Schools'
Green Initiative Challenge

Growing Trees and Fruit Species in Dry lands

Technical Manual for small forests & woodlots

Schools' green initiative challenge

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Cover photo: Ernest Nyamasyo, KenGen Foundation.

Wonders of Dryland Forestry

Schools' green initiative challenge

The Schools' Green Initiative Challenge is a unique project implemented by KenGen Foundation in partnership with Better Globe Forestry and Bamburi Cement Ltd.

The main objective is the greening of over 460 acres in the semi-arid counties of Embu, Kitui and Machakos with Mukau (*Melia volkensii*) and Muveshi (*Senna siamea*) tree species as a way of mitigating climate change and providing wood fuel and alternative income opportunities for the local communities.

Through the setting up of woodlots in participating schools, the project acts as a change agent to establish a tree-planting culture for multiple benefits in dry-land areas.

The ten-year project is designed as a competition amongst the participating institutions for the highest seedling survival rates through the application of various innovations at the schools' woodlots.

Currently, there are 500 schools from the three counties taking part in the afforestation contest for the ultimate prize of educational trips, scholarship opportunities, and other prizes. Plans are underway to add more schools in the coming years.

The afforestation competition is in line with the Government of Kenya's Vision 2030 to achieve 10% forest cover across the country.

Panda Miti, Hifadhi Mazingira

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Schools' green initiative challenge

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KENYA Forest Service

The GIC and SDGs

The Schools' Green Initiative Challenge (GIC) is a unique program` that incorporates three of the 17 recently unveiled UN Sustainable Development Goals (SDGs) namely Quality Education (SDG 4), Climate Change (SDG 13), Clean Water and Sanitation (SDG 6).

The afforestation program interconnects the three SDGS and promotes mitigation measures against the effects of climate change through the planting of indigenous trees in school woodlots for multiple benefits. The participating schools play a huge role in increasing forest cover in the semi-arid counties of Embu, Machakos, and Kitui that will ultimately lead to better moisture capture, carbon sequestration, and the reduction of topsoil loss through erosion.

As the program expands in its coverage area, participating schools involved in the tree planting competition also improve the learning environment for all students by providing a serene ambience that ultimately leads to better overall performance.

The GIC also includes the setting up of gutters for effective rainwater harvesting structures for participating schools, and the distribution on water tanks for the top three winning schools at each concluding phase in order to address the students' daily water needs, while at the same time curb waterborne diseases.

Green Teachers

Phase II introduced the concept of the 'Green' teacher in the GIC, an environment patron who helps in managing the tree planting activities.

The 'Green' teachers' roles include

- Attending capacity building exercises to learn more about dry-land forestry
- Mobilizing and mentoring students participating in the competition
- Planning and executing all GIC activities in their schools

Annual Capacity Buildings

Since the project's expansion in Phase II the GIC includes now includes 3 annual capacity building sessions for participating schools' 'Green' teachers and head teachers. Project partners Bamburi Cement Ltd., and Better Globe Forestry facilitate the capacity building sessions, with support from National Environment Management Authority, Kenya Forest Service and Ministry of Education.

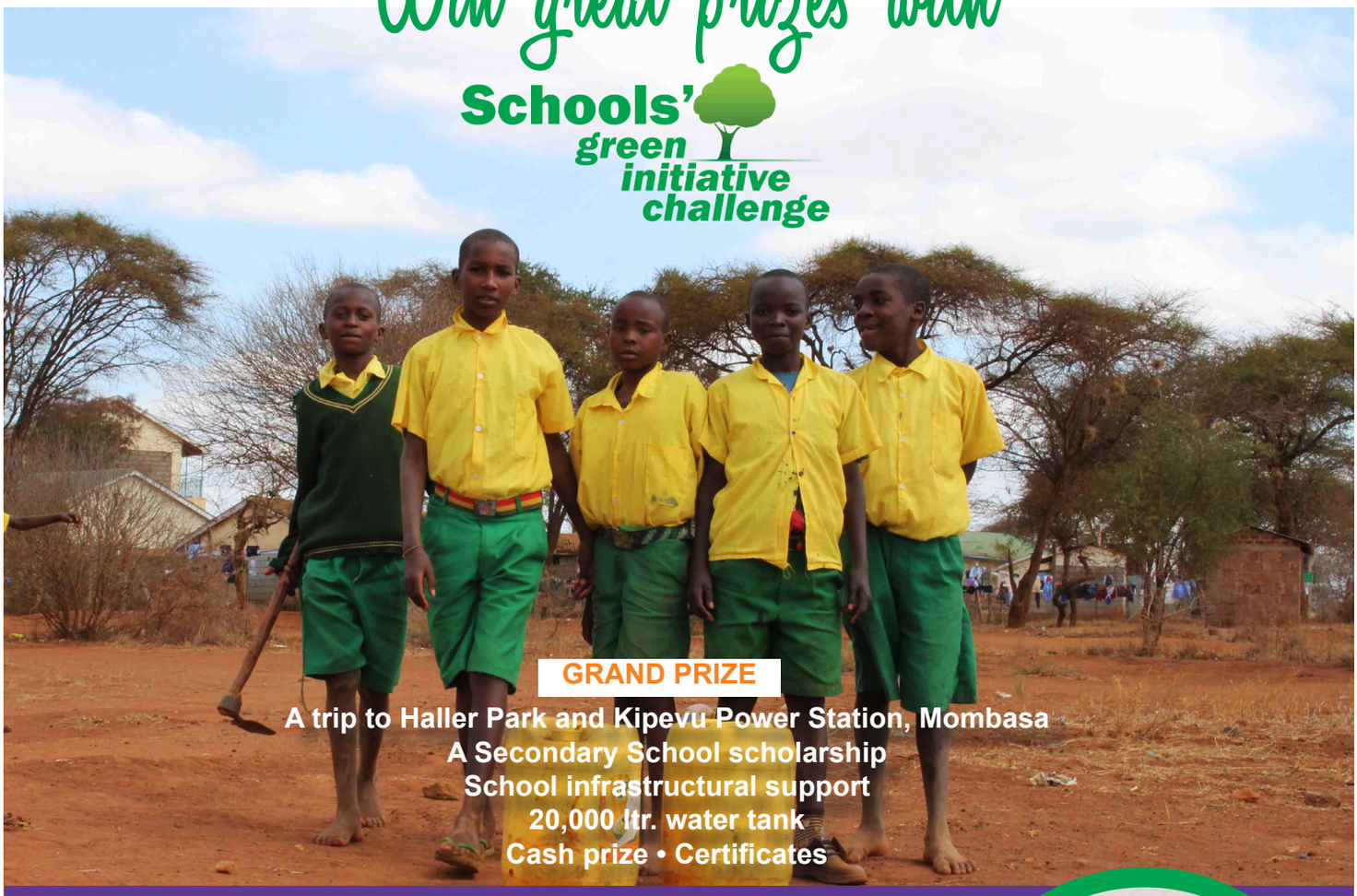
Monitoring & Evaluation

Phase II of the GIC Expansion project introduced M&E Officers from Better Globe Forestry. The officers' are involved in:

- Offer expertise to participating schools
- Seedling distribution
- Setting up capacity building exercises
- Data collection and monthly reports

Win great prizes with

Schools' green initiative challenge



GRAND PRIZE

A trip to Haller Park and Kipevu Power Station, Mombasa
A Secondary School scholarship
School infrastructural support
20,000 ltr. water tank
Cash prize • Certificates

2nd Position

A trip to Hell's Gate National Park and Olkaria Power Station, Naivasha
A Secondary School scholarship
School infrastructural support
16,000 ltr. water tank
Cash prize • Certificates

3rd Position

An excursion to Gitaru Power Plant
10,000 ltr. water tank
Cash prize
Certificates

Free subscription to Miti Magazine for all schools.

Most Innovative Green Teacher: A trip to Mombasa, Cash Prize, Shopping Voucher, Certificate

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Melia volkensii

A good/healthy/impressive stand of five-year-old mukau at Kiambere. Competition has set in and thinning is required.

Mukau is the name given in Eastern Province to the species *Melia volkensii,* a tree indigenous to East Africa and occurring mostly in Kenya, and to a lesser extent in North Tanzania, South Somalia and South Ethiopia. The trees can grow quite big, over 15m high. Some rare individual trees show stem diameters of up to 50cm. It grows fast and can attain those dimensions by 20 years of age.

The species is drought-resistant and can grow in dry areas with mean average rainfall between 400-1000mm. It prefers red sandy soils but survives in heavier, clayish ones though it cannot stand water logging and will die after a couple of days if its root system is flooded with water. Equally, at planting, it is not advisable to plant it in a pit where water can accumulate, as the seedling will die. The species is also resistant to termites, although when weakened it might succumb to termites. It is not uncommon to see mukau trees whose stems are covered with brown patches of soil, under which termites seek protection from predators and the hot sun. These patches are superficial, only on the bark, and do not affect the tree.

What however can affect the tree is browsing by livestock. Goats in particular like the leaves, and the bark can also be gnawed by donkeys. Farmers in dry areas use the tree for animal fodder during the dry season.

The species has a high commercial value, and as such much of the natural population in the wild has been cut. The best trees, straight and healthy, have mostly disappeared, and poor quality specimens, with crooked stems and heavy branches have been left. This means getting good quality seeds of superior trees is a problem.

The germination process requires special attention. The fruits contain two to four seeds that are encased

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in a hard nut. The nut has to be cracked with care, so that the seeds are not damaged. Once extracted, the seeds are nipped at the top, and soaked in water to allow germination.

From this point onwards, the seeds are open to attack by fungi and bacteria, because they are rich in oil and fats. Several fungicides are used to reduce these attacks.

A cracked nut with three seeds.

Germination requires a hot and moist environment, conditions that also favour fungal development. To deal with this, the substrate (coarse sand) used during the sowing should be as clean as possible, and watering should be done with a solution containing a fungicide.

The hot and moist environment for germination can be achieved by various means, a popular one being the use of so-called “propagators”. These are boxes made out of plastic nailed to a wooden frame, which act as little greenhouses. After some seven to ten days, with proper care, about 70% of the seeds will germinate. The little seedlings are then transplanted into pots for further growing.

These freshly pricked-out seedlings need initial protection against cold and direct sun, and after some weeks of growth can be hardened off towards final planting in the field.

In the conditions of Seven Forks, the total process of seedling production, between sowing and obtaining seedlings of plantable size (one foot high) takes about three to three-and-a-half months. To shorten the process, farmers often collect root suckers from existing trees, and plant them in their farms. Sometimes seeds germinate in the wild, notably after fires or after dispersal by goats. Such seedlings are called wildings.

The final objective is to produce logs for timber, out of stems that have a diameter of over 40cm and a clean bole (without branches) of 5m. Several operations are important here: planting, spacing, protection/ weeding, pruning and thinning.

Planting

To ensure survival of the seedling, watering is recommended except when the rains are really good. Economic and efficient watering can be done by drip-irrigation, for instance with a plastic bottle put close to the seedling stem. The bottles are put upside-down, slanted, with their top punctured to allow the dripping, and the bottom partly cut, to allow regular refilling.

The seedlings must also be mulched, to protect the underlying soil from drying and heating up. This way, the young root system will be protected. Generally, the mulching is done with dry grass or weeds, and it needs to be repeated every three months, because termites consume the mulch. The seedlings should be planted without the polybags, and in a pit one foot wide and deep.

Spacing

This is the distance between the pits. Mukau needs full sunlight for its development. The minimum

About one week old germination of mukau in a propagator

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spacing should be four meters, although complete agroforestry practices require a spacing of seven to ten meters. Initial growth is fast and soon the branches of neighbouring trees start competing with each other, and then the growth slows down. At a spacing of four meters, this competition sets in after some four to five years.

Protection/Weeding

This is specifically against goats and humans. It can be done by fencing the complete plot where the seedlings are grown, or by making little fences around each individual seedling. Weeding is essential for survival and fast initial growth. Grasses and herbs can kill the seedlings. Apart from that, the weeds compete for the same scarce moisture that the roots of the seedlings need.

Pruning

The objective of pruning is to obtain a clean bole of up to 5m height, with all pruning scars confined to a central cylinder within this bole of a maximum of 10cm diameter. This can be achieved through a regular pruning schedule of about 10 prunings during the first four years of growth. In this way, first rate timber clean of knots can be produced.
It is a delicate operation. The tools and timing are important. For tools, secateurs and pruning saws are recommended, later on in combination with ladders. Pangas should never be used.

During the first months after planting, farmers traditionally pinch off buds and cut off small branches so that they can see a stem emerging and not a bush. But as a result, the young tree often becomes top-heavy, and bends over even under a moderate gust of wind, as its stem is not thick and strong enough. Therefore, we recommend almost no pruning during the first five to six months, up to a height of 1.5 – 2m.

Even afterwards, only light pruning should be done to encourage the formation of a sturdy thick stem. This light pruning should be selective, meaning only thick branches (over one inch) and double leaders should be cut off, while smaller branches can stay to provide more photosynthesis or growing power.

Thinning

The objective here is to cut small and bad looking trees, providing the bigger and nicer ones with enough space to grow. This is an operation that starts after some five years if the trees were planted at a spacing of 4 by 4 meters. It is repeated once or twice in the following years, always when the branches of neighbouring trees start touching and competing for space.

Senna siamea

Flowers of Senna siamea

bark is grey or light brown, smooth but becoming slightly fissured with age. The root system consists of a few thick roots, growing to considerable depth, and a dense mat of rootlets in the top 10-20cm of soil, which may reach a distance of 7m from the stem in 1 year and eventually up to 15m.

Leaves are compounded, 23-33cm long, with 6-12 pairs of short leaflets. Flower clusters are upright at the ends of the twigs, large branched, 20-30cm long, 13cm broad, with many bright yellow flowers.

Senna siamea was formerly known as *Cassia siamea* and belongs to the *Fabaceae* family. It is locally known as mjohoro (Swahili), mubeci (Mbeere), mukengeta (Kamba), kassod tree and yellow cassia (English).

Introduction

Senna siamea originates from SE Asia, and is a medium-size, evergreen tree growing up to 5-10m tall in semi-arid zones, with a straight trunk of up to 30cm in diameter. It has a short bole. The crown is usually dense and rounded at first, later becoming irregular and spreading with drooping branches. The Pods are numerous, long (5-25cm) and narrow (12-20mm), flat and dark brown; seeds are bean shaped, shiny, dark brown, 8mm long.

Environment

Senna siamea will grow in a range of climatic conditions but is particularly suited to lowland tropics (up to 1,200masl) with a monsoon climate. It will grow only when its roots have access to groundwater, and the maximum length of the dry period should not exceed 4-8 months. It is susceptible to cold and frost and does not do well at altitudes above 1300m. Its light requirements are high.

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Mean annual temperature: 20-31° Celsius
Mean annual rainfall: 400-1,500 mm

Soil type: The tree performs best on deep, well-drained fertile soils with pH 5.5-7.5, but will grow on degraded lateritic soils provided they are well-drained. The species is intolerant of saline soils.

Establishment and management

There are 35,000-40,000 seeds per kg; they remain viable 3-4 years in arid and semi-arid conditions. Young seeds germinate readily without any treatment, while older seeds need scarification. Immersion in concentrated sulphuric acid for 10-30 min has been effective. Germination of untreated seeds is about 75% in 4-29 days.

Senna siamea as an ornamental and shade providing tree at the roadside.

It is a fast-growing species, for production of poles and fuel wood and it regenerates vigorously by coppicing. Weeding is necessary in the first one or two years of growth. Moisture conservation measures (trenching, micro-catchments) help establishment and growth for *S. siamea* planted in semi-arid areas.

Planting density varies depending on use. In fuel wood plantations, spacing ranges from 1x1m to 1x3m, depending on available moisture. In general, drier areas require wider spacing to give roots more room for moisture collection. The tree is good for shelter belts, but less favourable for agroforestry because of root competition with crops.

Trees grow fast even in comparatively infertile soils. For the production of fuel wood and charcoal, plantations are generally pollarded or regenerated by coppice. If coppiced, 2-3 shoots per stump are left after one year. The species can produce several coppice cycles, with a rotation of 4-7 years for pole production.

Products and uses (World Agroforestry Centre)
Food: In Thailand, young fruits and leaves are eaten as a vegetable. During preparation, the cooking liquid is replaced three times to remove toxins. In Sri Lanka, the flowers and young fruits are used in curries.

Fodder: *S. siamea* is widely grown for fodder, but the trees can be browsed. The alkaloids and other secondary plant compounds in the leaves, flowers and pods are highly toxic to non-ruminants, such as pigs and poultry, and these animals should be kept away from *S. siamea* plantations.

Fuel: The dense, dark-coloured wood of *S. siamea* makes good fuel, although it produces some smoke when burning. The energy value of the wood is 22,400 kJ/kg, and the density is 600-800 kg/m³. The wood was formerly preferred for locomotive engines. Its charcoal is also of excellent quality.

Timber: *S. siamea* yields a medium-weight to heavy hardwood with a density of 600-1010 kg/m³ at 15% moisture content. The heartwood is black-brown with paler streaks, sharply demarcated from the 6-cm wide, pale sapwood; grain is interlocked and occasionally straight; texture is slightly coarse but even. Shrinkage of the wood during seasoning is moderate to high but it seasons with little degradation. The wood is hard to very hard, resistant to termites, strong, durable, difficult to work, with a tendency to pick up in planing and it takes a high polish. The dark heartwood of *C. siamea*, which is often nicely figured, is used for joinery, cabinet making, inlaying, handles, sticks and other decorative uses. The wood has also been used for poles, posts, bridges, mine poles and beams.

Tannin or dyestuff: All parts of the plant can be used for tanning. The concentrations of tannin vary slightly from 17% in the leaves to 9% in the bark and 7% in the fruits.

Medicine: In traditional medicine, the fruit is used to charm away intestinal worms and to prevent convulsions in children. The heartwood is said to be a laxative, and in Cambodia a decoction is used against scabies.

Erosion control: When used as a hedgerow, it effectively increases topsoil infiltration, reducing runoff and combating soil erosion.

Shade or shelter: *C. siamea* is grown as a shade tree along roads and in cocoa, coffee and tea plantations. It is also planted as a dense windbreak and shelterbelt.

Reclamation: Used extensively for rehabilitation of degraded land.

Soil improver: Leaves are used as green manure, and a well-grown tree can yield 500 kg/year of fresh leaves. *C. siamea* forms ecto-mycorrhizae and provides very useful mulch, especially in alley-cropping systems. Caution: leaves are said to be poisonous.

Ornamental: *C. siamea* is often planted as an ornamental for its abundant yellow flowers.

Boundary or barrier or support: It is pruned into hedgerows and used as a live fence around food crops.

Intercropping: Although not a nitrogen-fixing tree, *C. siamea* has been increasingly used in alley cropping systems, largely because of its coppicing ability and high biomass production.

Other services: In India, it is used as a host for sandalwood (*Santalum* spp.), a parasitic tree producing the well-known fragrance.

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Terminalia brownii

Three-years-old T. brownii in Kibwezi area

Belongs to a family of trees known as *Combretaceae.*

Local names: mbarao (Swahili), muuku (Kamba), mururuku (Embu)

Description

Terminalia brownii is a semi-deciduous tree with an attractive somewhat layered appearance, usually 4-15 (25) m high. Foliage is drooping with leaves oval-shaped, 7-10cm long, a bit wider at the tip. The leaf stalk and the underleaf are hairy, and the leaves turn red before falling.

The flowers, white to cream-coloured, are growing in spikes to 12cm long. They have an unpleasant smell. The fruit is winged, smooth, greenish when young, red to purple when mature, some 5cm long with the tip rounded or notched.

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The generic name comes from the Latin ‘terminalis’ (ending), and refers to the habit of the leaves being crowded at the ends of the shoots.

Mature Terminalia brownii in Kibwezi area

Environment

This is a very useful species of the semi-arid areas, found in deciduous woodland, bushland and riverine vegetation.

Altitude: 600-2,000 masl, Mean annual rainfall: 500-1,300 mm
It prefers well-drained soils.

Propagation:

This species is a prolific seeder, but with a rather low germination rate. The tree seeds more or less continuously, with some 3,000 seeds per kg. The fruit wings are clipped and the seed is soaked in cold water overnight, nipped at the end so that the tip of the seed is just visible, care being taken not damaging the seed itself. The seed can be stored for up to a year, if insect-free.

Management & products/uses:

The species is fairly fast growing on good sites or being properly taken care off (weeding!). It can be coppiced so that it regrows and produces poles for construction.

Its wood is yellow-brown, medium hard, light and termite-resistant. Hence it is highly valued for house construction, grain stores etc. It is good firewood and makes good charcoal.

n spite of its dense canopy, crops do well underneath which makes it a good agroforestry tree.

It also has medicinal uses (coughs, asthma, respiratory disorders (bark & fruits), ulcers, convulsions (bark) and fever (roots and fruits).
Bark and fruits contain 19% tannin and a yellow dye comes from its roots.

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Pawpaw - Carica papaya

Young pawpaw plantation, as a waiting crop for mango trees.

Common Names: Papai (Swahili), Pawpaw (English)

Carica papaya belongs to the family of the *Caricaceae*, originating from tropical America, but now grown all over the tropics.

Botanically, the pawpaw is a large herb, without wooden tissue, hence it is not a tree. It has a tendency to be dioecious, meaning that male and female flowers do not grow on the same plant. So the plant is either male or female. Male plants are completely unproductive but are needed for cross-pollination, at the rate of about one male plant to twenty female plants (the cross-pollination is done by insects and to a lesser extent, by wind and birds). However, new cultivars introduced in Kenya from Hawaii (e.g. "Solo", "Sunrise", "Wilder" etc), can be hermaphrodite, bearing bisexual flowers.

The plant grows very fast and may reach a height of 3-10m, but it is short-lived. In semi-arid areas without adequate irrigation, it doesn't last longer than two or three years. Normally, there is one stem, branching only when the terminal shoot is injured. Its leaves are big, with several lobes, usually produced at the top of the trunk, and last for about one year. Flowering starts after less than one year, and afterwards can continue year-round if climatic conditions allow. Male flowers are produced on long, hanging panicles (stalks) while female flowers are larger with shorter stalks.

Pawpaws are mostly eaten fresh when ripe, although green fruits may also be cooked and served as a vegetable. Other methods of processing are drying, canning and pickling. Pawpaws can also be used to

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produce papain, which contains an enzyme used as a meat tenderizer, or for clarifying beer. They may also be used for making wine.

Propagation

Pawpaw plants are usually produced by seed. They may also be produced through grafting or using root cuttings. Some farmers will graft female plants onto male ones to increase the number of productive trees. Each fruit has 300-700 seeds and there are approximately 20,000 seeds per kilogram. Seeds need to be washed to remove the gelatinous aril, and dried slightly. Fresh seeds should germinate within 2-3 weeks.

Environment

Pawpaws need a hot climate with optimum temperature between 26-30°C. The plant will not grow at temperatures below 10°C, and it is extremely sensitive to hail, which will tear the leaves to shreds. As with all fruit trees, it requires windbreaks as it cannot stand strong winds. Roots are sensitive to water logging and floods can kill the plants within a week.

Pawpaws require adequate rain, and evenly distributed annual precipitation of 1000-1500mm is ideal for its cultivation. Lack of moisture over a prolonged period will result in decreased growth and production.

Pawpaw can be grown in many types of soil provided they are well drained, fertile and rich in organic matter.

Mean annual temperature: 21-33° C,
Mean annual rainfall: 1,000-2,000mm
Soil type: Well-drained, permeable, well aerated, root-knot nematode free, fertile, loamy, preferably rich in organic matter with neutral reaction (pH 6-7) is ideal for papaya growth. Very acid soils are unsuitable and a pH range of 6-7 is considered best.

Establishment and maintenance

At a recommended planting distance of 2.5 x 3m, one hectare takes 1,333 plants. The planting holes need well-decomposed manure, and if possible, a handful of Superphosphate.

When using dioecious pawpaw strains, several seedlings (2-4) can be planted in the same pit, to be culled after about six months, when the male and female plants can be distinguished. Weeds must be controlled regularly during this period. Mulching to maintain soil moisture is required, and heavy mulch can help to control weed growth.

Pawpaw is a demanding crop when it comes to soil fertility, as it is fast-growing and needs an abundant supply of nutrients, both organic and inorganic, to become highly productive. Applications, particularly

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Improved pawpaw seeds are available on the market

of nitrogen and phosphorus, should be given at regular intervals. As a rough guideline, 500-800g of CAN (Calcium Ammonium Nitrate) given in two applications, and 400g of Triple Superphosphate per tree per year are recommended (Griesbach, 1992).

Pests and diseases (Griesbach, 1992).

Two insect pests are notorious in Kenya:

- Mites (among them, the red spider mites *Tetranychus*) occur during long dry spells. The mites are tiny (0.5mm) and puncture the plant tissue and make cob-like webs. The leaf surface is bleached with feeding punctures and the fruits are scarred and discoloured, greatly reducing their market value. When the attack is not severe, spraying sulphur controls the mite population, otherwise insecticides containing Abamectin or Diafenthurion will help.
- Thrips are small (1-2mm long) insects, also of the piercing-sucking kind. They puncture the leaf surface and suck the juice. Young infested leaves become distorted with a silvery colour and finally dry up.

Pawpaw diseases include the following fungi and viruses:

- *Phytophtora, Pythium, Fusarium and Rhizoctonia* are all soil-borne fungi which can attack roots and stems of plants and are associated with poor drainage. They create diseases such as damping-off, root and stem rot and wilt. Specific fungicides exist to deal with the fungi, but infected plants should be removed from the field and burned.
- *Colletotrichum* is another fungus that causes anthracnose and attacks the fruits and the leaf stalks. The first symptoms are small, round water-soaked areas on ripening portions of the fruit. The spots increase rapidly and the fruits start rotting. Control is preventive by spraying mancozeb or other fungicides.
- Black spot is caused by the fungus *Cercospora*, and infects leaves and fruits. The leaf spots are greyish-white, circular and turn black and corky when a fruit has been attacked. Again, yield can be seriously affected.
- Powdery mildew (*Oidium*) is found mainly on the underside of leaves where it develops a white, powdery growth. Severely infected leaves turn yellow and drop prematurely. Cool and cloudy weather favours the infection. Spraying with sulphur is effective.
- The Pawpaw Mosaic Virus is very destructive and plant losses up to 5-20% are common. A severe defoliation of leaves occurs, and younger leaves turn stunted and severely chlorotic. With a virus, once a plant is infected, it will always be infected. The virus is transmitted mechanically by insects and diseased trees are a source for further infection and need to be discarded.

Harvesting and yield

Usually it takes six months to flower and another five before fruit is ready for picking. In commercial orchards, the tree is cultivated for three to four years, after which it becomes too tall for economic harvesting and yields are reduced.

Harvesting is easy when the trees are small, but afterwards, a wooden or bamboo pole can be used. Depending on location, maintenance and cultivar, yields vary considerably between 25-150 fruits per year per tree.

Nutritional value of the fruits

The approximate content per 100g edible portion is water 86.6g, protein 0.5g, fat 0.3g, carbohydrates 12.1g, fibre 0.7g, ash 0.5 g, potassium 204mg, calcium 34mg, phosphorus 11mg, iron 1mg, sodium 3mg, vitamin A 450mg, vitamin C 74mg, thiamine 0.03mg, niacin 0.5mg and riboflavin 0.04mg. The energy value is 200 kJ/100g. Total sugar content is about 8.4-14%.

Yellow Passion Fruit

Fruits of the yellow passion, almost mature.

The botanical name is *Passiflora edulis var flavicarpa* and it belongs to the *Passifloraceae* family.

Introduction & description

Passion fruit is an evergreen, flowering vine from Brazil that climbs by tendrils. Its height and spread varies depending on the structure it climbs on. Passion fruits were introduced in the 1920s in Kenya for commercial growing. There are several species and varieties, of which the purple passion fruit (*Passiflora edulis var edulis)* has the biggest commercial potential. Most of the fruits are processed, but it is also eaten fresh.

The yellow passion is similar to the purple passion, but is more vigorous, more adapted to tropical lowlands and more drought resistant. The fruit pulp is very aromatic but rather acidic. The average fruit is slightly larger and turns from green to yellow at maturity. Ripe fruits drop from the vine.

The flower is a lovely purple and white and generally reaches a width of 2 to 4 inches. Each unique flower lasts about one day - it opens at noon and closes in the evening, which has consequences for pollination. The passion fruit is a round to oval berry, with a soft to firm, juicy interior filled with numerous seeds. The fruit is both eaten and juiced; passion fruit juice is often added to other fruit juices to enhance the aroma. It is quite tasty and is also served fresh. The evergreen leaves are cut deeply into three lobes with entire margins.

Environment

The purple passion is grown at altitudes of 1,500-2000m, while the yellow one prefers warmer, lower

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regions. Rainfall for purple passion is 900-1500mm Mean Annual Rainfall. The yellow variety requires less rain, although it might need irrigation in the dry season.
Passion fruits can grow in very diverse soil types, provided they are well drained and not too compacted. The plant also tolerates some salinity.

Propagation

Propagation is mainly by seeds, but also by vegetative means (cuttings or grafting). To obtain seeds, select the best fruits, extract the pulp and wash thoroughly in water to separate seeds from pulp. The seeds are then dried in the shade. They are sown in trays or seedbeds. They will be ready for transplanting in two and a half to three months.

Management & production (Griesbach, 1992)

Staking is essential and depends on the planting density. Spacing should be 2m between the rows and 3m in the row. Stakes should be placed every 6m, with a height of 2m above ground. The stakes should be treated poles, 10cm in diameter and 2.4m long, of which 40cm should be dug into the soil. A galvanized wire (12-14 gauge) should be attached to the top of the poles.

The structure needs to be strong to bear the weight of the plants and withstand the force of the winds. End posts should be secured with an anchor. Windbreaks would make for a well-protected orchard.
Planting should be done at the start of the rainy season, and manure added to the pit, as well as 200g of Superphosphate. Only two shoots of the young plants should be trained to reach the wire, supported by a temporary stick or a sisal rope. When they have reached the wire, they should be wound around the wire carefully, in opposite directions. No other shoots should be allowed to reach the wire and any that appear should be removed.

The two main shoots will continue to grow along the wire and will sooner or later produce secondary shoots and flowers. These shoots must be allowed to hang down freely. However, after they have produced their last fruit they must be pruned back to the main (horizontal) leader as closely as possible to stimulate new growth and fruiting.

Twice a year, always at the beginning of the rainy season, 150g of CAN (Calcium Ammonium Nitrate) per plant can be applied to maintain the productivity of the orchard.

The first fruits appear some eight to ten months after planting. This will go on for the next five years. Yield of purple passion can be up to 13 tonnes per hectare or even higher, but it starts to decline after three years. The harvesting peaks coincide with the rainy seasons, two per year.

Pests & diseases (Griesbach, 1992)

Aphids are an important pest because they are vectors of the passion fruit woodliness virus.
Stink bugs suck on terminal shoots which will eventually wither and die. Attacked fruits develop dark, depressed spots which become hardened.

Woodliness virus is transmitted by mechanical tools (secateurs!) and aphids. Affected leaves become stunted, curled and discoloured, while the fruits are often under-sized, misshapen, hard and dry.
Root rot is caused by various soil-borne fungi. Affected plants decline in vigour, develop discoloration of leaves and the whole plant may eventually die. The purple passion is far more susceptible to this than the yellow one. To produce purple passion resistant to this disease, its cuttings are grafted upon yellow passion rootstock.

The Mango Tree

Young tree (6-7 years old) in fruit.

The botanical name is *Mangifera indica* and it belongs to the Anacardiaceae family.

Introduction & description

Everybody knows mangoes so there is no need to go deep into their description. Be it sufficient to say that it is one of the most important fruit trees in the world, and that the species originates in South-East Asia from where it was introduced in Africa some hundreds of years ago. There exist hundreds of varieties, usually multiplied by grafting on selected rootstock. The most important in Kenya include Apple, Ngowe, Keit, Tommy Atkin and Van Dyke, to name but a few.

Environment

For Eastern Province, the most commercial variety is Apple, which is very appreciated in the local market, as well as exported. It has to be grafted on good rootstock, for which the local non-grafted mango trees well qualify. Mango trees do best on light soils (red soils) though they will survive on clay. The Apple variety is adapted to high temperatures, but needs sufficient water for high yields.

Management & production

Spacing is preferably between 7 and 8m, to allow for plenty of sunlight. This makes for an individual area of around 50-56m2, and allows for instance for line planting of 6m in the row, and 8-9m between the rows (for easy access when harvesting).

Pruning is required to stimulate fruiting, as flowers only grow on new shoots. Mango branches multiply into multiple shoots, which have to be culled to a maximum of three shoots per branch. Another guideline is to remove “wild” branches that shoot straight out of an older branch, and in general to open up the crown to let the sunlight penetrate inside the tree’s

Notes

canopy (it is also good for phytosanitary measures as spraying reaches the inside of the tree). Pruning can be heavy to keep the tree short, for easy harvesting (no climbing required).

Pruning has to take place immediately after harvesting. The harvesting period for “Apple” varies according to the area, like Oct-Jan in the Kibwezi area, and (Jan)-Feb-Mar around Wote and Machakos.

Water requirements: the rainfall condition of Seven Forks, with 700-800 mm Mean Annual Rainfall, is not sufficient for good fruiting of the trees. Additional watering is required notably upon flowering to avoid abortion of fruits and getting big mangoes. This has to take place during the dry months of May-Jun-Jul-Aug-Sep and eventually Oct. Towards the months of Aug-Oct, a fully bearing tree needs at least some 300 liter of water per week, applied in a basin matching the canopy of the tree. Unfortunately most of this water is lost to the tree as it immediately percolates down through the sand to deeper layers of the soil. Limiting loss of water can be done in two ways: use of organic matter (see “fertilizing”) and mulch, to avoid drying out of the soil by sunlight. Any vegetable material (leaves, grass, branches…) can be used for mulching, though it is slowly consumed by termites and will have to be renewed. Some growers prefer clean soil around their trees because mulch can harbour pests & diseases (insects and fungi).

Mango trees in an orchard after pruning, in the month of February. Note the use of the pruned branches as mulch.

Fertilizing: organic fertiliser like manure is strongly recommended because organic matter absorbs and fixes water the way inorganic fertiliser (NPK) cannot. Nevertheless, some superphosphate or NPK can be given (like a kg per tree).

Yield is considered medium for Apple, which starts as early as year 3, reaches a peak by year 8 and

decreases after year 15, and by 20-25 years the tree can be replaced. At its peak, and with sufficient water and fertiliser, but depending on the size of the tree, an individual tree can bear some 300 fruits. Big fruits weigh around 0.3kg, and smaller ones down to 0.2kg. This translates into 60-90kg per tree (or alternatively 3 to 5 fruits per kg).

Pests & diseases

Mealy bugs: Whitish insects, usually in groups, and a serious pest, difficult to get rid of. Standard insecticides apply.

Mango gall midge: An insect that during feeding forms galls on the leaves that look like pimples. Serious outbreaks lead to defoliation and reduced fruit yield. Can be combated with insecticides.

Fruit flies: A biological solution, fly traps, is now commonly available, where female flies are attracted into a plastic container where they get killed by a toxic element.

Thrips: These insects can seriously affect the leaves, resulting in important leaf loss of the trees. Neem oil is effective, cheaper than chemical insecticides and it can be prepared by the growers themselves (grind seed kernels, place them in a bowl covered with water during 48hrs, mix with liquid soap as a sticker, shake and spray).

Powdery mildew: A fungus, notably present during the cold spell in Jun-Jul, attacking flowers and destroying them. The whole crop can be wiped out. Good but expensive fungicides available on the market.

Anthracnose: A fungus that attacks both leaves and fruits, that can be battled with chemicals based on copper, like Copperoxychloride or Mancozeb.

Markets:

Apple mangoes have a shelf life of some ten days, allowing for transport and storage time. Local sales prices depend much on the period and the location, and it is safe to say that one mango goes for 5-10sh, occasionally reaching 15sh.

Frequently Asked Questions

1. Should I plant the tree seedlings with the plastic still on?
No. The plastic will constrain the roots of the seedlings leading to deformity or even death.

2. Should I plant in a deep pit to allow for more water retention?
For Melia volkensii, you should not. For the rest of the seedlings, this is o.k.

3. During the dry season, what is the minimum water requirements for the seedlings?
5 liters per week, or 10 liters if possible.

4. Can we water the seedlings using water from a sand river?
Yes, but you have to be careful that the water is not salty.

5. Is livestock a threat to the seedlings?
Yes, especially goats as these are voracious browsers.

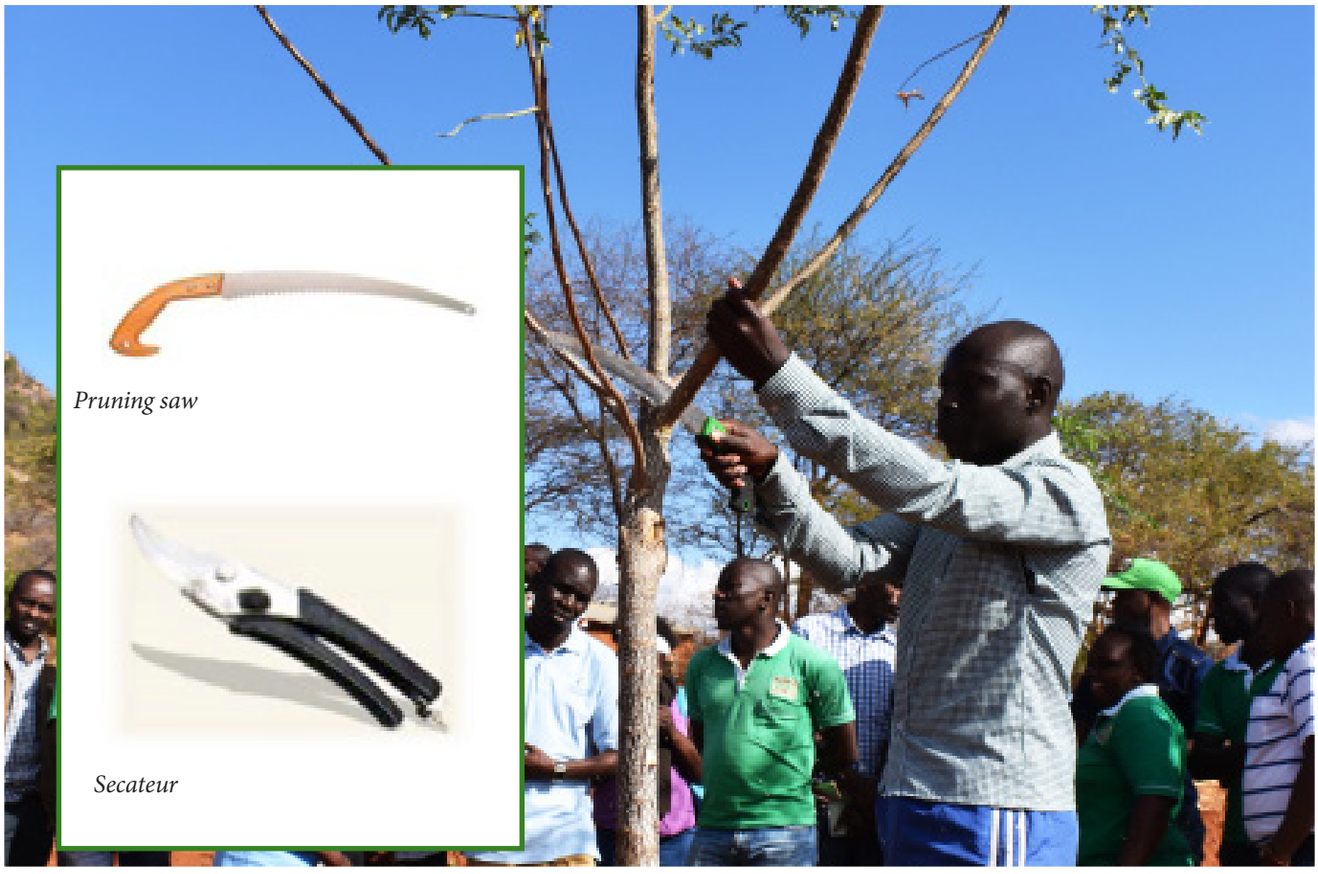
6. How do I handle threats from livestock?
Fencing is good, but good neighborliness is critical for the survival of the seedlings.

7. What is the purpose of mulching?
Mulching is necessary to protect the tree seedling from the sun and the hot top soil as this heat can damage the roots. It's also necessary for conserving soil moisture.

8. How do I ensure the correct spacing for the tree seedlings?
The general spacing requirements is 3M X 3M or even 4M so as to allow the roots to have space to grow.

9. Do the tree seedlings compete with other crops?
Yes they do.

Pruning Instructions



Main objectives:

- Main objective: producing a clean bole of min 5m long with 10cm DBH by year 4. All pruning scars must be inside this inner core of 10cm diameter
- Secondary objective: produce a stout, fat stem for the young seedling (1-2 years) that is NOT top-heavy and that does not bend over through a gust of wind

Instructions:

- Year one: no pruning, except for removing double leaders and whorls
- Year two: pruning after rains (May/Jun and Nov/Dec)
- Year three: 2-4 passages
- Year four: 2-4 passages

Rule Of Three

1. No double leaders
2. No whorls
3. No branches over 2cm

Notes:

- Branches are removed selectively with the biggest ones (2.0cm) going and the smaller ones staying. This goes also for whorls.
- Take care to leave branches along the stem to allow for increased diameter growth so that the stem gets stronger and will not bend easily in the event of strong winds i.e DO NOT REMOVE BRANCHES LESS THAN 2.0 CM
- This is NOT the cleaning of the stem of branches like in the case of pine or cypress trees.
- Special attention to reduce branch density towards the TOP of the tree.
- Remove branches with secateur when small less than 2cm or with pruning saw when bigger (max diameter 2.0cm)
- For trees taller than 2 meters, an aluminum ladder (3 meters) is used to access the branches to be pruned or an extended handle pruning saw.
- Two people use one ladder; one person holds down the ladder while the other does the pruning.
- Pruning with a pruning saw should be done carefully to prevent tearing of the bark.

Proper pruning:	**Improper pruning:**
1. Under cut	4. Stub too long—improper cut
2. Upper cut to remove branch	5. Split below stub—injury to stem
3. Final cut	

Some cheap and effective water harvesting techniques

This information captures
- Roof catchments
- Road catchments
- Contour ditches on farm land

Roof catchments

First we'll go into roof catchments. They have an enormous potential, both in urban and rural areas, for alleviating water shortages brought about by erratic rainfall. This overview aims at showing the potential, while technical details of actually building the required fittings and storage tanks, are not dealt with here. These need the services of a competent fundi, with special attention to construction of the gutters and a splash-guard to guide the water running from the roof into the gutters.

Consider a house in a suburb of Nairobi, with a roof area of medium dimensions of 15m x 30m, which makes a total of 450m2. The roof of this house is the catchment or harvesting area. Let's hope the design of the roof is not too complicated, allowing for simple construction of gutters and a rainwater pipe leading to a water storage tank. (Kenyan roof architecture has a tendency towards several little roofs on different levels, which is fine for aesthetic reasons

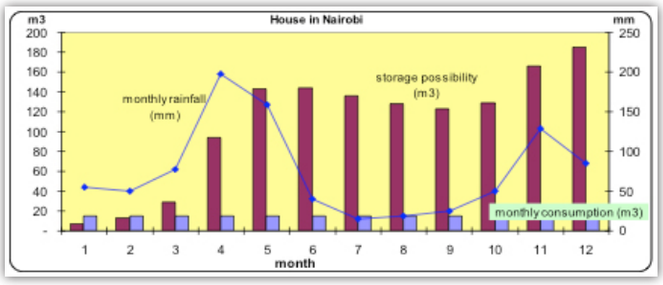
Roof catchment for Primary School in Eastern Mwingi.

but not helpful for rainwater collection.)
Average annual rainfall for Nairobi is about 900mm, of which 250mm falls in October-November-December, and 400mm in March-April-May (see graph).

1mm of rain on 1m² of surface is equal to 1 litre of water

The relationship between rainfall and litres of water is very simple:

In our example, that results in:
400 litres x 450m² = 180,000 litres or 180m³ of water for the March-May rains, and
250 litres x 450m² = 112,500 litres or 112.5m³ of water for the October-December rains.



Total for those months: 292,500 litres or 292m³.
We allow for 10% losses due to splash, evaporation, leaking gutters and rainwater pipes:
292m³ minus 10% or approximately 30m3 = 262m³.

Now, this is enormous. Suppose that a family of six people lives in the house, with a fairly high water consumption, say 500 litres per day. That makes for a monthly consumption of 15m³, and an annual consumption of 180m³. This is easily covered by the water harvested, and even leaves a balance of 262m³ – 180m3 = 82m³, that can be sold or used for irrigating a vegetable garden (see graph).
Let's take another example; a house in a semi-arid place like Mwingi town, with a simple mabati roof of 10m x 20m (200m²).
We do the same calculation as above.
Average annual rainfall: 770mm, with 350mm concentrated in November-December and 200mm in April-May.
Potential water collection is then respectively:
350 litres x 200m² = 70m³ for November-December and
200 litres x 200m² = 40m³ for April-May.
Total: 110m³ (110,000 litres of water).
Again we allow for a loss of 10% or 11m³. This leaves 99m³.
A family of six with a smaller water consumption (put at 200 litres per day) will use on a monthly basis 6,000 litres or 6m³. Yearly consumption is 72m³ and balance is 27m3 (see graph).

As we can see, the water is there, and it is for free, but it has to be captured and stored, for which an initial investment is needed plus some small annual maintenance costs (e.g. repair of gutters).

What are the options? First, the tank has to be big enough for capturing the water when it rains, and for storing a surplus to ensure availability during the long dry season. This means for Nairobi a tank with a capacity of at least 75m^3 (five dry months during May-September x 15m^3/month). For the Mwingi example, this means a capacity of minimum 50m^3 (to capture the November-December rains). Secondly, it has to be affordable.

There is an extensive range of tanks and reservoirs for storing water. Best known in Kenya are the plastic ones for small storage capacities (up to 20m^3), and the masonry and concrete ones for bigger capacities. Some companies offer tanks made of galvanized iron sheets with a plastic liner inside with a maximum capacity of 100m^3.

Road catchments

Roads collect sizeable amounts of water during even a light shower, due to their generally impermeable surfaces. This is valid for both tarmac and earth roads, and orderly collection of this water is often a problem, as shown by erosion of earth roads, and by accumulation of water on tarmac roads. Well-constructed roads should be a bit higher in the middle, to stimulate good run-off and drainage of the water, meaning that water is directed towards one side of the road where it accumulates into a ditch. Earth roads are not that level and water can flow into any direction.

A simple calculation brings to light the quantities of rainwater we are talking about. Take the example of a 3-metre wide country earth road. The same formula as above applies (1mm of rainfall is equivalent to 1 litre of water per square metre). Suppose there is a rainfall of 20mm during a couple of hours, on a stretch of a sloping 300-m long road. We factor in a loss of 20%, for run-off efficiency.

Amount of water then is:
20mmx300mx3mx0.8 = 14,400 litres or 14.4m^3.

In the countryside, earth roads are mostly surrounded by fields or fallow land, to which the rainwater can be channelled. Although people use run-off from tarmac roads for drinking, this is not advisable because the water can be contaminated. It is safer to use it for irrigation. However, if it is boiled or exposed to ultra-violet light from the sun it will be disinfected, which takes care of bacteria but not of contaminants like oil residues.

Harvesting water from a road can be tricky because erosion needs to be avoided. A simple channel with a slight slope can guide the water towards a pond excavated for the purpose or a system of trenches in a field.

Uses of this rainwater in a rural context:

- Tree nurseries, extra watering of woodlots and orchards
- Manufacturing of bricks and other building materials
- Sale of water to neighbours
- Raising ducks, geese, etc.
- Irrigation of fields

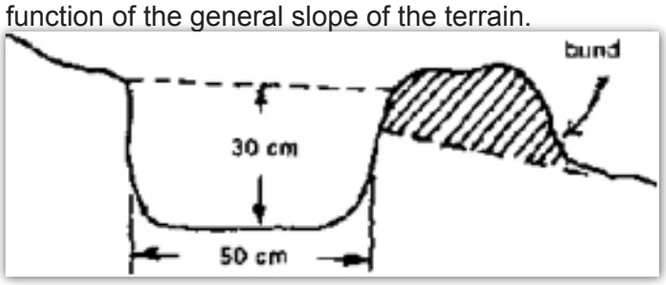
Contour ditches dug in fields

This is more formally included in what is called “Soil & Water Conservation”, as practised by the Ministry of Agriculture. The central element of the exercise is correct establishment of contour lines. Contour lines are made is such a way that they run across a slope at the same height, without running up or down, because that would increase the risk of erosion. The ditches are used to intercept water running down the hill. The water stays in the ditch and gradually infiltrates the soil, where it slowly sinks in and can be used to dramatically stimulate crop growth.

“Fanya chini” divided in compartments, after rainfall, in a mango orchard (Kibwezi)

“Fanya Juu” terracing in Makueni County, on areas with steeper slopes.

The ditch is made 30-40cm deep and 50cm wide. It can be divided into separate sections to trap water more effectively, by leaving “a bridge” of soil (see photo). The spacing between contour lines is function of the general slope of the terrain.



Contour lines can be made with different instruments, like an A-frame (pictured).

The A-frame is a simple device for laying out contour lines across the slope. It is made of a carpenter’s level and three wooden poles nailed together in the shape of a capital letter A with a base of about 90 cm. The carpenter’s level is mounted on the crossbar, or a stone is suspended on a piece of rope that has to align with a mark in the middle of the crossbar, to To mark the contour line, one leg of the A-frame is planted on the ground; then the other leg is swung until the carpenter’s level (or the stone) shows that both legs are touching the ground on the same level. A helper drives a stake beside the A-frame’s rear (first) leg. The same level-finding process is repeated with stakes every 5-metre distance until a complete line is laid out.
There are other instruments for making contour lines, for example, “O rings” or “water levels”.
There are also other soil conservation and water harvesting methods, like half-moon micro-catchments and zai-pits or planting pits.

The following calculation gives an idea of the water that can be harvested on one hectare of land (10,000m^2 which is 2.5 acres) during a period of one year:

Parameter	Quantity	Remarks
Main Annual Rainfall (mm)	597	BGF’s data over 6 years
MAR/ha (ltr)	5,970,000	At 1mm ~ 1ltr per m^2.
Run-off coeffi-cient in %	30	For cultivated land, flat, and sandy loam
Captured run-off in ltr/ha/yr	1,791,000	This is 1,791 cubic meters

The run-off coefficient gives the percentage of water that runs off the surface of the land, instead of infiltrating the soil. It depends on several variables, like the state of the land (cultivated, vegetation cover, the slope and the soil texture).

A system of ditches will not only help in harvesting rain water, but also limit soil erosion and in fact conserve the fertility of the land

Written/compiled by Jan Vandenabeele, Executive Director, Better Globe Forestry Ltd”.
Photos: Better Globe Forestry Ltd and/or Jan Vandenabeele; KenGen Foundation and/or Ernest Nyamasyo
Design & Layout by Ernest Nyamasyo

The Green Initiative Challenge

The Green Initiative Challenge (GIC) is a KenGen Foundation, Better Globe Forestry, and Bamburi Cement afforestation program designed to encourageand enable schools to participate in environment activities by developing small forests and woodlots within their compounds for multiple benefits.

Through the GIC programme, KenGen Foundation and partners work together with schools around the 7-Forks power stations to raise environmental awareness and create an involvement of schools and students in improving their environment through a participatory and rewarding initiative.

Project partners:

KenGen Foundation
Touching lives, enabling communities

KenGen
Energy for the nation

Better Globe Forestry
Prosperity With Purpose

Bamburi cement
Part of you. From the start

Support partners:

REPUBLIC OF KENYA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

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KENYA Forest Service

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