

ROADSIDE TREE PLANTING MANUAL

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REPUBLIC OF KENYA



GLOBAL
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1. General information

1.1 Introduction

Humans and other living things depend on water for life and health. People living on Arid and Semi-Arid Land (ASAL) face water shortages, long periods of droughts, and sporadic intense outbursts of rainfall. In ASAL regions, soil erosion is a big challenge that is exacerbated by road construction. Hard road surfaces change the hydrology and alternate subsurface flows, and they often generate higher run-off flows with higher velocity. In this way, roads cause problems such as erosion, gully formation, waterlogging, and washing away of fertile soil. These issues greatly affect roads, the landscape, and adjacent farmland. However, the negative effects can be turned into positive impacts through planting trees and other types of vegetation, coupled with water harvesting. Safeguarding roads, the environment, and farmland is essential to ensuring resilient and thriving livelihoods.

Roadside tree planting can make significant improvements to the quality of roads and the environment and can protect key natural resources, especially in ASAL regions where vegetation is essential in binding the soil with organic matter that aids in enhanced infiltration and water retention in the soil. Road corridors can be a focus area for the restoration of vegetation cover, as vegetation supports many additional benefits, such as trapping dust and reducing run-off flows. Several studies indicate that the benefits accumulated from roadside tree planting include better soil formation by shedding dead leaves, increased water quality by reducing sediment flow, reduced erosion, road beautification, flood control as the trees slow and absorb road runoff, windbreaking, providing important pollinator habitats, improving peoples' health, and protecting crops (Steenbergen et al., 2019; Perez et al., 2016).

Despite the long list of the benefits of roadside tree planting, this practice has not been widely adopted in developing countries. For instance, in Kenya, several tree-planting initiatives have been developed. However, these initiatives focus mainly on tree planting on farmland, forgetting the benefits

that can be accumulated from roadside tree planting like reducing the air pollution levels in the country. The air in Kenya's capital, Nairobi, and other major cities is very polluted by industrial activities and the many motor vehicles powered by diesel and petrol. They release particulate matter into the air, affecting the health of thousands of city dwellers. These negative outcomes can be averted by roadside tree planting. The dust generated by the many vehicles traversing the worn-out and unpaved roads in rural areas is quite alarming.



Source: (MetaMeta)

Apart from the health benefits, roadside tree planting can help in achieving the goal of 10% tree cover as stipulated in Kenya's vision 2030. Trees hold the soil firmly in the ground and help to slow and absorb runoff, averting local environmental problems.

Currently, Kenya's forest cover is at 7.6%. A combination of the several aforementioned advantages and the challenges that can be averted by roadside tree planting inform the need for this manual, which can be a guide to road users and the general public. The main objective of the manual is to highlight step-by-step procedures for roadside tree planting, maintenance, and management strategies as well as the benefits that can be accumulated from this activity. This manual provides useful working information to road engineers/designers, urban planners, field workers, and farmers in Kenya.



Source: (MetaMeta)

1.2 Reading Guide

Sections covered in the manual are:

Section 1 - Introduction: The introduction outlines the main purpose of the manual and the benefits of roadside tree planting according to studies conducted in other countries. It also highlights how roadside tree planting assists in achieving the country's vision 2030 on improving forest cover.

Section 2 - Tree selection: This section summarizes specific criteria to be used in selecting suitable roadside tree species for roadside planting and the process of analyzing the suitability of streets for tree planting. This section also identifies general tree selection considerations based on community needs and desires.

Section 3 - Setting up and running a tree nursery: Before trees are planted, they are set in a nursery for establishment. This section summarizes nursery site selection, design and construction, alternative sources of water for use in the nursery, pest and disease management, and planning and record-keeping for good management and survival of seedlings.

Section 4 - Designing Roadside Plantations: This section summarizes the general principles of roadside tree planting and available planting designs. The section also discusses road safety measures that are very important factors to consider when designing roadside plantations.

Section 5 - Pre-planting management: This section summarizes site preparation, tree species selection, and site matching.

Section 6 - Tree planting and watering: This section provides a step-by-step guide of tree planting. It also discusses proper tree watering regimes to enhance tree survival and foster collaborative work between communities and nursery out-growers.

Section 7 - Maintenance and Post-Planting Management: This section summarizes general maintenance operations and requirements. The necessary tools for each activity are also illustrated.

Section 8 - Cost-benefit analysis: This section summarizes the monetary and social benefits of roadside tree planting and the resources required for the achievement of these benefits.

Section 9 - Recommendations: This section recommends activities that can be undertaken for successful roadside tree planting. Some of the activities include the active involvement and participation of the government, community engagement, regulations, awareness creation, and multi-stakeholder engagement.

Section 10 - Summary: This section summarizes the general socioeconomic benefits of tree planting and why trees are to be planted along roads. The organizations that deal with tree planting in Kenya are also highlighted, as are links for possible follow up.

2. Tree selection

The right tree in the right position is the key principle in roadside tree planting, as the roadside environment is harsh. To fully realize the benefits of roadside trees, tree species should be carefully selected according to the site's typology, the hardness of the tree species, a clear above and below ground site analysis, and the ability of the tree species to improve drainage, trap dust, and reduce surface runoff. Selection criteria are based on the medicinal, nutritional, economic and ecological value of the trees, as

well as their adaptability, the cultural values associated with specific tree species, and their ability to absorb carbon dioxide. Chosen trees should be evergreen so they will trap dust throughout the year, especially during the dry season when the dust is a nuisance to farms and households located near the road. Some trees are a source of food, especially those that provide fruit to the communities living adjacent to the road and passersby such as school children. Shade is also very important to passersby who walk long distances on their way home in the scorching sun. Table 1 outlines factors to consider tree selection.

Table 1: Roadside tree species selection (Gilman & Sadowski, 2007)

Site factors	Characteristics to consider
Social factors	Purpose of the trees: beauty, fruit, shade, serving as windbreaks, a filter of pollutants Functional utility: medicinal, nutritional, economic
Economic factors	Establishment costs Maintenance and management costs
Institutional factors	Landscape policies, framework, and plan
Tree characteristic factors/ Resistance to urban environments	Flowering, adaptability, diversity, tolerance, structure, wind tolerance; resistance to termites, drought, poor soil, cold, high temperatures, diseases and pests, and mechanical damage; crown, height, and canopy density Selected trees should have a good canopy, providing shade to cool the area along the road, making it more comfortable for the pedestrians.
Education factors	Knowledge, skills, experience, expertise
Environmental Constraints	Climatic conditions (heat, drought, and waterlogging tolerance), soil conditions, The selected trees should be adaptable to various conditions such as drought.

Cultural constraints	Utilities such as structures (buildings) and power lines (the selected trees should not grow tall enough to disrupt power lines, but if that is the case there must be a pollarding strategy.
Limitation constraints	Space and planting location (are you planting along a superhighway, at junctions, or corners, etc.?)

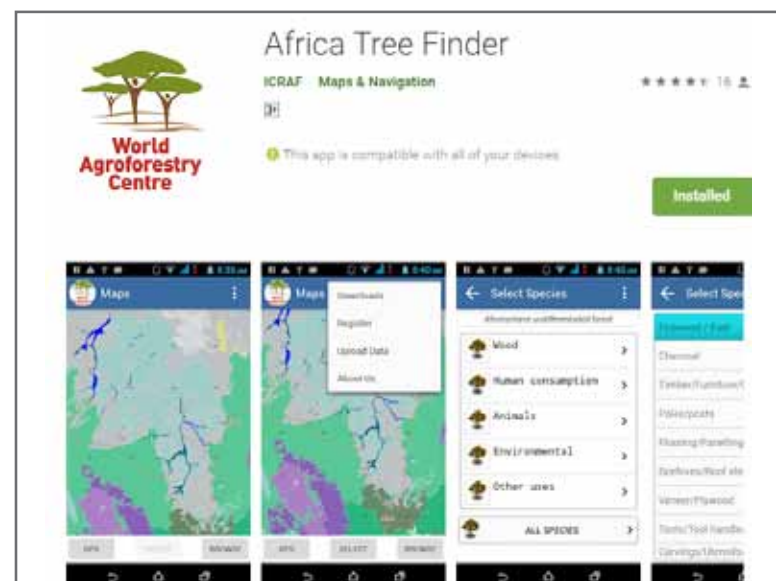


Figure 1: Tree species selection app

The World Agroforestry Centre, the University of Copenhagen, and other partners have developed an android application (vegetationmap4africa) to help those in landscape restoration to make better decisions on suitable trees and shrub species. Users can select the tree species via the web, smartphone, and Google Earth interfaces. The steps for using the tool are found at this link. The app can be used in offline mode and provides the user with information about natural vegetation and useful species. The app so far

covers Burundi, Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda, and Zambia, and it has the following capabilities:

1. The app shows the distribution of potential natural vegetation
2. The app includes a species selection tool—'the right tree for the right place'—that accounts for the goods and services desired
3. The app links tree species to online databases
4. The app informs users about the trees and shrubs that originally occurred at the location of interest
5. The app identifies potential ecotypes within species and recommends well-adapted seed sources for particular sites. (Kindt et al., 2015)

Sample trees suitable for roadside planting are shown in Table 2.

Table 2: List of common roadside tree species and their characteristics (source: <http://tropical.theferns.info/>)

No.	Scientific name	Common Name	Criteria for selection
1.	Jacaranda mimosifolia	Jacaranda	Evergreen, grows 5-16 m tall, ornamental, fast-growing, drought-resistant, termite resistant, sprouts easily if damaged
2.	Spathodea campanulata	Nandi flame	Grows to be a large tree, up to 25 m, with a broad crown; ornamental, drought-resistant, termite resistant
3.	Delonix regia	Flame tree	Deciduous, medium-sized tree with spreading canopy; drought-resistant, termite resistant
4.	Azadirachta indica	Neem	Fast-growing, evergreen, drought and pest resistant

5.	Senna siamea	Yellow cassia, Bombay blackwood (English)	Medium-sized (rarely exceeding 20 m in height), evergreen (drought resistant), ornamental, fast-growing
6.	Senna spectabilis	white cassia, mhomba (Kiswahili)	Medium-sized, evergreen (drought resistant) ornamental, fast-growing, boundary marker
7.	Vitex payos	Chocolate Berry	Drought resistant tree found near rock outcrops, high water tables
8.	Berchamia discholar	brown ivory	Grows naturally, adaptable in semi-desert and grassland regions
9.	Terminalia catappa	Bastard almond	Evergreen, tall tree
10.	Anthocephalus chinensis	Prosea	Evergreen, tall tree with large foliage
11.	Cassia fistula	Golden shower tree	Evergreen, medium-sized tree with large leaves
12.	Pongamia pinnata	Pongam	Evergreen, medium-sized tree with dense foliage
13.	Ficus benghalensis	Bunyan tree	Semi-evergreen tree with spreading canopy and compact leaves
14.	Ficus religiosa	Sacred Fig	Semi-evergreen tree with shiny leaves
15.	Gmelina arborea	Gmelina	Deciduous tree with hairy leaves
16.	Putranjiva roxburghii	Putranjiva tree	Evergreen tree with shiny leaves
17.	Croton macrostachyus	Croton	Evergreen tree, well adapted to a dry climate and numerous side roots



Photo 1: Photos of some of the roadside tree species (<http://tropical.theferns.info/>)



Table 3 presents some pollution-tolerant shrubs that can be used in roadside planting.

Table 3: A sample list of shrubs suitable for roadside tree planting

No.	Scientific Name	Common Name	Criteria for Selection
1.	Bougainvillea spectabilis	Bougainvillea	Evergreen, climbing shrub producing stems up to 10 m long, ornamental
2.	Lantana camara	Wild Sage	Evergreen, can grow up to 2 m tall, erosion control
3.	Vernonia angustifolia	Common ironweed	Drought tolerant, ornamental, stalks are 2-3 ft tall
4.	Tecoma stans	Yellow bells	Commonly known as a roadside weed, ornamental, adapts well in tropical and subtropical environments

i. Bougainvillea spectabilis (Bougainvillea)



Source: (Stock photo)

ii. Lantana camara (Wild Sage)



Source: (Wikipedia)

iii. Vernonia angustifolia (Common ironweed)



Source: (Pinterest)

iv. Tecoma stans (Yellow bells)



Source: <http://tropical.theferns.info/viewtropical.php?id=Tecoma+stans>

Table 4: List of grasses for roadside planting

No.	Scientific Name	Common Name	Criteria for Selection
1.	Bouteloua gracilis	Sideoats grama/ mosquito grass	Excellent drought tolerance
2.	Sporobolus heterolepis	Prairie dropseed	Perennial, deciduous, ornamental grass with hair-like leaves
3.	Pennisetum clandestinum	Kikuyu grass	Very fast-growing grass, good shade tolerance, excellent cold tolerance, and has the ability to smother weeds.
4.	Stenotaphrum secundatum	Pemba grass/ buffalo grass/ St. Augustine grass	Excellent shade tolerance, completely
5.	Chloris gayana	Zimbabwe grass	Shade tolerant grass, suitable for weed and erosion control

i. Kikuyu grass



Source: Stock Photo

ii. Zimbabwe grass



Source: <https://asepsis-kenya.com/product/zimbabwe-grass-plugs>

In the list, Kikuyu, Pemba, and Zimbabwe grasses can be used as footpaths on road pavements or for beautification purposes. Table 4 provides a list of grasses that can be used.

3. Setting up and managing a tree nursery

In setting up a nursery, several factors are taken into consideration: the nursery site selection, design, and construction; pest and disease management; and planning and record keeping. There are two types of tree nurseries;

1. Temporary Nursery – This is established in or near the planting site and can be used for a year or two (one or two seasons).
2. Permanent Nursery – This nursery is meant to serve a longer period, hence seedlings can be raised from year to year. The size of the nursery is dependent on the number of seedlings to be raised.

3.1 Nursery site selection

The selection of the area for a nursery is very important and should be sited as centrally as possible to the sites to be planted. Critical points to consider in the selection of a nursery area are:

- The area should be well drained and free from waterlogging
- The plants should be exposed to direct sunlight
- The nursery should be close to a water source for ease of irrigation. Road water harvesting has been occasionally used for roadside tree planting.
- The area should be well protected from pets and wild animals.
- The area should be flat or gently sloping, with a slope ranging from 0 to 30 degrees.
- The number of seedlings depends on the planting pattern used, which can either be square or rectangular. The recommended spacing between two lines is either 10 cm or the width of your palm, and spacing between the plants is 10 cm (ICRAF, 2013). Further, the

recommended height for transplanting trees is between 30 cm and 45 cm.

3.2 Water source for the tree nursery

Nursery establishment requires enough water for proper management and the development of good, healthy seedlings. Different water harvesting technologies have been developed. For instance, road surfaces, drainage channels, and culverts can be used to redirect water for recharge or productive use. Water can be stored in soaking pits or storage reservoirs such as ponds, water pans, and borrow pits. The harvested water can be used in tree nurseries, for tree planting, and for additional vegetation. Some water harvesting techniques that can be a source of water for the nursery are:

i. Rooftop catchment: Intercepts rainwater from hard roof surfaces and conveys water to a storage tank via a system of gutters.



Photo 2: Roof water harvesting in Kwa Vonza, Kitui County (Photo credit: MetaMeta)

ii. Road drift: A low causeway can be a simple way to recharge shallow groundwater when built to function as a sand dam. It functions in slowing down the flow upstream and building up sand, thereby allowing the water to reach underground storage, contributing to recharge.



Photo 3: Road drift water harvesting in Kitui county (photo credit: MetaMeta)

iii. Runoff harvesting: The runoff from roads can be harvested and stored in an on-farm pond or a reshaped borrow pit. This water can be used in the nursery to water seedlings.



Source: (MetaMeta)

4. Designing Roadside Plantations

All roadside landscape planting designs should conform to the general principles of transportation, landscape, and environmental design. Roadside planting and roadway design should be correlated to achieve an overall unified plan (Hasan et al., 2018).

4.1 Principles of roadside planting

There are a few mandatory rules for landscape planting design. Good design depends upon the knowledge and creativity of the designer. However, a few basic guidelines, as reported by Steenbergen et al. (2019), include:

- a. The designer should first gather knowledge of any special problems that may affect the location or survival of the plant material (soil data, utilities, water table, contour grading plan, etc.).
- b. Highway planting should achieve a mass effect to be in scale for the viewer traveling at the design speed of the highway. Planting design should also achieve a well-balanced combination of both planted areas and open spaces.

c. Planting should be both functional and aesthetic to serve a definite purpose such as traffic delineation, screening, erosion control, etc.

d. Where possible, especially in rural areas, planting designs should reflect naturalistic conditions, with informal flowing arrangements of material ecologically adapted to the site and purpose of the design. Avoid symmetrical, straight-line arrangements.

e. Form and shape should be used for harmony and contrast. Round-headed or spreading plants form more desirable masses, while columnar or conical shapes add greater visual emphasis. As they mature, plants change size and can quickly overgrow a particular planting site. Avoid planting trees too close together such that they limit the potential width or height development of either plant. For example, trees that grow up to 30 ft should be planted at least 3-4 ft from sidewalks or concrete areas. Trees that grow 30-50 ft tall should be planted 5-6 ft from sidewalks. Trees that grow more than 50 ft tall should be planted at least 8 ft from sidewalks.



Source : Roads for water, n.d.



f. Shrub use should be limited because of high maintenance costs, their relatively short life, and large quantities of plants necessary to achieve large masses. Small flowering trees generally require less maintenance, live longer, and can create larger and taller plant masses.

g. Consider the plant's adaptability to various environmental, climate, and soil conditions. Some of the tree species' characteristics include cold hardiness, salt spray tolerance, soil moisture requirements, drought tolerance, insect susceptibility, disease resistance, ease of transplanting, sunlight or shade tolerance, and availability of trees or seedlings.

h. Plant selection should emphasize the use of native plants to the greatest extent possible. Efforts should be taken, when appropriate, to use regionally native plants for landscaping. However, the design should also strive to use the best plant selection possible for the prospective site and design concept.

i. Avoid selecting plants that have the potential to invade areas adjacent to the highway right-of-way and adversely harm other plant communities. Such plant species include prosopis spp, water fern (*Salvinia molesta*), wild garlic (*Allium vineale*), and prickly pear (*Opuntia* spp).

j. Creating naturalized plant areas using decorative native shrubs, perennial bulbs, daylilies, and wildflowers can be effective in providing colourful focal areas along the highway.



Source: Miami-Dade County, 2007

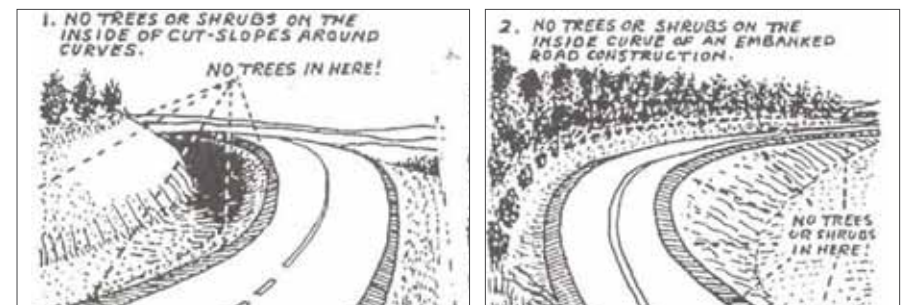


Photo 4: assorted flower plants, flower trees, landscape green belt (source: PNGWing, n.d.)

k. Avoid placing trees and shrubs over underground utility lines and drainage pipes. Avoid planting trees under overhead utility lines unless the mature tree size is recognized as a tree type recommended for this purpose. Avoid placing trees and shrubs in the centre of proposed drainage swales and in front of drainage pipe discharges.

4.2 Planting designs

Different tree planting designs can be applied depending on the intended purpose of the plantation as well as the availability of space. Only one species of trees should be planted for a long distance of the road (Randhawa & Mukhopadhyay, 1986). This is because this setting is more beautiful, gives a wavy appearance to the skyline, and makes the management and gap-filling of the trees easier. The same authors report that trees should be planted 12 m apart in the row and at least 5-6 m away from the edge of the road so that they have enough space to spread and not interfere with the traffic. If a road is as wide as 30 m or more, double rows of trees should be planted, with rows spaced 10-12 m apart. According to the authority guidelines, no trees or shrubs should be planted on the inside of cut-slopes, around curves, or on the inside curve of an embanked road.



Source: (MetaMeta)

The different types of roadside tree planting designs are avenue plantations, greenbelt plantations, and vegetative roadside barriers, as described in the subsequent sections.

1. Planting along avenues (avenue plantation)



Photo 5: Avenue plantation (Source: MetaMeta)

Avenue plantation involves a straight path or road with a line of trees or large shrubs running along each side. It helps in minimizing dust loads, gaseous pollutants, and noise pollution from traffic. Evergreen and deciduous trees are effective in minimizing air pollution by filtering, intercepting, and effectively absorbing pollutants for environmental improvement.

2. Planting along avenues (avenue plantation)



Photo 6: Grasses used as a greenbelt (Source: Wikipedia)

Greenbelt plantations are made up of species of trees and shrubs selected to reduce the effect of pollutants. According to Pokhriyal & Nautiyal (1991), the use of a green belt resulted in a 27% reduction of dust particles in London (Hyde Park). Maher et al. (2013) reported that more than 50% of particulate matter is reduced by roadside tree planting and even more if the leaves are hairy.

However, Perez et al. (2016) note that there is limited information on how effectively roadside tree lines intercept dust.

Other benefits that can be achieved from a well-implemented greenbelt include:

- Control of rainwater runoff
- Increase of underground water levels
- Prevention of soil erosion
- Increased biodiversity index

Grasses (Table 3) and shrubs (Table 2) can be used as greenbelt vegetation. Grasses reduce the velocity of flow, trapping sediments and reducing roadside erosion.

3. Design of roadside vegetative barriers

Several decisions must be made when designing roadside vegetative barriers: the combination of trees and shrubs, the porosity of the barrier, and the number of tree lines.

The selection of species will determine the plant spacing, i.e., the distance between the shrubs and trees. Shrubs, for instance, grow at a much closer spacing than trees; this should be taken into consideration when determining the combination of species to be planted. The general guidance for row plantings is to plant larger trees at 3 to 5 m apart, larger shrubs at 2.5 to 4 m apart, and smaller shrubs at 1.5 to 2.5 m apart. Single-row plantings should only be used on higher-value land and where space is limited. When possible, it is preferable to have plantings of two to four rows to protect a larger area. One- and two-row plantings are cost-effective options but require a uniform and high survival rate.

Figure 2 shows the different types of roadside plantings. Porous barriers have the most beneficial impact on dust control. Dust capture is enhanced by turbulence in the planting caused by the presence of irregularities such as branches, leaves, and complex leaf structures. The more irregularities the structure contains, the more dust and pollutants will be trapped. In comparison, almost all dust will “leap” over solid barriers, and little will be

intercepted. Porous plantings allow a large part of the airflow to traverse the planting. Dust will be trapped better, because there is more contact with the leaves of the trees and shrubs. To achieve a good degree of porosity, plantings should be approximately 5 to 20 m wide, consisting of tall trees with a bush layer underneath.

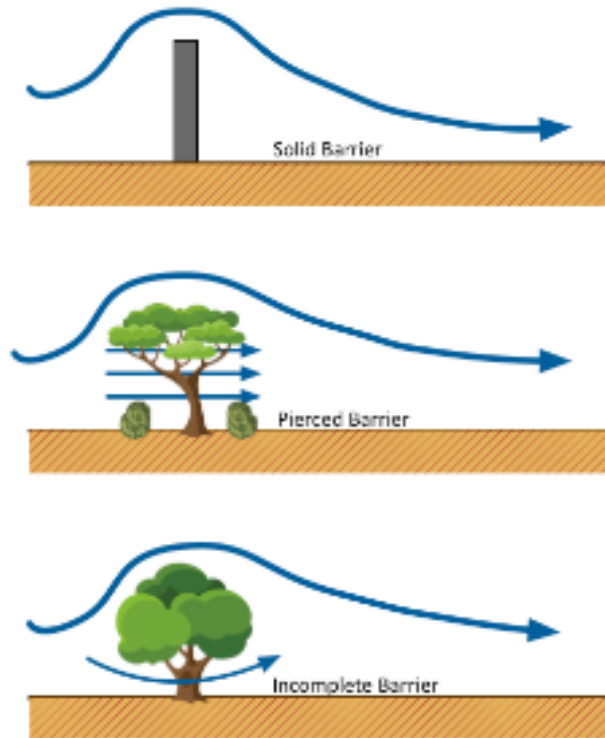


Figure 2: Roadside tree barriers and dust movement

Hagen and Skidmore (1971) investigate the effectiveness of windbreaks and establish that the porosity of a windbreak should be less than 35 percent (including roadside planting) to have a significant effect on wind

speeds. This is best achieved with double rows of trees and bushes. This would balance both effects: trapping dust and other pollutants and bringing downwind velocity on the leeward side.

4.3 Road safety

Safety is the main concern for highways and streets, thus an important factor to contemplate when designing roadside plantations is road safety. Trees can cause accidents, and special mitigation measures are necessary at certain speeds to avoid them (Perez et al., 2016). Trees near the road can present a fixed object hazard. Grass, weeds, brush, and tree limbs can obscure or limit a driver's view of traffic control devices, approaching vehicles, wildlife and livestock, and pedestrians and bicycles (Federal Highway Administration, 2008). Controlling vegetation helps reduce crashes and injuries (Training on Roads for Water and Resilience, n.d.; Perez et al., 2016). Table 2 shows safety mitigation measures depending on the speed zone, keeping signs visible to drivers.

5. Pre-Planting Management

5.1 Site preparation

Appropriate planning of the planting location is very important for good root development of trees. The main aim of site preparation is to create favourable growing conditions for seedlings. Site preparation also creates space for root development (Canker, 2020). In urban setups, site preparation may require some planning, unlike in rural settings. In preparing the site for tree planting, the size of the planting area should be well determined, the competing vegetation should be removed, and the soil should be prepared. The three steps for site preparation are:

- a) Determine the size of the planting area
- b) Remove the competing vegetation
- c) Prepare the soil

Table 5: Road Safety Mitigation Measures

Speed zone	Road safety mitigation method	
40 km/h	The impact force is unlikely to exceed human tolerances, so no specific mitigation is needed.	
50 km/h	A minimum lateral distance from the road edge of 1 m should be maintained to reduce incidental interaction between vehicles and trees.	
60 km/h	Intersections	at least 10 m beyond intersection on the approach and departure side
	Driveways	at least 3 m between driveway and tree
	Lane merge locations	3.6 m lateral distance from the road edge
	Curves	3.6 m lateral distance from road edge for gentle curves; barrier for moderate/tight curves
70-100 km/h	The impact force is highly likely to exceed human tolerances. Safety barriers are the most appropriate mitigation (wire rope safety barrier, guard rail, or other approved safety barrier that is suitable in high-speed environments).	

Source: (Agujetas Perez et al., 2016)

5.1.1 Determining the size of the planting area

The planting area has to be shallow and wide to suit the development of roots, because most of the root growth happens within the upper 12 inches of the soil. Three measurements to consider when estimating the planting area are:

- a. Width: The planting area should be 3 to 5 times as wide as the roots or root ball.
- b. Depth: The planting area should be shallow enough to allow for the topmost root to be 1 to 3 inches above the soil surface (Gilman & Sadowski, 2007). Planting a tree too deep limits the soil oxygen available for root respiration. This can cause several problems, including the death of the tree.
- c. Volume: There needs to be enough loose soil in the planting area for adequate root growth. The amount of soil needed for healthy root and tree growth depends on the tree species, size at maturity, expected lifespan, and environmental stress factors (Trees Energy Conservation, 2019).

5.1.2 Competition control

Planting sites have weeds and other competing vegetation that have to be evacuated before tree planting. Evacuating the competing vegetation can either be done mechanically or chemically. Mechanical site preparation involves loosening the soil and consolidating organic matter to supply short term vegetation control. This avoids competition for water, sunlight, and nutrients that are required for the development. Chemical site preparation is less labour-intensive compared to mechanical site preparation. Both mechanical and chemical location preparation techniques can be effective, but each has its limitations.

Mechanical location planning is expensive and may lead to compaction, causing soil disintegration. On the other hand, chemical site preparation involves the use of pesticides, which can be naturally destructive to the living biological system. Despite the challenges, location preparation is fundamental for a high success rate. Both mechanical and chemical competition control mechanisms include:

- a. **Herbicides:** It is important to apply herbicides according to the manufacturers' directions, and sometimes a license is needed to apply herbicides in an area.
- b. **Multiple tilling** can help control weeds and vegetation. One option is to till once or twice during the dry season and once again immediately before planting. Precautions must be taken if heavy equipment is used to prevent soil compaction, especially if the soil is wet.
- c. **Plastic sheeting:** A sheet of dark plastic staked over the planting area for 2 to 3 weeks during the growing season kills grass and weeds. Remove the sheet before planting the tree.
- d. **Hand weeding** is labor and time-intensive, making it practical only for small planting areas.
- e. **Stripping the sod** is sometimes necessary to remove sod from the planting site. Topsoil might be removed in some locations, and thus it is necessary to add topsoil or compost when planting (Trees Energy Conservation, 2019).

5.1.3 Preparation of the soil

Soil conditions of the planting area greatly influence the ability of the tree to survive and mature. Problems with soil conditions should be identified during site selection and corrected before planting. However, this is not always possible. If planting must continue without site preparation, the soil in the planting area has to be loosened thoroughly to enhance root growth. Do not disturb the bottom of the planting area to reduce the settling of the planting area. The soil has to be pressed down if disturbed to decrease settling. To enable the roots to penetrate the soil surfaces, roughen the sides of the planting area (The American Rhodes Society, 2020 & Jason Griffin, n.d.).

5.2 Tree species and site matching

Urban/roadside vegetation includes trees, shrubs, and herbs on public and private lands (parks, streets, and backyards), all intercepted within a landscape dominated by paved surfaces. This kind of vegetation plays a vital role in moderating micro-climates, sequestering greenhouse gases such as CO₂, and aiding in the percolation of water and beautification. Table 1 shows some of the tree species that play this vital role. Before planting trees along the road, one has to determine species site suitability to ensure proper selection of the trees to be planted. The trees selected should have unique characteristics (Plan et al., 2003) as presented in section 2.

5.2.1 Site matching

The site location offers clues on potential stresses that will impact tree health and maintenance. For instance, a tree located alongside a downtown sidewalk will probably require more maintenance than one located in a very dark park. Sites with pedestrian and vehicle traffic require special attention.

a. Streets, Sidewalks, and Other Paved Areas

If tree is positioned near a street, sidewalk, bike path, or other paved area, several site factors must be considered. For instance;

- **Pedestrian and vehicular areas** - For any site near where pedestrians or vehicles travel, tree species selection is critical. Species with thorns or prickly foliage or soft, messy fruit should be avoided. Trees with drooping branches would force frequent pruning. For public safety, it is always important that traffic lights, signs, and intersections not be obstructed by trees. Select a species tolerant to high salt levels within the soil if the tree is positioned near a road where de-icing salts are used.
- **Conflicts with roots and pavement** - Tree roots may grow under asphalt or cement pavement, which might cause the pavement to crack and buckle (Urban Forestry, 2019). Some communities have tried using root

barriers and root training to avoid root-pavement conflict with differing types of root barriers, from cylinders to herbicide strips placed within the planting site. These measures are designed to physically deflect the roots away from the pavement. In some cases, these measures are implemented to prevent root growth near sidewalks, but they will also limit tree growth. Root training is an option that uses chemical and physical barriers, deep fertilization, and irrigation or aeration structures to enhance the soil conditions within the deeper soil horizons. If the barriers are successful, the roots will grow deeper, avoiding surface problems like cracked sidewalks.

b. Structures

Trees must be far enough from buildings to permit correct crown and root development (Gilman & Sadowski, 2007). Trees that grow large, like oaks, should be planted at a minimum of 15 ft from a building. Small and medium-sized trees are also planted closer to the building, but regular pruning is also required (Gilman & Sadowski, 2007).

c. Utility Lines

Utility lines for water, sewer, phone, electric, or cable may cause problems for trees. When selecting a site, check for underground or aboveground lines that may interfere with the long-term growth of the tree.

- Above ground utility lines - If the tree positioning has aboveground utility lines, select a small-growing species that may top out at a minimum of 5 ft below the wire, or select a species with a narrow crown and place it so that it will not grow into the utility line (Valerie 2004; Trees-energy-conservation, 2019).
- Below ground utility lines - The planting site should be located a minimum of 12 ft from a serious underground utility line for big trees (Gilman 2004; Sather et al., 2004). A standard misconception about tree roots is that they actively grow into sewer and water lines. Roots will follow a path of effort and only grow into sewer and water lines that are broken.

d. Site Activities

The type of activities (past, current, and future) on the site can help in evaluating planting options. Has construction occurred on the site that will have changed soil conditions? How many people or vehicles use the area around the site? Are there safety concerns associated with tree planting, like personal welfare or property damage? Will the trees be protected against compaction, vandalism, or potential injuries? This kind of data can usually be determined by visiting the site and talking with folks who are familiar with the area. The landholder or local planning departments are good resources for locating plans for the positioning.

6. Tree planting and watering

6.1 Pit preparation and Tree establishment

Generally, tree planting should start immediately after the rainy season begins. Holes should be dug preferably 1-2 weeks before the rains commence. For instance, in Kitui County and other similar areas, planting is considered ideal during the October-December rains.

PRECAUTION: If possible, plant on a cloudy day to enhance the survival of your seedlings. Select only healthy and strong seedlings of at least 30 cm in height for planting. The number of seedlings earmarked for planting should not exceed available labour. This will minimize waste due to unplanted seedlings left in the field at the end of the planting period.

6.1.1 Seedling handling before planting (hardening up)

For a few weeks (1 month) before the planting season begins, seedlings earmarked for planting should be well prepared for the harsh field conditions. To achieve this:

- Reduce the watering frequency by half

- Expose the seedlings to more sunshine
- Root prune frequently

The following is a step-by-step guide to tree planting:



Source: Gardens Illustrated, 2020)

i. Planting holes should be dug before the rainy season commences if possible, since water collects in the hole and improves survival even when there is less rain. Neil (2013) suggests that you should dig a hole of 30 cm x 30 cm (the distance from your wrist to your elbow), 45 cm x 45 cm, or 60 cm x 60 cm (especially in dry areas). The dimensions of the hole will depend on the size of the seedling. The planting hole softens the soil so that the roots of the tree can easily penetrate; loose soil can catch and contain more moisture.



Source: iStock

ii. Use a small spade and cut of chunk out of the ground, turn it over, and split the hole into almost in half. The pit must be 1 ft wider and 1 ft deeper than the tree's roots (Cheshire, 2018).



Source: (Wikipedia)

iii. Dig out the remainder of the hole and move the soil one foot away from the hole.

iv. Hold the young tree in the hole, roots first. Keep the soil at bay and gently press it down onto the roots.



Source: (Valerie, 2019)



Source: MetaMeta

v. Look for the “collar” on the sapling – this is often the point where the tree has grown above ground. The top of the collar should be level with the top of the soil (Cheshire, 2018). A properly planted seedling should have a root collar (the zone between root and stem) even with ground level (Indiana Department of Natural Resources, 2020).

vi. Seedlings planted too deep, too shallow, or J-rooted (tap root facing up) will not fulfill their capacity to produce roots and foliage, and

they are less likely to survive (Engledow, 2013). Place the seedling back into the hole and stamp the ground with your foot to make it stand firm.

PRECAUTION: Long-rooted plants should be planted with caution to avoid the development of coiling roots, which promotes poor root development. Pruning/trimming of elongated roots is recommended before planting.



Source: (Utah State University, 2010)



Source: (The loop, 2016)

- i. Gently compact the surface around the planting spot by hand and by foot to increase contact between the tree roots and soil.

6.1.2 Tending after planting

i. Weed control

Remove weeds by uprooting them as soon as they appear. A jembe is useful for clear weeding. Spot weeding can be adopted to save time/labour. The spot weeded area should be twice as big the tree height or at least cover a 2 m diameter. Weeding should be done two or three times in one rainy season to help the immature root system access as much as water as possible.



Source: (Jones, 2020)

ii. Catchment repair

Catchment structures should be repaired or be reinforced whenever necessary or during the weeding time.

iii. Replanting (beating up)

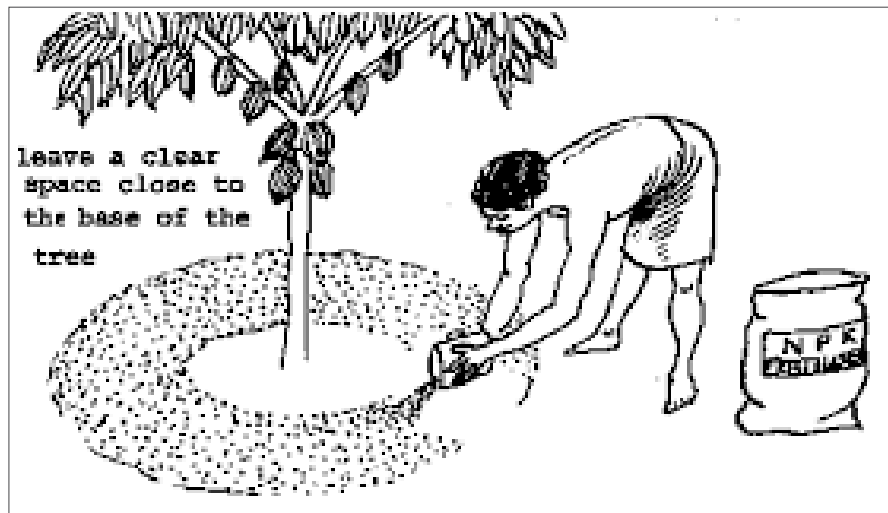
Replacement of dead trees should be done two weeks after planting. This

activity will depend on the availability of extra seedlings in the nursery.

iv. Protection

a. Protection from animals/livestock

This can be done using dead branches of thorny Acacia species as a fence. In other circumstances barbed wire can be used, if available, to keep animals away. Patrol officers can be deployed to enhance protection. In other cases, leave a ring approximately 10 cm wide directly adjacent to the base of the tree. This can help protect the roots from scratching by hens or roving animals (Cheshire, 2018).



Source: (Elfick, 2020)

b. Protection from termite attack

Termites will attack trees that are under stress. The first step in stress reduction is to minimize competition through proper and timely weeding. Second, remove all debris from your planting site as soon as possible to avoid attracting termites.

6.2 Watering

Trees perpetually lose water to the atmosphere. Water is the most limiting factor for tree survival and development. Water shortages severely harm young plants that have not acclimatized to the new environment after planting. Trees will experience inferior growth, infestation by pests, and even death. Watering of young and newly planted trees will enhance their survival throughout the year. Watering of plants throughout a dry season should be emphasized. For example, during the dry season, one tree can be watered with 10 litres of water twice a week to enhance the possibility of survival. The time of the day you water your plants influences the amount of water accessible for plant use within the soil.



Watering of newly planted plants in the evening or early morning reduces the quantity of water lost through evaporation and the amount of water needed to maintain growth and adapt to the new environment.

Drip irrigation using waste bottles is a good option. Small holes drilled into bottle caps release water slowly into the soil, penetrating the roots of the plant and making it thrive. This helps to reduce workload and provide water to trees over time efficiently without water loss through evaporation.

6.2.1 Early Morning

The best time to water your trees is in the morning before outside temperatures begin to rise. This takes advantage of the fact that winds are generally less strong, thus reducing water loss through evaporation.

6.2.2 Evening

If your schedule prevents you from watering your trees in the morning, water them in the late afternoon instead. Watering your plants 2 or 3 hours before sunset provides the leaves time to dry off, decreasing the probability of fungal infection.

6.2.3 Watering Newly Planted Trees

Young, newly planted trees need additional watering if drought prevails. Water does not move sideways in soil. Watering should be done wherever it is specifically required. For young, newly planted trees, concentrate water over the foundation ball and the planting area to ensure survival. This can be achieved by creating a circular mound of soil three to four inches high around the plant at the edge of the area where you planted. For the first few months after planting, most of the tree-root area is still inside the initial root ball, with some roots reaching down to develop past this space. The root ball and the surrounding soil should be kept evenly moist to encourage healthy root growth by applying mulch, e.g., sand to reduce soil moisture loss. To ensure high water retention, trees should be planted with soil mixed with charcoal dust.

Some months (e.g., 3 months) after the tree has been properly established, expand the watering zone to cover the whole area beneath the canopy. It takes 2 rainy seasons for the tree to be established. For example, within ASAL regions, the best time to plant trees is October-November-December (OND), enabling a short period requiring watering and relying on the

March-April-May (MAM) rains for roots to get well established in the soil. It is important to enhance dampness through watering and mulching the soil in those early times after planting in case nature does not provide the regular soaking through rainfall. During hot, dry weather periods in ASAL regions, new trees could need watering as frequently as three times per week to ensure that the root ball does not dry out.

6.2.4 Watering Established Trees

Large established trees can be watered by wetting the soil surrounding the plant's roots (DeJohn, 2019). This region is known as the "root zone," and it serves as a capacity tank from which the tree draws moisture. Most roots spread 1½ to 3 times as wide as the tree's canopy but are not very deep (usually in the upper 6 to 12 inches of soil). This depends upon the size of the plant and the type of soil. Shallow or compacted soils can result in shorter or wider root zones. Water the complete root zone area each time you irrigate.



Photo 7: How to water an established tree (Credit: DeJohn, 2019)

It is commonly assumed that tree roots are a mirror image of the tree canopy. Some well-established trees' roots grow beyond the canopy or the drip line (Pomery, 1987). Although some anchor roots can reach deep into the soil, most of the tree-root area is limited to the upper soil layer. When watering established trees, provide deep, soaking irrigation to the entire area beneath the tree canopy and extending several feet beyond the drip line by loosening the soil around the tree (DeJohn, 2019) following the line of the last leaf/stem (photo 8). Preferably, dampen the soil to a depth of 10 inches whenever you water. To avoid rot, do not apply water to the zone directly around the trunk

6.2.5 Know when to water

How frequently your trees need water depends on the weather, type and development of the tree, root depth, and soil type. Generally, trees ought to be watered once or twice a week during the planting season just in case there is no rainfall that particular week/season. Once you start watering, you should continue regularly until the rain reappears. It should be noted that plants use 3 to 5 times as much water during the hot, dry season as they do during the wet season.

Adjust your watering plan with the season and when there are critical weather changes. To avoid wilting, young plants need to be watered more often than older and well-established plants. After they have established (in 1 or 2 years), allow a slight drought between watering regimes. The plants will get acclimatized and become more drought tolerant.

Points to note:

- Seedlings, like other living organisms, require water for life.
- In water, the nutrients that the seedlings depend on are dissolved and are taken up by the plants through their hair roots. Watering is normally done twice in a day: in the morning and the evening for seedlings exposed to sunshine.
- Seedlings in the shade can be watered once a day. During the rainy season, watering is unnecessary.

6.3 Working with the community and nursery growers

Working with the community and different tree growers provides farmers with support across the forestry value chain, from seedlings to sawmills, and involves different interventions such as:

- Provision of top-quality forestry inputs and knowledge
- Provision of extensive training and lifetime support: Through this support, farmers receive deep training, from initial land surveys and site preparation to planting and seedling care, through to long-term monitoring and maintenance services for the lifetime of every tree planted. As a result, farmers are confident that they are growing the best trees and applying best practices.
- Tree harvesting, processing & sales



Photo 8: Collective community participation in designing RWH structures
(Source: MetaMeta)

7. Maintenance and post-planting management

Maintenance is one of the factors to consider before embarking on tree planting. Trees should not be planted until the necessary resources for maintenance have been arranged. According to Steenbergen (2015), some of the key maintenance strategies are preventing physical contact of the seedlings with livestock as well as watering during the dry season. Managing a roadside tree properly enhances public safety, making the city more livable and improving the environment (Hasan et al., 2016). Maintenance shall include, but is not limited to:

7.1 Mulching

All tree pits and individual shrub pits are mulched with appropriate material to reduce the rate of soil moisture water. Organic mulch, such as shredded bark or pine straw, helps conserve moisture and keeps weeds at bay (DeJohn, 2019). To prevent rot, do not pile mulch against the trunk (Pomery, 1987).



Source: (Fredericksburg, 2019)

Having grass grow under trees is beneficial, as it acts as a cover crop or natural mulch; hence, more water will be retained in the soil.



Source: (Pennington, 2019)

7.2 Staking

Staking provides extra support, protection, or help to the tree to stay anchored. In the case of roadside tree planting, staking protects trees from destruction from animals (since they are young and palatable) and passersby. Staking can be done with the use of sticks. However, staking is not to be done on all newly planted trees; only stake the following:

- i. Bare-root trees or trees with a small root ball
- ii. Trees planted in areas with lots of foot traffic
- iii. New trees that cannot stand on their own or that begin to lean
- iv. Tall, top-heavy trees with no lower branches
- v. Young trees, if you live in a very windy area or if the soil is too wet or loose. (Davey, 2017)



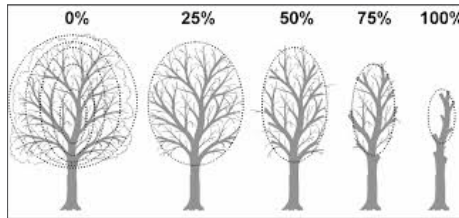
Source:(Kadenyi, 2017)



7.3 Lopping

Lopping is a form of harvesting in which only the lower branches are cut and

new branches re-sprout along the lower portion of the stem. This harvesting method can be used to reduce branches that may interfere with traffic.



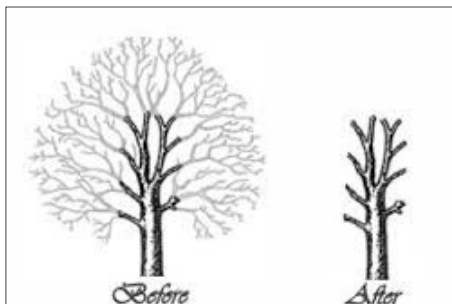
Source: (Meilby & Puri, 2007)



Source: (MetaMeta)

7.4 Pollarding

This is a tree harvesting system whereby all branches are removed but the main trunk is left standing. After the branches are cut off, new shoots are allowed to sprout from the main stem and form a new crown. When the tree loses its sprouting vigor, the main stem can also be cut for use as large diameter poles. An advantage of this method is that the new shoots are high enough off the ground that they are out of reach of most grazing animals.

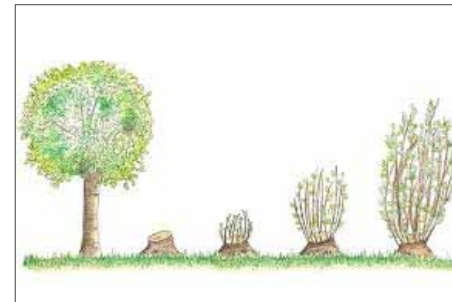


Source: (Forestrypedia, 2018).
<https://forestrypedia.com/coppice-system-detailed-note/>

7.5 Coppicing

This is a particularly suitable method for the production of firewood and small poles (withies). It is one of the most widely practiced harvesting methods for dryland species. When the main stem has reached the desired dimensions, it is cut at the base of the trunk. New shoots develop from the stump or roots. Only three to four vigorous shoots should be allowed to grow to full size. The others should be cut back to prevent competition for growing space.

Several rotations of coppicing are usually possible with most species. The length of the rotation depends on the size of the specific or desired wood products. After several harvests, the sprouting vigor will diminish, but this will vary from species to species.



Source: (Forestrypedia, 2018).
<https://forestrypedia.com/coppice-system-detailed-note/>

7.6 Pruning

Pruning usually involves the removal of smaller and lower branches of trees. Pruning can be a major source of firewood and wood for other purposes. Branches should be cut clearly and as close as possible to the main stem. Branches are also used as mulch between tree rows in alley cropping systems.

The main objective of pruning is to add value to the trees, and it is mostly undertaken at the end of the dry season to serve the following purposes: (Federation, 2011)

- To increase light reaching crops
- To check on the spread of pests and diseases
- To promote straight stem growth
- To give room for mechanized farm operations; and
- To improve growth rate of trees and the quality of poles or timber while providing immediate products.
- To reduce competition between trees and adjacent cropland (the best pruning is two-thirds of the maximum tree height) (Makee, 2016).
- To controls plant size and shape
- To keep shrubby evergreens well-proportioned and dense
- To remove unwanted branches, waterspouts, suckers, and undesirable fruiting structures that detract from plant appearance
- To improve the quality of the trunk for timber production
- To minimize shading



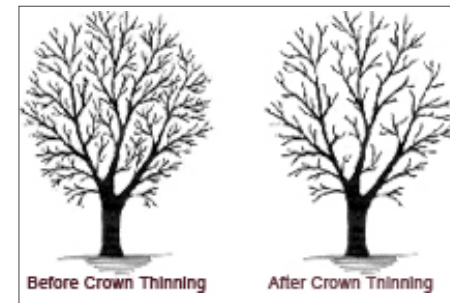
Source: (Africa Wood Grow)



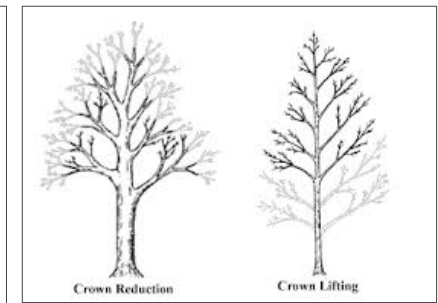
Source: (Bartlett Tree Experts, 2016)

The most common types of tree pruning are:

- i. Crown thinning, which involves selectively removing some secondary branches (particularly weak branches) to bring out the crown structure, without altering the overall size or shape of the tree. This method increases light and air penetration, which in turn promotes better form and health of the tree (Hibberd, n.d). (Do not overdo crown thinning on mature trees.)
- ii. Crown raising/lift, which is the removal of the lowest branches and the preparation of lower branches for future removal. This method shortens low branches to regularly suppress their growth and, in turn, force more growth in the upper branches. For roadside tree planting, removing lower branches allows more clearance.



Source: Chestnut trees (2020)



Source: (Woodland & Garden Tree Services, 2004)

- iii. Crown reduction, which involves removing larger branches at the top of the tree to reduce its height. When done properly, crown reduction pruning is different from topping, because branches are removed immediately above lateral branches, leaving no stubs. Crown reduction is the least desirable pruning practice. It should be done only when necessary.
- iv. Crown cleaning, which is the selective removal of dead, dying, and diseased wood from the crown.

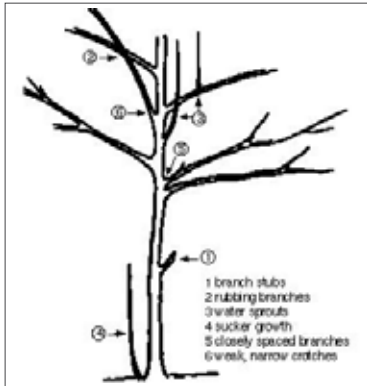


Figure 3: Issues to watch for when pruning (Source: Wikipedia)

The main issues to look out for in pruning are branch stubs, rubbing branches, water sprouts, sucker growth, closely spaced branches, and weak, narrow crotches.

Proper branch pruning

- Cut a small branch or twig about 1/4 inch above the bud.
- To shorten a branch or twig, cut it back to a side branch or cut about 1/4 inch above the bud.
- Always prune above a bud facing the outside of a plant to force the new branch to grow in that direction (University of Minnesota Extension, 2020).
- Use the right, sharp tools such as a pruning saw to minimize damage to the tree.
- Cuts should be slanted to prevent water entry and rotting (Makee, 2016).

The use of the right tools in pruning makes the work easier and helps you do a good job. Keeping tools well-maintained and sharp will improve their performance. There are many tools for pruning, but the following will suffice for most applications:

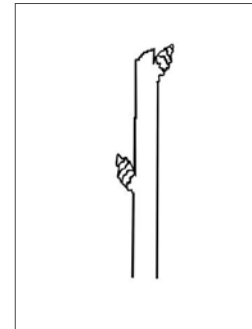


Photo 9: A properly pruned branch. (Source: Wikipedia)

i. Secateurs

A good pair of secateurs is probably one of the most important tools. It cuts branches of up to 3/4 inches in diameter.



Bypass secateurs (Source: amazon)



Falcon secateurs (Indiamart)

ii. Loppers

Loppers are similar to pruning shears, but their long handles provide greater leverage needed to cut branches up to 1 1/2 inches in diameter.



Source: (Wikipedia)

iii. Hedge shears

Hedge shears are meant only for pruning hedges, nothing else. They usually cut succulent or small stems.



Source: (Amazon)

iv. Pruning saw

Pruning saws are designed for the task: they have aggressive cutting teeth for greenwood, which are angled to work on the pull stroke. This makes cutting branches that you need to stretch to reach easy work. Their rigid blades allow you to accurately control the cut so that you do not tear the branch collar, while allowing you to get close enough to the stem.



Source: (Wikipedia)



v. Hand saws

Hand saws are very important for cutting branches over 1 inch in diameter. Many types of hand saws are available. Special tri-cut or razor tooth pruning saws cut through larger branches—up to 4 inches in diameter—with ease.



Source: (Amazon)

7.7 Mowing

Mowing is a maintenance activity that involves cutting grass to improve the visibility of the road, guideposts, or vehicles. It can also be undertaken for aesthetic purposes. According to Odom (2017), the three types of mowing are:

1. Safety mowing – This type of mowing is the most important and is done to ensure all signs and traffic control devices are visible.
2. Transition mowing – This is done to ensure a smooth change from a narrow-mowed width to a wide mowed width when different widths of right-of-way are mowed.
3. Contour or selective mowing – This is done for aesthetic purposes, i.e., to show off the landscape.

The following are the ‘Don’ts’ in mowing (Odom, 2017);

1. Mowing too often, as it may expose workers to too much danger and damage the vegetation
2. Mowing at the wrong time, as mowing at the right time reduces the frequency of mowing required
3. Mowing too short, as mowing at the proper height maintains the vegetation and hides small litter along the road.
4. Mowing on steep slopes, as this increases the rate of accidents
5. Mowing carelessly and scarring trees and shrubs; careful mowing around trees avoids damage.
6. Mowing in the direction opposite of the incoming traffic, as this impairs the visibility of the mower operator.



Source: (Igam.info)



Source: (Shutterstock)

7.8 Replacement

The number of replacement trees required is determined based on the continuous monitoring of the trees planted. All dead, dying, or diseased plants should be removed and disposed of appropriately. One tree must be planted for each tree removed, diseased, or dying. If a fruit tree is required for replacement, two fruit trees should be planted for every tree removed. Replacement tree must be of deciduous (3-5 cm tall) or evergreen species (minimum of 1.75 m). When replacing, a tree with the characteristics of hedges, dwarf varieties, shrubs, or palms should not take the place of a lost tree (Mateo et al., 2017).

7.9 Fencing

A fence is built to protect seedlings from animals, and they should be adaptive to the availability and capacity of local people. Protection is necessary, since trees are palatable to browsers such as goats. Grazing animals can cause extensive damage to trees by browsing and debarking.

Fencing is the best way to protect young trees from destruction by humans and livestock. There are other methods of protecting trees, including:

- a. Installing plastic tree guards and stakes made of shrubs, branches, and bamboos. of trees such as shrubs, branches, and bamboos (Photo under staking illustrates cheaply affordable methods to protect trees)
- b. Stacking used tyres over the tree using three-star steel posts driven into the ground
- c. Using an old drum, kept in place with a triangle of steel posts. Wire mesh can be added to the top of the drum for further protection as the tree grows.
- d. Constructing a guard around the tree using old wooden fence posts

8. Recommendations

In this section, recommendations are provided based on a roadside tree planting project in Kathome/Kawongo, Kitui rural sub-county, and Kitui County, and the results of the socioeconomic impact study that was conducted (Kadenyi, 2017).

- a. Future users should be well-educated about the operation of roadside tree planting and how to use and maintain it, with a special focus on the protection of the planted trees.
- b. Whereas the consequences of future climate change in combination with reduced forest cover are unclear, more research on the importance of trees in mitigating climate change effects and reviving ecosystems is needed.
- c. Active involvement and participation of the government is highly recommended. For active community participation and ownership of the project, the government could follow the following measures:
 - Start a roadside tree planting project to be implemented by county governments to widen the target base of the effect of roadside trees.

- Provide a remuneration strategy where the participants are rewarded. This could be done in phases.
- Introduce an incentive program as a way of encouraging the community to support the project, for example by recognizing and rewarding farmers who have managed their trees well.



Photo by: Kadenyi, 2017

- The success of this project can also be realized through sensitizing local administrations, such as chiefs, sub-chiefs, and village heads, to encourage the community during their normal barazas and gatherings to support the project through their active participation (Kadenyi, 2017).
- Awareness creation: For roadside planting to succeed, it is vital to create awareness of the actual benefits of tree planting among roadside communities. Provide more time and resources for community mobilization and awareness creation than actual project implementation activities (tree planting) (Steenbergen, 2015).
- Participation: Encourage full participation in project implementation by national, district, and local authorities and communities.
- Corporate-smallholder partnerships in plantation forestry are increasingly promoted as a means of ensuring tree growers have access to markets.
- Consultation: select tree species together with roadside communities and local experts.
- Include minority groups and women.

9. Summary

Roadside tree planting needs to be embraced in Kenya. Among the various tree species that can be planted, several are locally and readily available and have added advantages for communities. Before venturing into roadside tree planting, one has to consider several factors, including

- Costs required for land preparation, seedlings, pitting, manuring, pit creation and refilling, seedling planting and mulching, watering, fertilizer/manure, pruning, fungicides, weeding, security, transportation, processing and other miscellaneous items needed throughout implementation and management until the tree reaches maturity annually.
- Site factors, social factors, economic factors, institutional factors, tree characteristic factors such as resistance to urban environments, education factors, environmental constraints, cultural constraints, and other limitations
- Associated impacts and benefits, such as trees fruit production, honey (bees use the flowers from the trees), timber, firewood from pruning, and the environmental non-tangible benefits such as fresh air, shade, aesthetic beauty, carbon sequestration, stormwater attenuation from the tree canopy, reduced runoff, enhanced roads, and reduced dust to farms and homesteads
- Maintenance and management, as planting and maintaining trees require an investment of not only monetary resources but human resources as well (Urban Forestry Network, 1999). It should be noted that without proper planning and maintenance, trees can have negative impacts: uprooted sidewalks, leaf collection in streets and culverts, disrupted utilities, and tree damage.

Some of the organizations in Kenya dealing with tree planting include:

- i. World Agroforestry (ICRAF)
- ii. Trees for Kenya

iii. Trees for the Future

iv. Kenya Forest Service

v. The Green Belt Movement

vi. Kenya Forestry Research Institute

vii. Kenya Electricity Generating Company in collaboration with Bamburi Cement Ltd and Better Globe Forestry Foundation.

This manual was prepared in collaboration with the Green Roads for Water Initiative, World Agroforestry, Kenya Forestry Research Institute, WSTF, and KRB.



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