Title: **Giant Bamboo Propagation Using Stem Cuttings On-farm in Kiambu County, Kenya**

Target Audience: Crop and Livestock Farmers, Extension Agents, Learning and Research Institutions

Introduction

Kiambu County has a population of about 1,623,282 people with an average density of 638 persons per km^2. The County covers a land area of about 2,543.5 km^2. Karumuru village in Kiambu County lies within a latitude -1.08330 degrees and longitude 36.8167 degrees. The mean annual temperature is 24^0C and rainfall ranges between 600-1,200 mm per year. Livelihood activities in Karumuru village are mostly within the agricultural production systems. Crops grown include: tea, coffee, pineapple, potatoes, bananas, wheat, pyrethrum, maize and macadamia nuts. Animal production include; cattle, sheep, goats and poultry farming. Farmers within Karumuru village have continued to diversify plant types and have introduced crops such as Bamboo. Mr. Ndungu Wamucheru, is one of the pioneer farmers to introduce Giant bamboo (*Bambusa dendrocalamus*) farming in the village. Giant Bamboo is preferred by farmers due to its fast growth, wide range of uses including provision of various products and ecological services. Bamboo ecological benefits include soil erosion control and river bank stabilization while significant uses include: food and fodder, roofing, fencing, fuelwood and furniture.

Objectives

Objectives of propagating giant bamboo are:

- Provision of products for domestic use.
- Enhance income through sale of products.
- Provision of seedlings to establish on-farm for environmental conservation measures.

Approach

Mr. Mucheru acquired bamboo propagation and management skills from a British farmer residing in Thika, Kenya who had a lot of experience on bamboo production and utilization. Multiplication of bamboo seedlings on-farm is undertaken through vegetative propagation by using stem cuttings.

Propagation procedure employed by the farmer:

- Collect cuttings from a mature bamboo stem (culm), which is about 2 years old and with protruding buds. A mature culm should not have a coating of white powdery dust.
- Use a hand-saw to obtain cuttings measuring 20 - 30 cm from the culms. The cut should be made at least 2 cm below the nodes.
- Prepare a mixture of water and rooting hormone in a clean container.
- Prepare a cool spacious area where the cuttings will be arranged to develop shoots and roots.
- Dip each cutting into the prepared mixture of water and rooting hormone.
- Put the same mixture to fill the hollow tube of the cuttings.
- Arrange/place the cuttings in a vertically slating manner (about 45^0) and cover the parts that will sprout with mulch and soil sparingly. *Grevillea robusta* leaves are preferred due their higher water holding capacity and heat generation and retention.
- Leave the cuttings under shed covered with leaves until they sprout.
- Maintain the water and root hormone mixture in the hollow top part of the cuttings with water-rooting hormone mixture to avoid drying and to ensure faster shooting and rooting. This should be checked once a week for 2 months.
- Maintain the shade until the shoots have developed.
- Prepare appropriate soil mixture and large transplant pots or bags ready for transplanting sprouted seedling
- Fill a planting bag with prepared forest soil mixture half-way, then place the sprouted cutting into each bag, after which you fill the bag with soil while avoiding root damage.
- Transfer the pots to a shaded nursery area and take care of the seedlings for approximately 2-3 months before transplanting in the field or sale.
- Water the plants until they are ready for transplanting.

Bamboo cuttings in the shade

Giant bamboo clumb on-farm

Impact

- Use of stem cuttings ensures production of giant bamboo plants that are exactly the same as the parent plant.
- Bamboo takes a shorter period to reach maturity, and continuously provides material for sale and domestic use.
- Increased income through sale of various products that include seedlings which are sold at Ksh 400 each, bamboo culm of about 20-30 cm sold at Ksh 50 while 1 kg of bamboo shoots for consumption costs about Ksh 400. Other products sold include tea harvesting baskets and furniture.
- Conservation of indigenous tree species as bamboo provides wood products for buildings and fuelwood.
- The propagation technique is easy to learn, enabling many farmers to embrace the technique.
- Planting Giant bamboo on-farm has contributed to soil conservation by controlling soil erosion, acts as windbreakers on the farm, provides fodder and nutritional supplement for livestock, especially pregnant and lactating animals as shoots are rich in calcium.
- Due to its fast growth rate bamboo has high carbon sequestration ability.

Innovations and Success Factors

- Vegetative propagation of Giant bamboo continues to be adopted by many farmers in Kiambu County. Adoption has been enhanced through training of farmers on propagation techniques, who consequently start own nurseries to raise seedlings
- Use of stem cuttings technique is a viable procedure compared to raising bamboo from seed as the plant takes a cycle of 50-70 years to bear seeds after which it dies.

- Propagation may be done in two ways, i.e. the internodes are either buried in the soil (layering) or placed in the soil medium slanted vertically or horizontally.

Constraints

Some of the constraints experienced by the farmer include:

- The seedlings take long in the nursery about one year before they reach maturity.
- There is limited genetic diversity as planting materials is collected from limited number of plants on the farm.
- The survival rate of bamboo seedlings once out planted in the field is very low, at about 20% survival.
- Giant bamboo is not a common variety in Kenya as well as in many parts of Africa, therefore, there is therefore limited information on its propagation techniques.
- Giant bamboo is a cluster forming species that spreads outwards. It therefore occupies a lot of space as it spreads out, displacing annual crops planted on-farm.
- Lack of ready market for bamboo culms (stems) is a major discouragement in the growth of the enterprise.
- Leaves from bamboo do not decompose easily and cannot therefore, be used readily in compost making.

Lessons Learnt

Some lessons learnt include:

- Bamboo takes 50-70 years to bear seeds after which it dies. This means the production cycle would be too long if the seed was to be used for propagation purposes.
- To shorten production cycle vegetative propagation using stem cuttings is applied.
- Giant bamboo is a fast growing species and can deliver desired output to farmers within a short period of time
- Bamboo takes three years to mature once it is planted out in the field, thereby offering quick renewable wood products.
- The deference between a mature and immature bamboo culm is that mature culm does not have white powdery dust and starts to branch heavily at the top.
- Bamboo has many uses and social values, which include:
  - Food, feed and medicinal, i.e., highly nutritious as a source of calcium.
  - Provision of timber for roofing, fencing, ornaments, furniture making (chairs and tables).
  - Environmental services such as soil conservation, shade and windbreak.
- Giant bamboo has strong wood that can produce very resilient poles durable products.

- Due to its fast growth bamboo has high carbon sequestration ability.
- There is need to create awareness on uses and benefits of bamboo so as to motivate many farmers take up bamboo growing.
- Extension agencies need to familiarize themselves with bamboo value-chain to be able to link bamboo farmers to buyers.

Conclusion

The growing of giant bamboo is a feasible enterprise and has got potential to: conserve the environment, increase farmers income, and improve farmers livelihood.

Acknowledgement

The authors acknowledge Mr. Ndungu Wamucheru of Karumuru village, Kiambu County for providing information on Giant bamboo propagation, which enabled the compilation of this manuscript.

Title: On-farm Green Tourism in Laikipia County, Kenya

Target Audience: Farmers, extension agents, learning and research institutions

Introduction

Laikipia County experiences a cool temperate climate, with mean annual temperatures of between 16°C and 26°C. The county receives an average of 400 mm and 750 mm rainfall annually. Agriculture is the dominant economic activity. Majority of residents keep livestock and grow different food cash crops as well as horticultural crops. However, due to climate change there is need for diversification of crop production system to provide alternative sources of food and income through adoption of innovative strategies. One such strategy is application of green tourism, an approach that provides sustainable tourism activities that are environmentally.

One of the Green Tourism farm in Laikipia County is found in Sipili location. The farm was started in 2005 on 3 ha land by Mr. Charles Mureithi, who is a farmer and a high school teacher. The vision of the farm is "Being the most beautiful farm in the world". The Mission is "Making agriculture and environmental conservation romantic" while the core values are innovation, quality, aesthetic, efficiency, and peace. The main operations in the farm include: fruit farming beekeeping; root-crop growing; capacity building of farmers, primary and high school pupils, as well as international visitors.

Objectives

Objectives of on-farm green tourism include:

- To conserve the environment through on-farm green tourism.
- To improve farm productivity.
- To improve livelihoods.

Approach

Over the years, farmers in Laikipia County had limited information on the farming practices they could engage in to ensure sustainable crop production, livelihood improvement and enhanced income generation as well as environmental conservation. Mr. Charles Mureithi started green tourism on his farm in 2005 after attending a training in Japan on "Implementation and Promotion of Agribusiness for African Countries". The main activities on Mr. Mureithi's include: Orchard development where fruits such as mangoes, pineapples, pawpaws and passion are grown. Soil and water conservation, beekeeping, seedlings production, provision of picnic sites, awareness creation on environmental conservation by training students and farmers are also undertaken. Mr Mureithi carries out fruit-tree grafting on his farm. Grafting ensures increased fruit yields and production of high quality crop. For instance, the farmer has grafted mangoes in such a way that five to seven varieties can be produced from the same mango tree.

The fruit orchard is kept free clean through regular weeding. Pests and diseases are managed through constant monitoring and application of cultural treatment. At flowering stage, farm yard manure is applied to fruit trees to allow optimum growth and fruiting. Pruning is carried out especially for mango crop to allow crown spread and light penetration.

The framer practices organic farming especially on orphan crops such as yams, a crop believed to have high calcium content.

The farmer harvests surface run-off water from rains. The water is either stored in a tanks or ponds, or is directed into farm for irrigation.

Under the Green tourism concept, visitors pay Ksh1000, are then allowed to walk around the farm, during which time they can pick own fruits straight from the trees, for consumption only. All parts of fruits that are not eaten such as seed, nuts or skin are left on the farm. Visitors also learn about different crops from the farmer during the farm tours.

Impact

- The farmer turned a once non-productive land to a green farm of high productivity.
- Food security and nutritional security is ensured with produce from the farm
- On-farm green tourism has improved farmers income through sale of farm produce, eco-tourism and sale of seedlings raised in the crop and tree nurseries.
- Activities in the farm have also has contributed to; soil and water conservation, improved soil fertility, enriched bio-diversity and improved resilience to climate change.
- Trees have also improved microclimate on the farm, aesthetic value and act as windbreak.

- Neighbours have also learnt a lot from Mr. Mureithi on how to turn land green, make it more productive and how to be economically empowered from farming.
- Bees are not only kept for honey production but also to act as pollinators for the fruit trees, an approach that has enhanced fruit production

Innovations and Success Factors

- On-farm green tourism has been adopted by many farmers in Laikipia County. This has been enhanced through training of farmers, water harvesting, own seedlings production and growing of food crops and various types of fruits.
- To improve on water harvesting techniques, the farmer has built big ponds and lined the same with polythene sheets to prevent water loss through percolation.
- The whole family is involved in the farm activities with the wife concentrating on marketing. Family involvement ensures sustainability of the project.
- Green tourism has promoted conservation of many food and tree crop.
- The county government promotion of crop production and marketing by providing extension services and linking producers to buyers has encouraged farmers to farm
- Visitors to the farm cause little damage to the environment, but provide socio-economic benefits to farmer through payment for eco-tourism.

Constraints

Some of the constraints experienced by the farmer include:

- Scarcity of water.
- Wastage of fruits by visitors.
- Pest and diseases such as; aphids affecting oranges; lizards causing absconding of bees from the hives; birds destroying fruits.

Lessons Learnt

Some lessons learnt include:

- Proper planning and utilisation of land by applying different farming practices such as fruit tree planting, root-and orphan crop farming, tourism, zero-grazing, beekeeping, and water harvesting are integrated to maximize farm productivity.
- Appropriate integration of formal employment and farming. The farmer is a high school teacher but able to undertake farming as well as conduct informal trainings to different groups of people such as schools, farmers, and individuals.

- Improvement of tree varieties through grafting including mature plants e.g. mango, tree tomato and avocado.
- Green tourism is an enterprise that allows land productivity improvement as well as increases income
- To succeed in agribusiness there is need to conduct appropriate research on kind of farming suited to particular ecological conditions, requirements, availability of market for the products.
- Record keeping is also very important in order to monitor expenses and profits.
- Mixed farming for small scale farmers affords them many benefits and avoids risks that is associated with monoculture
- The farmer hopes to make agriculture attractive to young people by incorporating environmental conservation and income generation from farming and ensuring low-cost farming technique and making agriculture a profitable business.

Conclusion

On-farm green tourism is a viable enterprise and has potential to; improve farmer's income, conserve environment, and enhance mitigation and adaptation to climate change.

Acknowledgements

The authors acknowledge Mr. Charles Mureithi of Laikipia County for providing information on on-farm green tourism which enabled the compilation of this manuscript.

Title: Sustainable Livelihood through Integrated Tree-Crop-Livestock Farming System in Makueni County, Kenya

Target Audience: Farmers and Extension Agents

Introduction

Makueni County is located in Eastern Kenya and is generally semi-arid in nature. The average annual rainfall within the count is 600 mm while temperatures are 23^0C. The soils are primarily sandy and acidic in nature. The County is characterized by a rapidly growing population, water scarcity, low food production, and low resilience to climate change. These challenges lead to food insecurity, low income, and malnutrition for many small holder farm families.

Mr. Jonathan Kituku, a farmer in Makueni County, Kibwezi sub-county is involved in integrated farming where he practices scale on-farm plantation development, fruit farming and pasture growing. Mr. Kituku owns about 95 acres of land much of which is under *Melia volkensii* (Melia) trees and mango orchard. The farmer selected *Melia volkensii* for woodlot development as the species is drought tolerant, grows fast, and is termite resistant. The farmer started tree farming in 1999 after receiving advice from KEFRI on Melia propagation procedures as well as tree nursery establishment and management.

Objectives

Objectives of integrated farming:

- To address challenges of inadequate food
- Improve income generation
- Avail pasture for livestock throughout the year
- Improve farm productivity

Approach

Over the years, rainfall in Makueni County has continued to decline leading to low crop production, hence the need for other investment alternatives such as tree growing, fruit farming, shift from free roaming to zero grazing of livestock rearing system. Melia growing was introduced on-farm after identification of the species as suitable for dryland conditions, and training of model farmers such as Mr. Jonathan Kituku by KEFRI.

Activities under integrated farming

- ***Melia volkensii* woodlot development**

To establish Melia, site preparation is carried out through; clearing of land, fencing, ploughing, harrowing and leveling. Planting holes measuring 45 cm deep x 45 cm wide x 45 cm long and spaced at 4 m x 4 m are dug. Melia seedlings are planted at the start of the rainy season. Management of the tree is undertaken through weeding, and pruning which is carried out through removal of buds (de-budding). Melia woodlot is long term enterprise.

The farmer also collects *Melia volkensii* seed from naturally growing mature trees on his farm and supplies to farmers and companies who require the seed. Melia growing constitutes part of the long-term enterprise.

- **Mango fruit orchard**

Mr. Kituku has an orchard of grafted mangoes which currently cover 17 acres. The mango trees are of different varieties with the main variety being apple, a variety favoured for export market. Due to water shortage, Mr Kituku also harvests run-off by collecting rainwater through terraces to improve mango crop productivity. Mango growing constitutes part of the mid-term enterprise.

- **Pasture growing**

The farmer harvests natural grass, bales, stores and sells to other farmers during the dry season. Much of the grass is harvested under the Melia plantations. The farmer ensures the hay is well stored till the next dry season and has therefore built a warehouse for this purpose. The warehouse can accommodate about 3,400 bales of hay.

The farmer also rears goats, cattle, poultry and donkey. Livestock rearing and pasture farming form part of the short-term enterprise for the farmer.

Impact

- Improved income for the farmer through; sale of Melia seed, seedlings, firewood, timber mango fruit and hay.
- Improved nutrition and food security from mangoes and vegetables produced

- Growing of Melia and mangoes crop has contributed to; soil and water conservation, improved soil fertility, enriched bio-diversity and improved resilience to climate change.
- Trees have also improved microclimate on the farm, aesthetic value and act as windbreak.

Innovations and Success Factors

- Melia growing, establishment of fruits orchards and pasture farming has been adopted by many farmers in Makueni County. This has been enhanced through training of farmers and raising seedlings in their own nurseries.
- In order to increase quality and volume of Melia timber, Mr. Kituku increased the tree spacing from initial 4 m x 4 m which was introduced by KEFRI to, 7 m x 7 m, and to 8 m x 8 m.
- The farmer also intercrops Melia trees with green-grams and natural pasture grasses maximizing land productivity
- Mango orchard contributes greatly to diversify income sources.
- The farmer has plans to add value to mangoes rather than selling them unprocessed,

Melia trees plantation established on-farm

Grass growing naturally under melia trees used for hay making

Constraints

Some of the constraints experienced by the farmer include:

- Shortage of water due to inadequate amount and poor distribution of rains.
- De-barking of Melia trees by goats negatively affecting tree growth.
- Retarded growth of Melia due to poor seed material used.
- Diseases incidences especially canker

Lessons Learnt

Some lessons learnt include:

- Intervention of extension agents is key in directing, and informing farmer's decisions.
- Growing drought resistance trees contributes greatly to livelihood improvement in the drylands.
- Livelihood improvement can be attained through tree nursery activities.
- Water harvesting is necessary for food and tree crop survival and productivity in the drylands
- Good management of mango orchards leads to a healthy orchard and high production.
- Intensified pasture grass production as an understory in Melia plantation gives livelihood sources for medium and long term.
- Good relation between model farmer and neighbouring community enhances farmer- to-farmer information dissemination
- Integrated farming is important in drylands to ensure food security and income generation for farmers.
- Melia is a tree species tolerant to drought and therefore grows well in dry areas
- Natural grass under Melia plantation can be managed for hay production thereby boosting income generation for farmers.
- Integrated farming enhances soil conservation and fertility.
- It is important to have a farm plan that involves short term (crop production), medium term (grafted fruits, livestock farming) and long term (tree farming) to ensure livelihood needs such food production and generation of income are met.

Conclusion

Growing of Melia, fruits crops such as mangos and pasture is a viable enterprise for small scale famers as it has potential to; improve farmer's income, conserve environment, and enhance mitigation and adaptation to climate change.

Acknowledgements

The authors acknowledge Mr. Jonathan Kituku of Kibwezi, Makueni County for providing information on tree growing and pasture production, which enabled the compilation of this manuscript.

Title: Moringa Plantation Development in Machakos County, Kenya

Target Audience: Farmers, extension Agents and SMEs

Introduction

Over the years, Machakos County have been experiencing low rainfall leading to low crop production, hence the need for alternative investment such tree farming which require little water for growth. *Moringa oleifera* was selected as a species that can do well in dryland Machakos due to its ability to do well in hot weather and low rainfall. The species also has many nutritional and medicinal benefits derived from the various plant parts. The leaves are a good source of protein, vitamins A, B and C, and minerals such as calcium and iron; the pods, green peas and seeds can also be eaten, while and the flowers can be either eaten or used to make tea. Products such as moringa powder, tea, and massage oil from the leaves and seeds can be made from the plant. Moringa powder can be used as a food supplement to treat ailments such as diabetes, high blood pressure, skin disorders indigestion, anaemia and aides in faster healing of wounds.

Moringa oleifera plantation development in Mukaa, Machakos County started in 2015, when the farm site was leased to a Chinese national by a local owner. The main purpose of the plantation was to produce various products for export market as well as to empower the local communities through creation of employment at the farm and through recruiting farmers in out grower schemes.

Objectives

Objectives include;

- To increase income generation through export of various moringa products
- To empower the local communities through employment opportunities.
- Improve farmers income through an out grower scheme
- To enhance land productivity.

Approach

- To establish the moringa plantation, the entrepreneur initially underook direct sowing, however the germination rate was poor. The entrepreneur then opted to start a nursery, where Moringa seedlings would be raised and latter planted on the farm. A water reservoir was also constructed to provide water needed for raising the seedlings.
- To plant moringa seedlings land is ploughed, planting holes are dug, 1 kg of compost manure added per hole, and 2 seeds planted per hole (direct seeding).
- If establishing from seedling, square holes 1 m deep and 1 m wide
  spaced at 3m x 2m apart are dung.
- Add compost manure mixed with soils from the hole, return mixture to the planting hole and water before planting
- Plant the seedlings and make water basins which are well mulched. Mulch should be put far from the moringa stem to keep termites away.
- Mechanically control termite by scraping away soil from the stem
- As the plant establishes and reaches a height of 1.5 m, the top is cut to allow for more top branching.
- Management of the plantation is done by weeding, pruning, occasional watering, and termite control, nipping flowers and leaves. Mulching to enhance soil water retention and prevent weeds emergency.
- The trees start to flower after eight months. Some of the flowers are harvested leaving 40% for seed production. Flowers have a higher monetary value compared to seeds. Harvesting flowers also avoids over seeding which could overburden the tree as the species is a prolific seeder.
- Pods are harvested when they are completely dry for maximum quality of the product. Pods are threshed and seeds prepared for export.
- The harvested flowers and seeds are exported to China.

Impact

- Moringa growing has led to improvement of livelihoods for the people in Mukaa area by providing job opportunities at the farm.
- Integrating the Moringa tree with *Aloe vera* and tobacco have also contributed to; soil and water conservation, improved soil fertility and plant cover, enriched bio-diversity, and improved resilience to climate change.
- Trees have also improved microclimate, aesthetic value and act as windbreak.

Innovations and Success Factors

- Integrating Moringa with *Aloe vera*, tobacco and beekeeping to enhance land productivity.
- When Moringa tree is about to 1.5 m, the top is cut off to encourage multiple branching while discouraging growth in height.
- The farm is centrally located for ease of accessibility and transportation of the produce.
- Out grower schemes encourages large amounts of products that can satisfy export market

Constraints

Some of the constraints experienced in Moringa farm include:

- Low rainfall
- Poor germination rate of about 25% only when direct sowing is undertaken
- Termite attack
- Fluctuation in Moringa productivity leads to job losses of farm workers.

Lessons Learnt

Some lessons learnt include:

- Collaborations between local administration and investor is important to boost acceptance of project within the community.
- Multiple branching for Moringa trees is encouraged to increase production.
- Mulching is necessary to prevent weed growth and to also encourage soil water retention.
- Integration of different crops on same land unit increases land productivity.
- Honey produced within the Moringa farm has high medicinal value.
- The farm is located near the road to ease accessibility and transportation of the produce.

Conclusion

Moringa growing and integration with *Aloe vera*, tobacco and beekeeping are viable enterprises and has potential to; improve community's income, conserve environment, and enhance mitigation and adaptation to climate change. The local communities have also benefited by being employed in the plantation and participating in the out grower scheme.

Acknowledgements

The authors acknowledge the Moringa farm manager Hussein for providing information on Moringa growing which enabled the compilation of this manuscript.

Title: Quarry Rehabilitation in Ngomongo Village of Mombasa County, Kenya

Target Audience: Farmers, extension agents, learning and research institutions

Introduction

Ngomongo Village in Mombasa is situated in a former coral limestone quarry. The area was degraded through mining of coral rocks used for cement production. The Mombasa municipal council later turned the quarry site into a dump site.The Ngomongo village was started with the aim of rehabilitating the quarry by converting it into hospitable land with an improved ecosystem that could be used by neighbouring community.

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Objectives

Objectives of establishing Ngomongo village weremainly to:

- Rehabilitation of the site
- Promote cultural conservation

Approach

In 1991 Dr. Gikandi in collaboration with the surrounding community agreed to rehabilitate the degraded quarry area by planting trees and then establishing cultural villages. Activities such as capacity building through establishment of learning institutions eg Globe Ville college, tree planting to rehabilitate the degraded land and conservation, and establishment of cultural villages were undertaken.

Casuarina was the first species to be introduced in the site. Trees were planted at 1 m spacing and later thinned to 2 m apart. Since causuarina leaves don't decompose easily, millipede population was collected by hand by the neighbourhood community and introduced in large

numbers into the quarry site to help break down the leaves. The proprietor also helped the community around the quarry, to start up a tree nursery.

The quarry houses various rural Kenya villages. Traditional rural home replica are displayed including huts, farms and the crops grown by the various Kenyan tribes and other activities such as fishing and hunting. To make cultural farms productive, the coral was loosened, a 4 inches soil and manure cover added after which each tribe planted their traditional crops which included bananas, sweet potatoes, sisal, cassava, sweet potatoes, cowpeas paw paw and millet.

The tribal villages offer ecotourism activities as a source of income.

Impact

- Rehabilitation of Ngomongo village has led to; soil and water conservation, improved soil fertility, enriched bio-diversity, and improved resilience to climate change.
- Trees have also improved microclimate, aesthetic value and act as windbreak.
- It is also a source of income through ecotourism as a result of the cultural villages that were established.

Innovations and Success Factors

- Rehabilitation of Ngomongo area brought together the communities adjacent the area through tree planting for conservation.
- Establishment of various cultural villages has promoted ecotourism in Ngomongo village.

Constraints

Some of the constraints experienced include:

- The area cannot accommodate villages for all the Kenyan tribes
- Activities are seasonal dependent i.e. the place is busy during tourism high season.

Lessons Learnt

Some lessons learnt include:

- It is important to involve communities in rehabilitation of environment that surround them
- Culture and environment conservation are interlinked

- Degraded areas can be turned to be sources of income
- Environmental conservation can contribute to improvement of social services e.g. subsidized college fee

Conclusion

Rehabilitation of Ngomongo village has been a great source of income through eco-tourism as a result of establishment of a cultural village. Tree planting also led to biodiversity conservation and enhance mitigation and adaptation to climate change.

Acknowledgements

The authors acknowledge Ngomongo village for providing information on rehabilitation and forest conservation which enabled the compilation of this manuscript.

Title: Sustainable livelihood and enterprise development through on-farm roof catchment water harvesting in Kwale Location, Makueni County

Target Audience: Farmers, Extension Agents learning and research institutions

Introduction

Mr. Sammy Mwangangi Kimuyu is a farmer and professional photographer from Kwale Location of Makueni County. Mr. Mwangangi has embraced conservation agriculture, which is sustained by an on-farm roof catchment water harvesting and storage technology. The farmer through intervention by agricultural and forestry extension agents adopted technologies in; water harvesting, water and soil conservation, intergrated farming, as well as improved local poultry and pasture production.

The farmer through assistant from extension agents developed a farm plan to act as a model for sustainable livelihood through agriculture.

Objectives

The specific objectives include;

- Rain water harvesting through roof catchment
- Improvement of local poultry farming
- Irrigation agriculture to sustain production of bulb onion
- Mixed farming to diversify farm produce

Approach

Over the years, rainfall in Makueni County including Mukaa area, has been declining leading to low crop production and deterioration of the natural pastures, hence the need for technologies for sustainable livelihoods. Some of the activities undertaken for improved livelihoods include: irrigation agriculture, mixed farming and rainwater harvesting. Mr. Mwangangi harvesting technique involves capture of rain water from rooftops of houses and channeling it to 10,000 litre capacity PVC tanks or excavated tank with a capacity of 80,000 litre which is PVC lined. Water is directed to the tanks through gutters and pipes.

To reduce rain water runoff, mango trees are planted in trenches that hold water for use by the fruit trees.

The farmer has been engaged in agroforestry practices where he plants maize, vegetables and fruits for subsistence and commercial use. The harvested water is used for irrigation mainly of onions through drip irrigation. The farmer also engages in livestock rearing by keeping goats, cows and poultry.

Impact

Rain water harvesting has improved the livelihood of the farmer as it is cheap to sustain once the required infrastructure is established compared to government supplied water. The technique has also helped to improve; water availability, agricultural productivity, food availability and coping mechanisms during dry seasons.

Mixed farming is a source of income as the farmer is able to sell the farm produce, livestock products and contribute to improving soil conservation. In addition, trees create a micro-climate in the farm and acts as a wind break.

Innovations and Success Factors

- Farmers in Mukaa area have embraced the technology of water harvesting. This has been enhanced by agricultural and forestry extension agents through training farmers on water harvesting, water and soil conservation, mixed farming pasture production.

- To avoid leakages, the excavated tank reservoir is lined with a high gauge black polythene lining. The filtering devices are put at strategic points to make sure that the water getting into the reservoir is clean.

- There is need for proper gradient from roof tops to effectively channel water towards reservoir without spillages. This is achieved through constructing and fitting gutters well along rooftops with iron sheets to channel the water towards desired reservoir

- Construct a water collection and storage reservoir of the desired size and fit filtering mechanisms/devises along the collection pipes to ensure water reaches the reservoir free from dirt and other materials such as leaves.

Constraints

Some of the constraints experienced by the farmer include:

- High initial cost for setting up the system.
- Requires technical expertise to set up.
- Fully dependent on rain.
- Water is not safe for human consumption if not treated.
- Reservoir provides breeding space for mosquitoes

Lessons Learnt

Some lessons learnt include:

- Production of vegetables especially bulb onions through drip irrigation using the harvested water is possible even in areas that receive low amounts of rainfall.
- Collaboration among stakeholders such as agriculture and forest service extension is of importance for farmers to succeed in undertaking integrated farming.
- Water and soil conservation is important in improving livelihoods in the drylands.
- Use of simple technologies for roof water harvesting and storage enhances adoption of the practice.
- Optimal use of a small area of land to improve livelihoods through conservation agriculture.
- Establishment of trees by irrigation through bottle feeding technology enhances tree survival in drylands.
- There is need for education and awareness creation as well as capacity building for more community members to adopt the technology.
- The government and development partners could subsidize establishment cost of the technique for vulnerable community members.
- There is need for improving the technology, taking into account best practices in water harvesting.

Conclusion

Water harvesting technique has been embraced by most farmers in Mukaa area and has helped to improve water availability and agricultural productivity. It also has improved food availability and enhanced coping mechanisms during dry seasons.

Acknowledgements

The authors acknowledge Mr. Sammy Mwangangi Kimuyu of Kwale Location of Makueni County for providing information on on-farm water harvesting which enabled the compilation of this manuscript.

Title: Tiriki Tropical Garden and On-farm Bamboo Enterprise in Shamakhokho, Vihiga County

Target Audience: Crop and livestock farmers, extension agents, learning and research institutions

Introduction

Tiriki Tropical Garden was started in 2007 with the intention of planting different tree species to address the challenges of climate change. Although the garden was started in 2007, Mr. Victor Mwanga, the farm owner, started bamboo production in 2012 in Shamakhokho area, Vihiga County, to address the problem of soil erosion in his farm and to introduce short rotation plants. The farmer domesticated different bamboo species using both vegetative and seed propagation methods. The farmer is currently producing 8 species of Bamboo.

Objectives

Objectives of Tiriki Tropical Garden:

- Production and propagation of bamboo.
- Livelihood development and improvements through different bamboo products.
- Adaptation to climate change through integration and diversification of different trees and plant species.

Approach

Bamboo production had not been embraced in many places in Kenya as it is one of the challenging enterprises globally. Many farmers did not have knowledge on how to domesticate bamboo species. Bamboo was introduced on-farm by Mr. Victor Mwanga to address the problem of soil erosion in his farm through propagating bamboo seedlings from seeds. In this process, where bamboo seedlings are raised from seeds, seeds are broadcasted in seedbeds and later pricked out into polythene bags after emergence.

The seeds should be from a known source. The seeds should be sown within 60 days of harvesting, while sufficient shade and moisture should be provided in the nursery during the early days of growth. Seedlings should hardened off before planting out. Ensure that bamboo plantation is kept clean to avoid rodents and snakes.

Impact

Bamboo seedlings production has improved the farmer's income through sale of seedlings and the ready market for bamboo products e.g. bamboo furniture.

Mature bamboo clusters on-farm have also greatly contributed to soil stabilization and water conservation as well as creating a good micro-climate around the homestead.

Innovations and Success Factors

Bamboo growing has been adopted by many farmers in Shamakhokho area. This has been enhanced through training of farmers and raising seedlings in their own nurseries. Domestication of different bamboo species using both vegetative and seed methods of propagation has been adopted by farmers.

Beekeeping and production of beehives using bamboo has also been adopted as additional enterprise for sustainable livelihood.

Constraints

Some of the constraints experienced by the farmer include:

- Short viability of bamboo seed i.e. high viability can only be achieved at 60 days or less after which mortality rate drastically increases.
- The steep farm terrain makes movement cumbersome, especially during planting and harvesting.
- Buying seed from the international market is strenuous as there are many logistical issues to be adhered to. Due to such lengthy processes, sometimes farmers fail to acquire seeds within set timeframe.
- Bamboo takes over 120 years to bear seed after which it dies. Seed propagation cannot therefore, be solely relied upon and there is need for different propagation methodologies to be devised.
- There is high mortality of bamboo seedlings propagated vegetatively, i.e. almost 80% mortality.

Lessons Learnt

Some lessons learnt include:

- Cross-boundary collaboration is important in the production of bamboo. The farmer managed to collaborate with other international organisations to improve his bamboo production.
- More money or revenue is accrued from adding value as opposed to trading in raw bamboo material.
- Bamboo production through seed propagation is better as it increases the survival rate of seedlings.
- Individual effort can be more significant than community initiatives on communal land.
- Networking of different institutions like KEFRI, KFS, Trade organisation, development partners can improve the livelihood of farmers both individually and collectively through encouraging growing bamboo on-farm.

Conclusion

Growing of bamboo is a viable enterprise and has potential to improve farmer's income, conserve environment, and enhance mitigation and adaptation to climate change.

Acknowledgements

The authors acknowledge Mr. Victor Mwanga of Shamakhokho Village in Vihiga County, for providing information on bamboo production which enabled the compilation of this manuscript.

Title: Conserving Indigenous Trees Species in Buteyo Miti Park in Sang'alo, Bungoma County

Target Audience: Crop and livestock farmers, extension Agents, learning and research institutions.

Introduction

Buteyo Miti Park was started by Mr. G. Wafula Buteyo in 1969 with the aim of conserving the environment through protection of indigenous tree species. "Miti" is an acronym which stands for Measures for Indigenous Tree Improvement. The Park is situated between Mt. Elgon and Kakamega forest. The main Park covers a total land area of 32 acres and has three extensions of two 6 and 10 acre plots in different areas. The Samaki Camp which is a constituent of the Park was started in 2005 as an ecotourism site. This site has a total land area of 7 acres and the main activity is fish production. There are 30 fish ponds of different sizes occupying an area of about 700 m^2.

Buteyo Miti Park constitutes of different indigenous tree species and a tree nursery. About 2 acres are set aside for herbal medicine production. This site won the second Presidential Award for protection of indigenous trees.

Objectives

Objectives of community-driven conservation and livelihood activities include:

- Being a leading promoter of measures for indigenous trees improvement.
- Enlightening communities on the values of conserving indigenous trees as unique natural heritage, spur scientific research in botanical genera, herbal medicine and sustainable use.
- Protecting the environment with the use of indigenous trees species that are adapted to climate change.
- Improve livelihood through eco-tourism, fish production, herbal medicines, and collaborating with different groups of people.

Approach

- Establishment and management of an indigenous seedlings tree nursery to raise different species for medicinal and non-medicinal purposes such *Kigelia africana, and Strychnos spinosa.*

- Processing of medicinal plants for different ailments, packaging and selling.
- Providing training on medicinal and non-medicinal plants to interested members of the community.
- Establishment of a herbal clinic.
- Established Samaki camp in 2005 as an eco-tourism site to improve livelihoods through fish production which is the process of multiplying and rearing fish in controlled environment to reduce time period of fish to maturity, produce large numbers of fish within a short period of time and to produce fish which can attract high market and nutritional value.

Impact

The only extensive remnant of indigenous forest area between Mt Elgon ecosystem and Kakamega Forest.

Community driven conservation has helped to improve the livelihood of the community though eco-tourism, production and sale of herbal medicine and fish production.

Trees have also improved microclimate within and the neighbouring areas, aesthetic value and act as windbreak.

Conserving indigenous species has contributed to improved soil and water conservation, soil fertility, enriched bio-diversity and resilience to climate change.

Innovations and Success Factors

Processing of medicinal plants for different ailments, packaging and selling.

Cautions that sometimes herbal medicines are not effective.

Eco-tourism and fish production has been of help to many farmers. This has been enhanced through training of farmers and establishing woodlots in their own farms.

In order to produce large numbers of fish, a saline medium for breeding is be used. An optimum temperature is also maintained.

Constraints

Some of the constraints experienced by the farmer include:

- Encroachment by the communities to get forest products.
- Soil erosion where tree density is low.
- Poaching of the trees.
- Water shortage to sustain fisheries throughout the year.
- Collaborating partners not sustaining their production.
- Financial constraints to improve the area as planned.

- The site is not well marketed and as a result very few people visit the Park.
- Fringe communities cutting grass pay small amount of money.

Lessons Learnt

Some lessons learnt include:

- Most indigenous trees have medicinal value.
- Proper management of indigenous trees species in the eco-tourism sites.
- Integration of traditional herbal medicines for the good health of people.
- Production of mono-sexual fish through hormones.

Conclusion

Community-driven conservation is a good venture for farmers as it enhances protection of environment with the use of indigenous tree species that are adapted to climate change, improves livelihood through tourism, fish production and herbal medicine. Farmers should be encouraged to set aside part of their farm to conserve indigenous tree species as a source of income.

Acknowledgement

The authors acknowledge Buteyo Miti Park for providing information on community-driven conservation and livelihood activities which enabled the compilation of this manuscript.

Title: Cultivating African Sandalwood On-farm in Kitui County

Target Audience: The main beneficiaries of this practice are the farmers, learning and research institutions, adjacent communities and extension agents.

Introduction

African sandalwood (*Osyris lanceolata*) exploitation in Kenya started in the 1980s when the tree bark and roots started illegally harvested. These tree parts contain essential oil used in the pharmaceutical and cosmetic industries. At local level, the species is also used to smoke containers used for milk fermentation. African sandalwood is semi-parasitic and requires a host plant in order to survive. Recent research findings by KEFRI have revealed that *Acacia kirkii, Euphorbia sp.* and *Croton megalocarpus* are some of the best host plants for sandalwood. Sandalwood has a rotation age of about 60 years.

The species is over-exploited from the wild. One alternative that offers great potential for sandalwood conservation is domestication of the species. Mr. Ngovi Mutunga in Wikilyle, Kitui County is one of the farmers taking part in domesticating and protecting the sandalwood trees on-farm.

Objectives

Objectives of cultivating sandalwood on-farm are:

- To propagate sandalwood as a tree of high value.
- To domesticate and conserve sandalwood.

Approach

Over the years, rainfall has been declining leading to low crop production in agricultural landscapes of Kitui County, hence the need for other investment alternatives such tree planting. Sandalwood prefers rocky areas and grows in association with other host species for mutual benefits. The species adaptation characteristics makes it a potential species for domestication in the dry land Kitui County.

Although the species takes many years to attain maturity, propagation from seeds is now a viable option provided the appropriate host plant is integrated. However, sandalwood is still very difficult to propagate from seeds because out of every ten (10) seeds only two (2) are viable. Seed viability is tested by use of floatation method. Viable seeds usually sink in the water and non-viable ones float.

Cultivation of sandalwood is carried out by farmers in Kitui using seedlings. Appropriate land preparation measures, which include timely clearing, pitting, back-filling, post-planting protection and weeding should be ensured.

Impact

African sandalwood is a high value tree and farmers are likely to benefit from lucrative marketing of its products.

Farmers in Wikilye are increasingly adopting the cultivation of sandalwood due to its contribution in; soil and water conservation, improved soil fertility, enriched biodiversity and enhanced resilience to climate change.

Trees have also improved farm micro-climate, aesthetic value and act as windbreak.

There are enhanced opportunities for species propagation from seeds and domestication on-farm.

Innovations and Success Factors

Training of farmers by KEFRI on alternative ways of raising sandalwood seedlings from air-layering and cuttings.

The most effective method of raising a large quantity of seedlings is through seeds and air-layering.

Raising seedlings through cuttings is only feasible in specialized tree nurseries that have the capacity to control fungal attack which is prevalent on cuttings.

Constraints

Some of the constraints experienced include:

- Semi-parasitic nature of sandalwood, hence there is need to identify the right host plant.
- Slow growing.
- Poor seed germination ability.

Lessons Learnt

Some of the lessons learnt are that:

- Sandalwood is an indigenous parasitic tree species with many uses.
- Sandalwood cannot grow on its own it needs a host plant.
- The species is highly threatened by poaching.
- The species can tolerate semi-arid conditions.
- Further research is required on seed handling, alternative propagation methods other than seed, and species-host relationships.

Conclusion

Cultivation of the African sandalwood is a viable enterprise and has potential to; improve farmer's income, conserve environment and the threatened species from over-exploitation, as well as strengthen resilience to climate change.

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