/11 plantation [13], [14]. However, the impact of this project is not yet observed along the rivers understudy. Lack of dispersal of forest seeds, seedling competition with pasture grasses, high seed predation, low seed germination, lack of nutrients, high light intensity, and rabbit herbivory have been identified as some of the barriers in forest restoration experiments that hinder tropical forest recovery [15]. Therefore these must be considered in afforestation and reforestation projects. Trees such as *Albizialebbeck, Faidherbiaalbida, Acacia polycantha* and *Senna siamea or Cassia Siamea*are recommended for reforestation in many areas worldwide as well as in Malawi especially in riparian system and in agroforestry programmes because they have multipurpose characteristics, provide quick benefit to the ecosystem and human, and have no or little negative ecological effect on the riparian system [16]-[18]. However the information on the initial establishment and growth rates of these trees species in Malawian conditions is not available. Some studies in tropical forest restoration recommend protection of forest areas from fire, seed and soil degradation; allowance of natural regeneration; and enrichment planting in degraded land because species richness recovers rapidly although with quite different composition from original forest sites [19].

II. Study Area

The study area is located in Domasi area in Zomba district which is found in the southern region of Malawi. Domasiarea lies between latitude $15^0$16' S and longitude $35^0$30' E. The study area is at elevations of 744m to 954m. The main research site falls under Mtogolo Local Forest Management Block which is part of Zomba-Malosa Forest Reserve. The main objective of conserving this Block is to protect and conserve natural resources in order to improve livelihoods of people found in Mtogolo group village. People in the area depend on gravity fed water system and trees from Mtogolo forest block. Most villagers in the area are poor and are engaged in early marriages. High level of poverty leads to villagers' overdependence on trees for construction, herbs, firewood and charcoal as sources of energy and income.

A. Geology of the Area

Domasi area and the rivers understudy in particular have sandy loam soils in general but they slightly vary in the proportion of sand and humus available making them also vary in texture. Domasi area has pre-karroo igneous rocks which are composed of three main mineral complexes namely Domasi granite, found in the Domasi river valley between Domasi and Mtwiche market; biotite-microtonalite, which has a little less Fe_2O_3, MgO and CaO and rather more than twice as much as K_2O and P_2O_5 and is a basic contaminate of the Domasi granite and microgranites as evident in the Domasi river near Domasi prison [20].

B. Rainfall and Agriculture

Crops most commonly grown in the area include maize, cassava, peas and beans, of which maize is the staple food. The agrochemicals applied to maize may have an impact on the nutrient concentrations along the rivers and in off-river gardens apart from the bed rock. Several reports describe the climatic pattern experienced in Zomba [21], [22]. The reports point out that Zomba experiences a tropical climate with three main seasons: cold-dry, hot dry and hot wet with the mean annual temperature of about 22.5^{o}C. The hottest months are September to November with mean day temperatures of 28^{o}C to 30^{o}C while June and July are the coldest months with mean day temperatures of 10^{o}C to 12^{o}C. The rainy season is from November to April with continuation in form of light cold showers from May-end to July while the dry season is from May to October. The average annual rainfall in Zomba ranges from 800mm to 1,200 mm while inDomasi, in winter there is much less rainfall than in summer with an average of 1218mm per annum and the day temperature averages 22.0 ℃.

III. Theoretical Orientation

The study is based on two theoretical foundations. Firstly, integration of technical and indigenous knowledge systems in natural resources management [23]. The indigenous knowledge in forest restoration was embedded in Adaptive Forest Co-management guiding this study which involved: Set-up phase (Stakeholder involvement; Clear objectives; Management actions; Comparative models; Monitoring plans) and Iterative phase (Decision making; Follow-up monitoring, and Feedback) [24]-[26]. Secondly, utilization of three core and interrelated Forest Restoration Principles and Criteria namely: Ecological Forest Restoration, Ecological Economics, and Communities and work force [27]. Therefore the designed theoretical framework of this study follows these foundations (Fig. 1)

IV. Methodology

A. Research Design

In this study, we used qualitative and quantitative designs, block design and natural snapshot experiments. The qualitative research design was appropriate because it would help in determining people's ideas regarding natural resources conservation and role of indigenous knowledge in forest restoration as well as biotic and abiotic factors affecting growth of the planted trees. The research was based on natural snapshot experiments coupled with plant growth observation and full community involvement in providing ideas and tree management. Fig. 2 below shows the villages and gardens (study blocks) where the study took place. The green colour in the figure indicates part of the forest reserve.

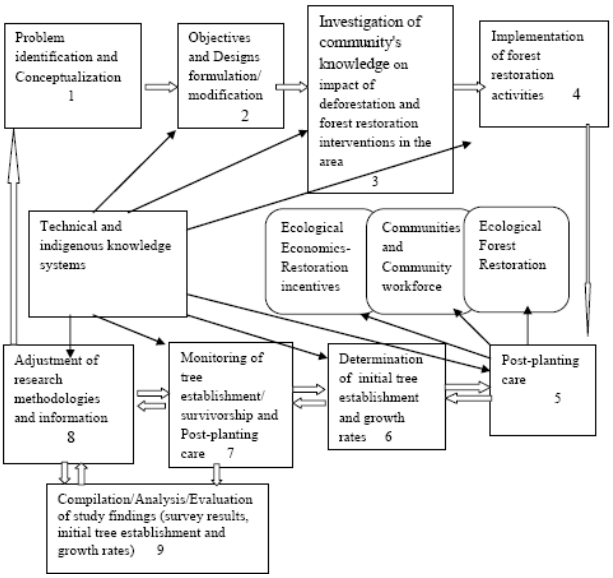


Fig. 1. Theoretical framework of the research study.

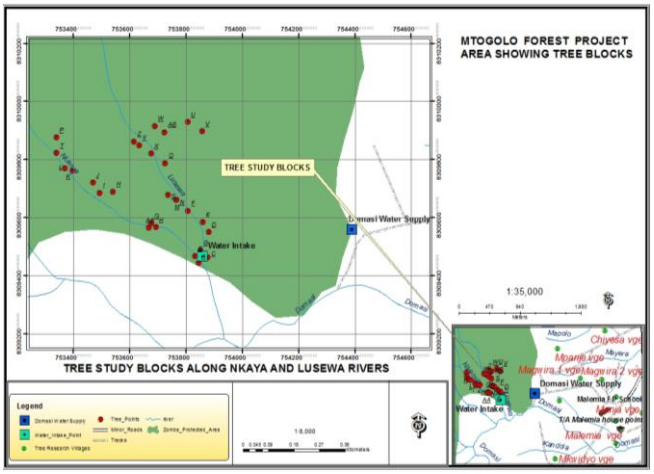


Fig. 2. Drawing showing study blocks (part of garden) along Nkanya and Lusewa rivers.

B. Procedures

1) Investigation of the community's knowledge on the impact of deforestation in an area and better possible ways of restoring trees along Nkanya and Lusewa rivers

We carried out the questionnaire guided interviews and prior to forest restoration activity to collect in-depth information on the community's livelihoods, and indigenous knowledge on the importance and impact of deforestation in an area as well as possible sustainable ways of restoring trees along Nkanya and Lusewa rivers. This activity was done in September, 2013 involving 591interviewees from 25 villages and parts of the findings are presented in Fig. 3, 4 and 5.

2) Forest restoration process and model testing

For effective implementation of the plants, we involved different stakeholders in forest restoration exercise which was done in three main phases. The initial tree planting activity took place on 1st February, 2014 by the villagers, chiefs, Mtogolo Forest Block committee, Domasi area Forest officers, Domasi Water Treatment Plant officers and students' representatives (Domasi College of Education, Domasi Day secondary school). The community was involved in tree planting to foster tree co- ownership and effective co-management which could in turn lead to high tree survival rate. Second tree planting took place from 1st to 5th February, 2014 involving only 28 forest reserve encroaching farmers who cultivate along Nkanya and Lusewa rivers and were willing to participate in the study. These farmers were selected as a study group to test the new approach. Three trees species: *S. siamea*, *F.albida* and *A. lebbeck* totaling 228 were planted in the 28 gardens (study blocks) (indicated by alphabetical letters in Fig. 2) as they were among the highly preferred tree species by the interviewees for various reasons. Out of the 28 gardens (blocks), 4 were located at least 30m away from Lusewa river for comparison sake. The seedlings were planted in gardens along the rivers within a width of 10 m on either side of the river bank taken as a buffer zone. Number of seedlings planted in each garden ranged from 4 to 16 depending on the size of garden portion under study (block) and in most cases, two tree species were planted in each garden. The third phase took place on 8th March, 2014 where 5 trees species namely *K. anthotheca*, *A. lebbeck*, *A. polyacantha*, *Parkiafilicordia* and *Afzeliaquanzensis* totalling 1,000 were cluster planted in the study area. The three village groups were empowered to take care of trees and in return they were rewarded with fruit seedlings as a group incentive. The trees planted in phase three (in clusters) were not included in the study for data analysis because they were off the study blocks although two clusters were in Nkanya-lusewa rivers catchment.

3) Determination of the initial establishment and survival rate of planted trees

We determined the initial population size of the study trees on the fifth day after planting in order to allow the seedlings to establish themselves in the soil and recover from transplanting shock. We tagged these seedlings with numbered papers sealed in cello tape for easy identification and then we determined every three months.

C. Data Analysis

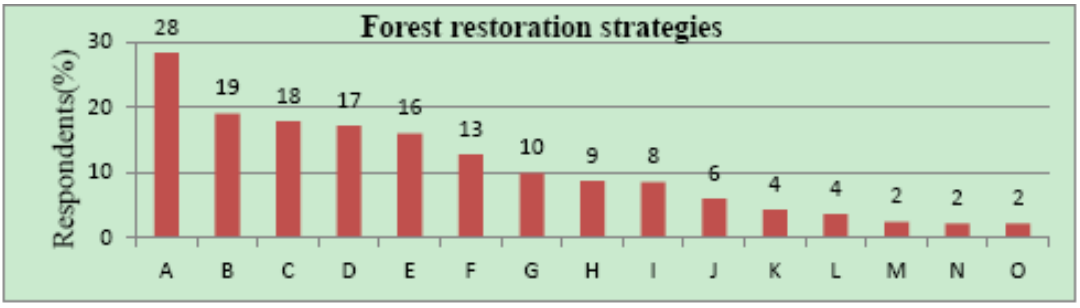
The collected data have been analyzed using SPSS and Excel computer packages. Besides that, equations from demography and population ecology were used to determined annual mortality, annual survival and cumulative survivorship where annual mortality is defined by $M_{annual} = 1- (N_t/N_o)^{1/t}$. The fraction (N_t/N_o) is the cumulative survivorship to time *t*, conventionally written l_t.

V. Results and Discussion

The study has shown that trees can better be re stored in forest reserve hot spots such as Nkanya-Lusewa rivers catchment if there is integration of indigenous and technocrat knowledge as well as full community involvement. A number of strategies and tree species priory suggested by the sampled community for consideration, were utilized in this study (Fig. 3, 4 and 5 show responses from respondents).

The trees planted during the study are promising to contribute considerably to forest restoration along the rivers as a good number of them have survived in the first fifteen months compared to the same period in the past years where most newly planted trees had been damaged within the first

month of planting (Fig.6). Most of the selected farmers fully and freely participated in the study activity. Tree survival rates varied among the gardens due to a number of reasons such as severing of roots during transplanting due to use of unskilled labourers, differences in soil moisture content, post-planting care and incidence of bush fires set by mice hunters in October. We observed that the highest average survival rate at the end of 15 months were in *A.lebbeck* (51%) followed by *S.siamea* (38%) and lastly *F. albida*(5%) (Fig.6) and a similar pattern was obtained in trial experiments conducted in Tanzania where it was found that at the end of 5 months and 17 months the survival rates of *S. Siamea* were 99.3% and 98.7% respectively as for F. albida rate they were 98.0% and 94.0% while *A. Lebbeck* had initial survival rates of 99.3% and 99.3% respectively simply because good management practices were followed [28]. In our case, we found that out of 101*S.seamea*seedlings planted in February in the study gardens, 81%, 68%, 51% and 38% of them survived by May, August, November and April respectively of the first fifteen months of the study.



KEY

A-Continue planting more trees B-Regular post-planting weeding in the plantation

C-Villagers should be employed as forest guards D-Have follow-up schedules after tree planting

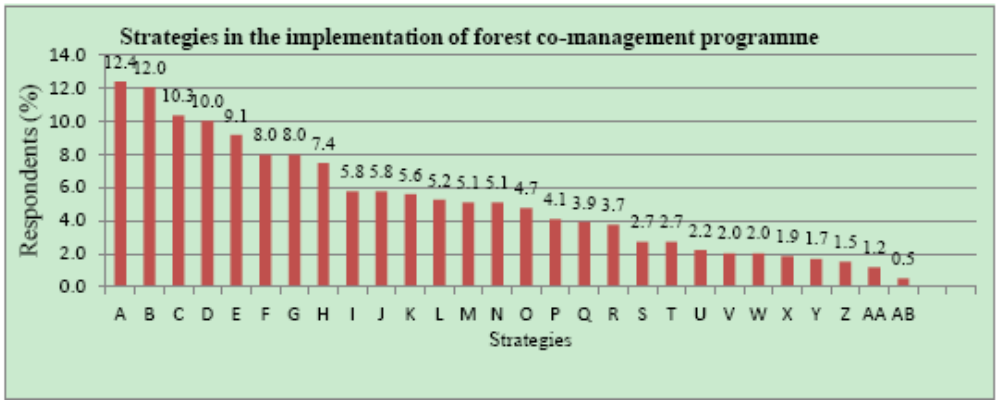
E-Community should be civic-educated F- Chiefs must be fully involved G-Institute strict forest rules

H-Practicing agro-forestry I-Proper tree harvesting and utilization J-Cooperation between villagers and Forest officials

K-Prepare fire brakes L-Farmers must be responsible for tree caring in their gardens

M-Consulting farmers before tree planting in their gardens N-Irrigating newly planted trees O-Diversifying tree species

Fig. 3. Graph showing suggested strategies for quick forest restoration in Domasi area.



KEY

A-Encouraging chiefs to fully participate B-Effectively civic educating people C- Post-planting weeding

D- Villagers and forest officers must co-operate E-Villagers be employed by government F-More follow-ups needed

G- Villagers to patrol trees H- Chiefs and villagers to work together I-Meetings must be conducted

J- Villagers must be encouraged to care for trees given to them K- Replanting trees yearly L-Police be actively involved

M- Following rules and regulations N- Prohibit cutting trees without permission O-Villagers to obey government needs

P- Deforesters must be punished Q- People must be given incentives R- Avoidance of bushfire

S- People to observe each other T- Implement discussed issues U- People to listen to each other

V- Gender equality needed in committee W- Watering planted seedlings X- Forming tree planting groups

Y- Prohibit charcoal production Z- Making fire brakes AA- Charcoal traders be given money for alternative businesses

AB- Invalid responses

Fig. 4. Graph showing suggested strategies for successful implementation of forest co-management programme

The highest seedling mortality of S.seamea within three month was recorded in May (19 plants dead) mainly due to transplanting root shocks, seconded by that recorded in November (17 dead plants). *S.seamea* however has been known to have the capability of growing under a wide variety of climatic conditions ranging from humid to arid although seedlings cannot withstand prolonged drought and subjection to fire. In its natural habitat, its mean annual temperature is

within 20-28℃, prefers moist soils with good drainage and a soil pH of 5.5-7.5 [29], [30]. Although the species is native to the area, these rivers have necessary climatic and edaphic conditions for the survival of these plants.

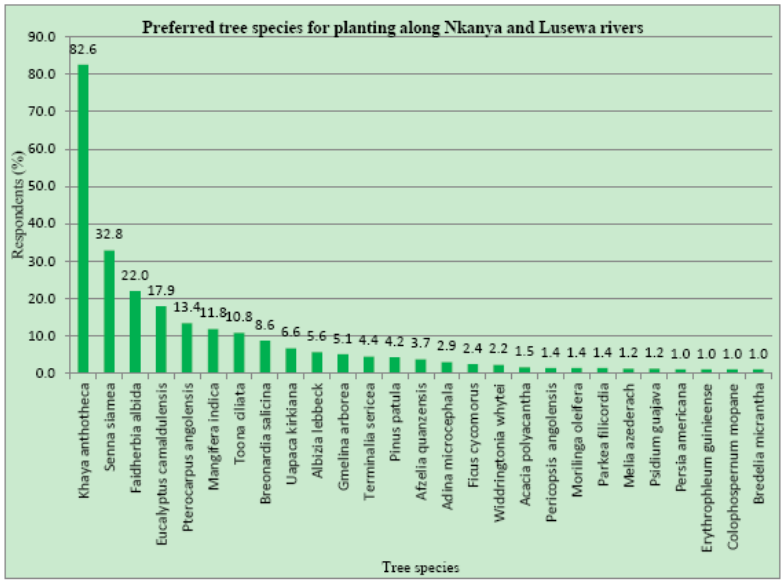


Fig. 5. Graph showing tree species suggested by the community for quick tree restoration along Nkanya and Lusewa rivers.

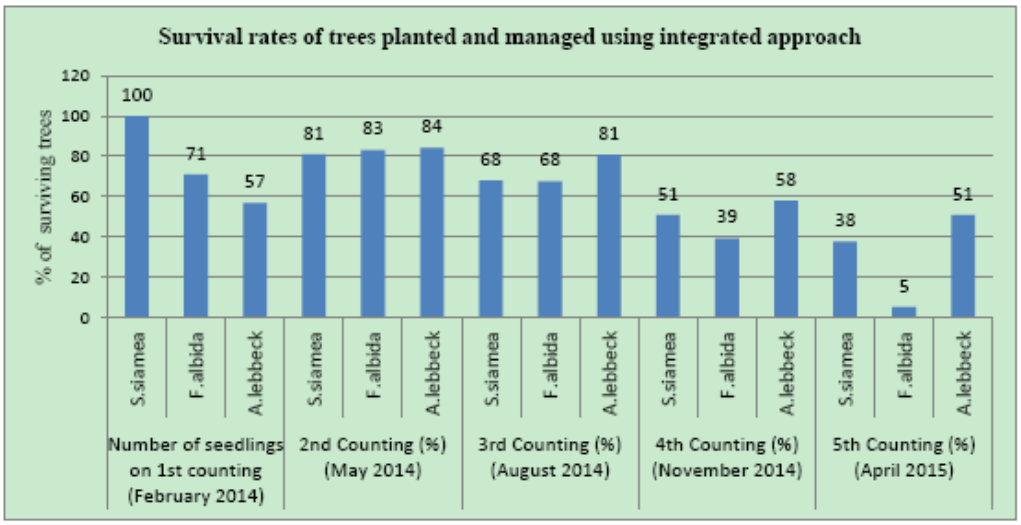


Fig. 6. Graph showing survival rates of tree species planted and managed by garden owners.

*F. albida*on the other hand has been known to grow in hot areas of Malawi such as Salima and Nkhotakota. This study along Nkanya and Lusewa rivers found the survival rates of the species to be 83%, 68%, 39% and 5 % in May, August, November and April respectively. This study has also found that *F.albida* has highest mortality of the three species. The decline in survival rates in our study was due to pre- and post-planting care and incidence of bush fire. Twelve *F.albida* trees (12) died between February and May, 11 died between May and August, 20 plants died between August and November and 24 died between November April. Therefore strict observance and management is required for this species to survive well in the area which may be of different climatic conditions and also more studies trials are needed in this research.

We further found that out of 57*A. lebbeck* planted seedlings, 84%, 81%, 58% and 51% of them survived by May, August, November and April respectively. The highest seedling mortality of *A. lebbeck* within three months was recorded in November (13 plants dead) and this was due to fierce fire set by mice hunters in October, seconded by the May reading (9 dead plants) where plant died mainly due to transplanting shock in February. The species was also observed to have survived better than two other plant species understudy. Literature has also shown that *A. lebbeck* is drought and salt tolerant, and it flourishes in areas mean annual temperature of 19 -35 ^{O}C , altitudes of 0-1800 m, wide soil pH range, heavy and eroded soils, and waterlogged soils which are also similar to conditions in the study area. Research has also shown that plant reserves in the root system enable young plants to survive total defoliation from fire or grazing [31], [32] thus why the species survived better. The survival of the plant in other places however can be affected by different diseases and insects but these were not observed in the study site.

Weeding and irrigation is seldom done in public forest in Domasi area and other areas in Malawi thereby leading to great loss of juvenile trees. Some trees dried up because they were planted relatively away from the water course in some

gardens. It was observed that owners of six gardens (21% of gardens) did not weed around the seedlings after planting while owners of three gardens (11% of gardens) weeded only around the seedlings leaving most garden part bushy. Besides that, only 17 out of 28 (61%) farmers cultivated again in the forest reserve in 2014/15 growing season after the Forestry Department had intensified the campaign against cultivating in the protected area hence nocare was given to those young plants. The April tree observation, which took place after campaign found that some trees survived in the gardens of the defiant farmers and this indicates that people have developed a positive attitude towards tree conservation programmes. It should however be noted that the we did not visit the uncultivated gardens this time because no villager was ready to accompany us to the abandoned gardens due to tense situation caused by the ban therefore it is likely that these gardens have some surviving trees which have not been counted.

VI. Conclusion

The research has found that *S.siamea, F.albida* and *A. lebbeck* planted by the community along the Nkanya and Lisewa rivers survived better than in the previous attempts for the same period because in this research the community was priory consulted and fully involved from the onset of the programme. The study has found that both technocrat and indigenous knowledge as well as continuous local community involvement are very important in natural resources restoration, conservation and management in areas where the community encroach the forest reserves. The major causes of tree mortality included transplanting shock and bush fires. In forest projects, resources should be set aside for monitoring and management of planted trees. Since the study was done for just one tree cohort and only for fifteen months, the results cannot be generalized therefore long term study is needed.

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