GUIDELINES FOR INTEGRATING TREES IN THE IRRIGATED AGRICULTURE LANDSCAPES OF KENYA

Edward Mengich, Joshua Cheboiwo, Jackson Mulatya, Jesse Owino and Paul Ongugo

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Kenya Forestry Research Institute (KEFRI)

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Cover caption:

Main picture: Canal irrigation system with few trees on farm at Katilu Irrigation Scheme

Top left: Boundary planting with Grevillea and Moringa at Lodwar
Top right: Drip irrigation practice devoid of trees at Kachoda.
Photos taken in Turkana by Jesse Owino.

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FOREWORD

Kenya, like many countries in Africa is highly dependent on agriculture for livelihood and economic development. Though the country has great potential for agricultural productivity, this aspiration has not been realized. Much of the agriculture is highly reliant on rainfall. The rainfall patterns have however undergone changes and become unpredictable due to climate change. Potential for increasing production of food and agricultural-based industrial raw materials therefore lies in application of science and technology such as use of irrigation.

In Vision 2030, Kenya's blueprint for economic development, agriculture has been recognized as a major development driver. Vision 2030 states that 'To promote agricultural productivity, the area under irrigation and drainage will increase from 140,000 to 300,000 hectares'. The Government of Kenya plans to rehabilitate and expand some of the key irrigation projects in the country that include; Bura, Hola, Kano, Nzoia, Perkera, Kerio Valley, Mwea, Taita Taveta, Ewaso Nyiro North and Ngrumani to enhance crop productivity. In its plan to ensure increased agricultural productivity the government has recently launched giant Galana-Kulalu Irrigation Scheme in Kilifi County that is proposed to cover approximately 6 million hectares under various crops. The country's massive investment in irrigation schemes is aimed at boosting non-rain fed agriculture to enhance food security and production of various industrial materials to meet the country's needs and surplus for export.

However, development of irrigation schemes involves massive deforestarion of the landscapes to; level land, lay out infrastructure that includes water, pipes and roads that if not well managed create large scale negative environmental impacts that may compromise the expected benefits from irrigation projects.

Kenya Forestry Research Institute (KEFRI) is mandated to carry out research in forestry and allied natural resources. The institute will work closely with other stakeholders to facilitate better management of fragile irrigation landscapes through innovative approaches that enhance environmental stability through introduction of appropriate trees. KEFRI will give scientific and technological advice on: potential tree species to introduce or retain within irrigated landscapes; tree configurations; and tree establishment and management techniques.

Though various stakeholders involved in irrigation scheme development and management are aware of the need to integrate trees into irrigation landscapes, they lacked adequate knowledge and skills on scientific and most practical approaches to tree introduction into schemes. This guideline therefore seeks to fill existing information gaps in integration of trees into irrigated landscapes by establishing a framework that will facilitate deployment of various science based tree planting and management options to establish and maintain/ manage tree cover within programmes implementing irrigation projects in the country. The guideline is therefore expected to offer the much needed practical approach for mainstreaming tree planting in development of irrigation infrastructure in the country. The guideline takes into account local and global best practices specifically in Kenya, Africa, Asia and Australia.

Target beneficiaries of this guideline include; irrigation development agencies, environment regulatory bodies, research institutions, extension agents, farmers, non - government organizations, and community based organizations involved in irrigation activities.

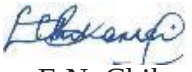

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TABLE OF CONTENTS

LIST OF PLATES

LIST OF FIGURES

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Part of the information contained in the guideline was gathered during field visits to irrigation schemes in Baringo, Turkana and Kisumu Counties, and interacting with National Irrigation Board (NIB) officials and small-scale Farmers residing in the schemes. The exercise would not have been possible without financial support from KEFRI and the goodwill, support and cooperation received from the National Irrigation Board officials and stakeholders. We are greatly indebted to all of them.

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1.0 INTRODUCTION

1.1 Background

Kenya like many developing countries relies heavily on agricultural activities for economic development and livelihood maintenance. Agriculture is therefore the backbone of Kenya's economy, and directly contributes; 26% of the Gross Domestic Product (GDP), 80% of formal employment and 60% of export earnings. The agriculture sector contributes a further 27% of the GDP through links with the manufacturing, distribution and service-related sectors. Agriculture is central to the realization of Kenya's aspirations of poverty reduction, wealth and employment creation for the citizens. Agriculture is among the six key sectors given priority for being a key growth driver to realization of Vision 2030, which is the country's blueprint for economic development.

Agriculture in the country is mainly rain-fed and is carried out in the high and medium rainfall regions which receive rainfall of 750->1,000 mm. These medium and high agricultural potential areas account for approximately 20% of Kenya's total land area but produce most of the food and cash crops. However, due to high human population pressure and diminishing land acreages in these regions, the country is now focusing on development of the lower agricultural potential drylands to enhance food production. The drylands which cover 84% of Kenya's total area receive low rainfall of 200-750 mm of rainfall annually and therefore sustainable agriculture in these areas can only be achieved through well-planned and operated irrigation schemes.

As envisaged in Kenya Vision 2030, irrigation has potential to make Kenya a food self-sufficient country, create wealth for the rural farming communities, provide employment for the youth, and lead to industrial growth by promoting production of industrial crops such as sugarcane, cotton and maize. To realize these aspirations, the Government, through National Irrigation Board (NIB) has made substantial effort to promote

Irrigation development in the country through continued rehabilitation and expansion of existing irrigation schemes and small holder irrigation projects.

Kenya has approximately 2.2% water surface in form of rivers and lakes, and various underground water systems. The National Government and County Governments are required to cooperate with, support and consult each other with regard to exploitation of natural resources including surface and ground water that may be used for various activities including agricultural irrigation. Both levels of government are required to embrace a system of consultation, negotiation and consensus building in development of agricultural irrigation. Irrigation in Kenya is guided by the National Irrigation Policy 2010 which seeks to stimulate and guide irrigation and drainage development through: targeted technical support; intensified investment in the sector; improved research and technology; provision of extension services and capacity building for staff in relevant government departments and farmer organizations to ensure development and sustainability of irrigation projects.

Trees and forests directly or indirectly support agriculture through: protection of water catchment, control of soil erosion; and improvement of farm productivity through agroforestry systems; and climate moderation. The Constitution of Kenya 2010 under sub-section 69 underpins the importance of natural resources conservation and commits the country to attaining 10% tree cover. Sectoral policies and laws such as: Draft Forest Policy 2014; The Forest Conservation and Management Act 2016; and The Agriculture (Farm Forestry) Rules 2009; emphasize attainment of 10% tree cover in the country. The Environmental Management and Coordination Act 2015 provides for measures to mitigate negative environmental impacts such as drastic change in tree cover that may be caused by clearing of trees and other vegetation during creation of irrigation schemes. The Agriculture (Farm Forestry) Rules 2009 is very explicit in requiring 10% tree cover on land under agricultural activities that include irrigated agricultural landscapes.

Kenya has an irrigation potential of 1,341,900 ha of which 170,000 ha (12.6 %) have been developed (Water Master Plan, 2012). After many years of low irrigation activities, the country has embarked on accelerated development of irrigation infrastructure and increased productivity per unit volume of water. However, most irrigation schemes involve mechanized clearing of vegetation and leveling of land to enable good performance of irrigation activities and management of water drainage. The clearing of vegetation leave swathes of land without tree cover. In the past, most irrigation schemes have not included clear blue prints on how to mitigate clearing of vegetation in their implementation plans. Reasons for inability of many stakeholders to internalize such contingencies include lack of guidelines to support integration of trees into irrigation schemes and belief that trees host crop pests that contribute to yield losses.

Plate 1: A drip irrigation system at Kaikor irrigation scheme in Turkana County

1.2 Irrigation Technologies and Projects in Kenya

Irrigation is a centuries old agricultural practice but its application in forestry is recent. Various forms of irrigation technologies are currently in use in Kenya and greatly vary on their impacts on trees and other environmental resources. The common irrigation technologies include: gravity irrigation which includes surface flooding, border irrigation, imbibation irrigation, and furrow irrigation; sprinkler irrigation; and focalized irrigation systems comprising various drip irrigation systems.

Development of irrigation projects in Kenya has been slow. For example, in 1986, it was estimated that Kenya had 5,000,000 ha with potential for irrigation of which only 4% had been put under irrigation by 1992. Recent statistics indicate that total area under irrigation in Kenya is 170,000 ha with National Irrigation Board (NIB) managing 129 irrigation projects distributed in all the 47 counties (Figure 1). However, recent government policy direction plans to increase land under irrigated agriculture to 0.4 million ha by 2017. A notable development is Galana -Kulalu irrigation along Sabaki River in Kilifi County that is estimated to cover 600,000 ha on completion. By 2016 about 4,000 ha had been developed for maize farming. The project will involve massive removal of vegetation during preparation of land for agricultural activities. To mitigate loss of vegetation cover within the irrigation scheme may require large scale tree planting in various formations to bring back resemblance environmental conditions.

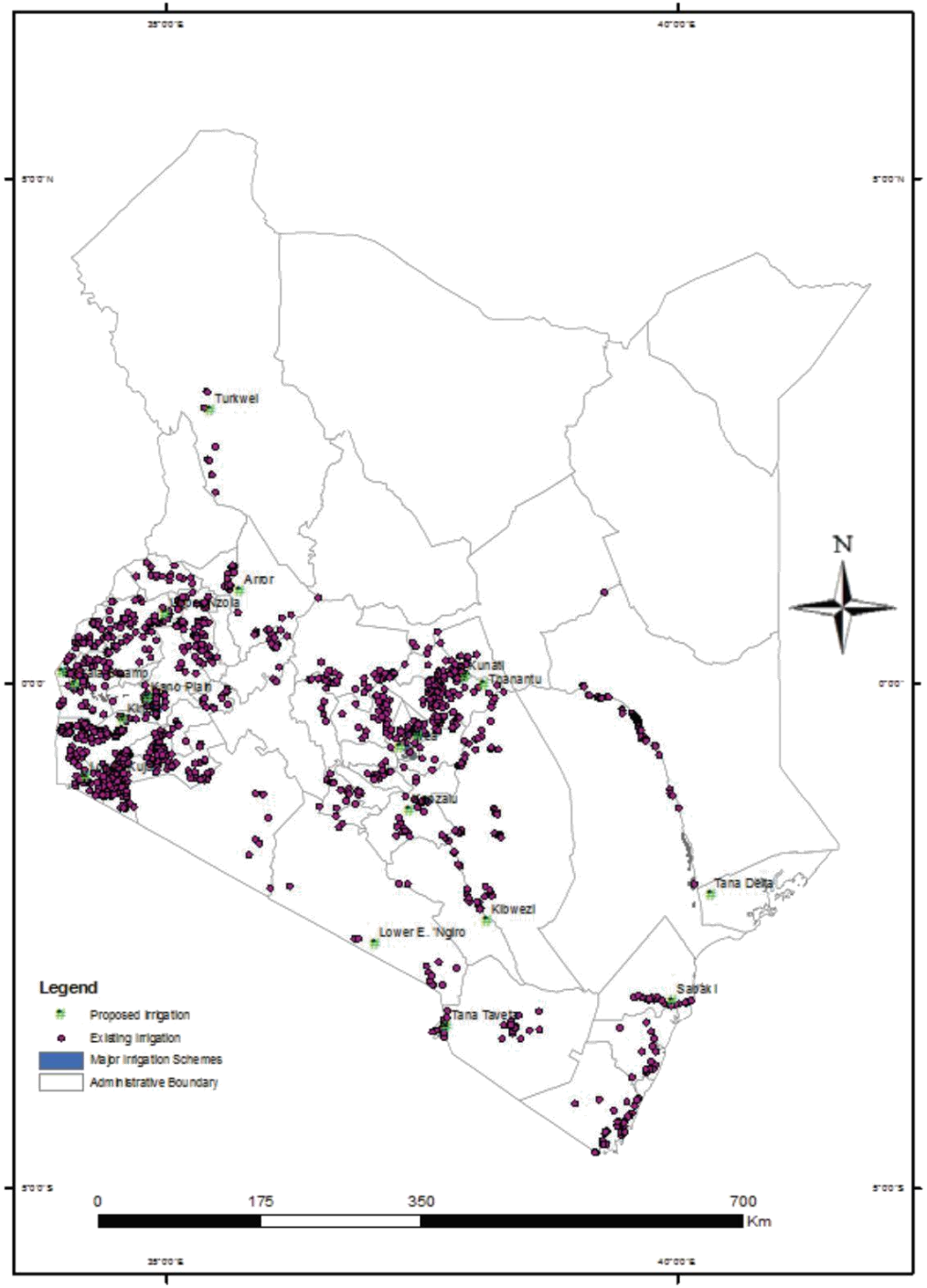

Figure 1: Existing and Proposed Irrigation Projects in Kenya
Source: WRI, 2012

1.3 Justification for Development of the Guidelines for Integrating Trees in Irrigated Landscapes

Many large -scale agriculture irrigation projects in Kenya are preceded by clearing of natural vegetation, thereby exposing large areas of land to agents of erosion and degradation (Plates 2 and Plate 3). The exposed land areas are also prone to intense direct heat from sun, as well as wind and water erosion, hence loss of fertile top soils and microbial organic matter. Replacing trees with shallower rooted crops leads to an imbalance in amount of water entering the soil through infiltration and the amount leaving it through evapotranspiration. High evapotranspiration leads to salinization of land under irrigation, making it unfit for agricultural purposes.

Well-planned tree planting is widely recognized as a possible means of restoring environmental balance in irrigated landscapes, especially when used with other land management practices. Requirements for tree introductions and maintenance of trees on landscapes are contained in various policy documents such as: Constitution of Kenya 2010; EMCA 1999; Physical Planning Act 1996; Forest Act 2005; and Agriculture (Farm Forestry) Rules 2009; that stipulate retention or attainment of at least 10% tree cover. However, information required to guide tree planting and agroforestry in irrigated areas is inadequate. The purpose of this guideline is therefore to give guidance for integration of trees into irrigated agricultural landscapes in a scientific and practical approach. The guideline gives information on: benefits of tree planting in irrigation schemes; procedures for integration of the trees into irrigation landscapes; potential tree species and their planting configurations; and general tree establishment and management practices. The guideline takes into account local and global best practices specifically in Kenya and other African countries, Asia and Australia. The guidelines will be useful to: irrigation development agencies, research institutions, environment regulatory bodies, extension agent's farmers and non-government organizations.

Plates 2 and 3: Vegetation clearing and land leveling to create conducive irrigation environment at Katilu and Nanyee irrigation schemes in Turkana County (Photo: Jesse Owino)

2.0 TREES IN IRRIGATED SCHEMES IN KENYA

2.1 Evolution of Forestry in Irrigation Schemes in Kenya Integration of trees into irrigated landscapes in Kenya has a long history dating back to 1965, when the first forestry trials in irrigation schemes were established in Hola. In 1979, new experiments were started to provide information on fuelwood production under irrigation. In 1984, a Forestry Research Project was initiated in Bura irrigation scheme with support of FINNIDA. Under the project a wide range of species were tested for their survival and biomass production. By the end of the project period in 1993, Bura Irrigation Scheme was the only large scale irrigated forestry research trial within an agricultural irrigation in the country and covered about 100 ha. Trees within the scheme were mostly planted in woodlots on blocks of land set aside for afforestation. Objective of the afforestation programme was to pilot firewood production model to enable the large population of farmers that was moved into Bura Irrigation Scheme to be self -sufficient in firewood and other wood requirements. Afforeststion also aimed at minimizing depletion of the surrounding natural vegetation by immigrant farmers.

Research results from Bura Irrigation Scheme indicated that it was possible to meet demand for fuelwood by community operating within irrigated areas from planted irrigated trees. The trials at Bura also identified suitable indigenous and exotic trees species and provenances for production of fuelwood and other purposes under irrigated schemes.

2.2 Benefits of Tree Planting in Irrigation Schemes

There are several benefits associated with tree planting in irrigated landscapes including: facilitation of groundwater recharge; lowering of water table; use of surplus water for tree irrigation; rehabilitation of saline soils; provision of shade and shelter; production of extra fodder; improvement of the environment; provision of extra income; and increasing property and aesthetic values.

2.2.1 Facilitation of groundwater recharge

Trees facilitate recharge of underground water by enhancing infiltration through the soil profile into ground water reservoirs. Deliberate planting of trees in poorly drained irrigated sites will therefore greatly enhance groundwater recharge.

2.2.2 Lowering of water table

Planting of deep rooted trees tolerant to water logging can mechanically open up lower soil profiles for water to percolate deeper depending on permeability of the underlying soil layers. In some cases planting high transpiring trees can act as groundwater pumps, lowering the water table directly below them and in the surrounding area. These attributes can create soil condition favourable for growing of crops.

2.2.3 Use of surplus water for tree irrigation

Excess water from crop irrigation schemes can be used to irrigate trees. Trees are reported to utilize substantial amounts of water depending on soil types, climatic conditions, their stage of growth, and the species.

2.2.4 Rehabilitation of saline soils

Long term use of water in irrigation schemes is known to increase salt accumulation in the soils rendering then unfavorable for crop production. Some trees are tolerant to salinity and are known to pump up salts from soil subsurface in conjunction with other techniques and slowly restore the soils to productive use. Highly degraded irrigated fields can therefore be rehabilitated by planting appropriate tree species that can pump up salts.

2.2.5. Provision of shade and shelter

Most agriculture irrigation schemes in Kenya are located in the ASALs where day temperatures are high and winds strong. Trees play a protective role by providing much needed shade for human beings and livestock. Trees also act as wind breaks for crops thereby minimizing evapotranspiration and loss of water from soil surface. Trees will therefore reduce heat and wind stress in livestock and crops enabling them to devote most of their resources in production rather than to alleviating stress.

2.2.6 Production of fodder

Fodder producing trees can be planted in irrigation schemes to boost livestock enterprises. Trees that can be grown for production of fodder under irrigation schemes include; saltbush, tree lucerne, allocasuarina, casuarinas, leucaenas and most acacias. The fodder produced from the trees provides extra feedstock that enables farming communities engage in livestock keeping to diversify enterprises. Livestock keeping also has an added advantage in the production of animal manure that can be used for soil management.

2.2.7 Improving the environment

Planting trees within irrigation schemes restore some of the natural characteristics of the landscape as much of the natural vegetation is cleared at the on-set of irrigation scheme development. Introduction of trees into the scheme improves diversity of wildlife in the area including preservation of viable populations of insect-eating birds, in turn protecting agricultural crops and pastures from damage by insect pests.

2.2.8 Provision of extra income

Planting fast growing tree species for subsistence and commercial timber production will diversify enterprises for farming communities in irrigation schemes, avoiding reliance on agricultural crops only. Planting multipurpose tree species for production of highly demanded tree products such as firewood, sawnwood, fence posts and charcoal, and non-wood tree products such as honey can generate extra incomes for farmers. Income from tree products can insulate farmers from oscillating incomes from crops if the timing of harvest of tree products can be scheduled during off-crop harvesting seasons.

2.2.9. Increasing property and aesthetic values

Planting trees in spaces set aside for infrastructure development such as houses and stores within irrigation schemes can improve a property's appearance and make it more pleasant to work, rest or live in.

Plate 4: Trees planted for aesthetic value within a home compound

3.0 PROCEDURES FOR INTEGRATION OF TREES IN IRRIGATION LANDSCAPES

Most agriculture irrigation schemes have minimal or no presence of trees as tree planting is rarely incorporated in initial design of the schemes. However, recent development in environmental safeguards require designers of future irrigation schemes to comply with existing laws on tree cover requirements. As requirements at least 10% tree cover are contained documents in various policy documents, it is therefore imperative that irrigation development agencies include tree configurations into irrigation plans. Tree integration should be undertaken in consultation with relevant stakeholders and beneficiaries from the onset and in every stage of irrigation project preparation and development.

Introduction of trees in irrigated landscapes is informed by various factors that include: tree requirements of the farmers; land use designs; and environmental requirements that need to be incorporated into the project

design. There are potential sites for introducing trees into irrigated landscape whilst minimizing potential negative impacts on crops and mechanical operations. Preferable planting sites include; infrastructure spaces, settlement areas, along riverbanks, and to a limited extend, within crop fields.

3.1 Building and Rehabilitation of Infrastructure

Irrigation development schemes involve construction of a wide range of structures to facilitate accessibility to the irrigation scheme and to improve efficiency of operations within the irrigation project site. Infrastructure projects include; building and grading of access roads, building of airstrips, building and rehabilitation of water pans as well as other water delivery and storage systems to facilitate operations in the project site. Sites for introduction or retention of vegetation components should be inbuilt in the plans of the wide range of structural developments under consideration.

Plate 5: Construction of roads and laying of water pipes in an irrigation site

3.2 Potential Tree Species and Configurations for Irrigated Landscapes

3.2.1 Species selection

In selecting trees for planting in irrigated areas, expected products and services, specific soil types, and climatic conditions should be taken into account. Some of the criteria that can be used in selection of trees for irrigated areas include; high yield at low water uptake, short rotation, high wood density, seed availability, ease of establishment and regeneration potential. A wide range of trees are considered suitable for planting in irrigation areas including; *Eucalyptus microtheca, Azadirachta indica, Eucalyptus camaldulensis, Eucalyptus tereticornis, Parkinsonia aculeata* and *Casuarina equisetifolia*. These species have shown good performance under irrigation at Bura Scheme in Kenya.

3.2.2 Potential tree configurations

Depending on user preferences and desired products and services, appropriate tree species may be selected from a wide range of available options. Choice of species exerts a major influence on planting arrangements to be adopted. The following are some of the planting arrangements (configurations) that may be adopted under different circumstances in areas under irrigation.

3.2.2.1 Large tree plantations

Depending on planting purpose, plantations up to 100 ha or more can be established in irrigation schemes. Such large forest plantations are feasible strategies to integrate trees into irrigation schemes for production of fuelwood and construction wood for use in villages within the irrigation schemes or sale to industries. Space for establishment of plantations should be provided for at the design stage of the irrigation scheme. Potential tree species suitable for irrigated forest plantations include; *Eucalyptus microtheca, Azadirachta indica* (Neem), *Eucalyptus camaldulensis, Eucalyptus tereticornis, Parkinsonia aculeata,* and *Casuarina equisetifolia.*

3.2.2.2 Woodlots

Woodlots can range between 0.1 - 5 ha, located around settlements and spatially distributed within the irrigated landscape. In small-scale irrigation farming areas, woodlots are often small, 0.1 ha or less, whilst in large-scale farms woodlots may be up to 5 ha. Woodlots may be established for either subsistence purposes to meet wood requirements of local populations or for commercial purposes. It is advisable to establish woodlot near settlements to reduce burden of carrying firewood for long distances. Depending on planting objectives woodlots can be established on poorer land sites within the irrigation scheme or on more productive sites for commercial purposes.

3.2.2.3 Wind breaks

Windbreaks are trees grown in lines within irrigation schemes and may have one or several layers. Windbreaks are mainly used to protect crops or animals from wind. In addition to playing the protective role, windbreaks often produce wood for timber and fuel wood. In fields where the crops under irrigation are not particularly susceptible to predatory birds, windbreaks may be established or maintained as widely spaced trees along boundaries of irrigation blocks or along water delivery canals. While establishing windbreaks in these niches, trees should be planted at wide spacing to ensure that tractors and other machinery used for routine operations such as ploughing and de-silting are not hindered. For instance, trees planted along main irrigation canals should be spaced in such a way that the machines can move in between the tree lines and the water channels on both sides of the canals.

Plate 6: Woodlots within an irrigation scheme in Ahero, Kisumu County

3.2.2.4 Agro -forestry trees in cropland

Trees that are beneficial to agricultural crops by virtue of soil fertility improvement such as through biological nitrogen-fixation or those that do not have adverse negative effects on desired crop yields can be integrated with crops in paddies at wide spacing of up to 10 - 15 meters. Potential species include; *Faidherbia albida, Moringa oleifera and Leucaena leucocephala.*

Plate 7: *Leucaena leucocephala* in Eldume irrigation scheme, Baringo County

3.2.2.5 Boundary planting

Boundary planting is used to delineate plots or farms within irrigation schemes. This is a common practice in many parts of the country and is the simplest method to incorporate trees into agricultural irrigation landscapes. Trees can be managed by lopping, pollarding, coppicing, or felled, depending on the species, type of product desired and need to reduce tree-crop competition. Potential species for boundary planting include *Grevillea robusta* and *Casuarina equisetifolia*.

3.2.2.6 Shelterbelts

Shelterbelts is a general term that describes any tree hedge that plays a protective role in the landscape. Shelterbelts play multiple roles including; protecting crops against wind, soil moisture conservation, protecting homes, keeping off wild animals, and protecting ecological conditions or minimizing climatic hazards, as well as beautifying the landscape. This technology is suitable for incorporation of trees into large scale irrigation schemes. Species suitable for shelterbelts in irrigated areas may include; *Eucalyptus camaldulensis, Eucalyptus tereticornis, Eucalyptus microtheca* and *Acacia nilotica* for the high canopy layers; *Euphorbia tirucalli* and *Parkinsonia aculeata* for middle canopy layers; and *Acacia mellifera* and *Acacia senegal* for the low canopy layers (Johansson *et al*., 1990).

3.2.2.7 Fodder trees

Trees and shrubs are a valuable source of fodder especially in arid and semi -arid areas. Families living in irrigation schemes and keep livestock may grow and maintain trees and shrubs as fodder banks, or grow fodder shrubs along irrigation canals. The trees are managed as cut and carry fodder system or for browse during fallow periods. Possible candidates species include; *Calliandra calothyrsus, Leucaena leucocephala, Gliricidia sepium* and *Morus alba.*

3.2.2.8 Amenity tree planting

Since most irrigation land development involves removal of natural vegetation during planning and development of irrigation schemes, settled villages are devoid of shade and ornamentals trees. Incorporation of trees within the settlements would: make the scheme a more hospitable environment; improve the aesthetic value of homesteads and villages; and provide desired tree products and other services. Some of the trees that may be grown for shade include: *Albizia lebbeck, Azadirachta indica, Senna siamea* and *Terminalia brownii.* Trees that may be used for ornamental purposes include; *Senna siamea, Delonix regia, Parkinsonia aculeata, Thevetia peruviana,* and *Tecoma stans*. Fruit trees such as *Carica papaya, Mangifera indica,* Citrus spp. and *Tamarindus indica* may also be planted as amenity species.

Plate 8: Amenity trees planted in homesteads and office compounds around an irrigation scheme

3.2.2.9 River bank tree planting

Many of the irrigation schemes in Kenya obtain water from rivers. The water either flows by gravity or is pumped using electric power generators. Every year, large quantities of soil are lost from banks of rivers used in irrigation through erosion due to diminishing woody vegetation cover resulting from deforestation. There is therefore need to re-vegetate riverbanks neighbouring irrigation schemes to ensure sustainable water flow. To ensure continued quality and quantity of water flow for irrigation, some appropriate tree species that can be planted along riverbanks include; *Ficus sycomorus*, Syzygium spp, *Tamarindus indica, Terminalia brownii*, and bamboo.

Plate 9: Deforested riverbanks that need re-vegetation

3.3 Tree Establishment and Management in Irrigated Landscapes

Establishment and management of trees within irrigation schemes will involve: propagation of planting material; planting and maintenance of trees; silvicultural operations; tree crop rotation, and tree product harvesting.

3.3.1 Tree nurseries

Development of irrigation schemes should involve establishment of tree nurseries to supply required seedlings at appropriate time, quantity ans species. Depending on size of the scheme, there may be one large central nursery or numerous satellite nurseries to ease access and distribution of seedlings. It is important that tree nurseries are situated close to a reliable water source, well protected and accessible, and situated in a well-drained site.

Where seedlings are established from seed, proper procedures of seed collection, processing, handling, storage, treatment and seedling establishment should be followed to ensure production of good quality trees.

3.3.2 Tree establishment and maintenance

Trees should be established at onset of the irrigation farming depending on the soil type and the method of irrigation. The choice of tree establishment method depends on the species, tree configurations, method of irrigation, and size of the tree component required. Trees in irrigation schemes may be established through direct sowing of seeds in the field, use of seedlings or vegetative propagation material such as cuttings.

Weeding should be done before tree establishment to facilitate flow of water through the furrows. Planted trees need to be protected from grazing animals.

3.3.3 Tree management operations

Desirable characteristics of appropriate tree species must be accompanied by good management practices for positive performance and interaction with associated food crops and/or livestock. Some management operations that may be applied to tree species in irrigation schemes include; thinning, coppicing, pruning and pollarding.

Thinning involves selective removal of individual trees in irrigated sites to ensure optimal number that provide minimal competition to main agricultural crop. Coppicing is when trees grow back after they have been cut. It differs from side pruning and pollarding in that the entire tree is cut usually at the base, at a height of 10 – 50 cm from the ground. Pruning is a specialized silvicultural practice involving selective removal of branches. Reasons to prune trees include; deadwood removal, improving timber quality, shaping trees to reduce competition and reducing risk from falling branches. The practice entails targeted removal of diseased, damaged and dead, non-productive, structurally unsound, or otherwise unwanted branches. Pollarding is the extensive cutting back of the crown of a tree retaining the trunk at least 2 metres high to minimize sunlight competition with crops.

3.3.4 Tree crop rotation

Rotating trees with crops reduces the negative effects of monoculture and helps reduce decline in crop yields and soil fertility, and minimize pest and disease incidences. Where leguminous trees and shrubs are planted after crop harvests, the nitrogen fixation associated with it could build up fertility for the succeeding crop, while breaking the life cycles of many pest and disease organisms.

3.3.5 Tree harvesting

Harvesting schedules for tree species grown in irrigation schemes may vary depending on desired products and services. For instance, trees intended for timber may be harvested at a more advanced age than those intended for poles. During harvest, there should be minimal damage on associated crops during tree felling and haulage. Likewise, there should be minimal damage is caused on existing furrows.

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