

ACLA COURSE STUDY GUIDE

Tree Planting & Reforestation
Technology

From seed to surviving forest: the science, nursery practice, planting technology and monitoring behind successful tree planting in African landscapes.

Grace Wanjiru Njoroge · Intermediate

4 modules · 20 lessons · 5 weeks

AFRICA CLIMATE LEADERSHIP ACADEMY

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About This Course

Tree planting looks simple — dig a hole, plant a seedling. Yet across Africa, poorly planned planting projects routinely lose more than half their trees within three years. This course teaches the technology and science that separate thriving forests from failed plantations: how trees interact with climate, water and soil; how to run a nursery that produces vigorous seedlings; how to match species to site and use modern tools from GIS mapping to drone seeding; and how to monitor survival, engage communities and connect restoration to carbon finance. Built around African restoration movements — the Great Green Wall, AFR100 and Farmer Managed Natural Regeneration — it turns good intentions into trees that actually survive.

Course information

Course	Tree Planting & Reforestation Technology
Instructor	Grace Wanjiru Njoroge
Level	Intermediate
Structure	4 modules · 20 lessons · 5 weeks
Assessment	Module quizzes (pass mark 60%) and a final test (pass mark 80%). Certificate issued on final success, verifiable at acla.io/verify .

What you will be able to do

1. Explain how trees regulate carbon, water and biodiversity, and why species-site matching decides survival.
2. Run a tree nursery: collect and store seed, propagate seedlings, harden them and apply quality standards.
3. Plan and execute planting with modern technology — GIS site assessment, planting techniques, drones and direct seeding.
4. Monitor survival with field and remote-sensing methods, engage communities and access restoration finance.

How to use this study guide

This guide is the complete companion to the Tapi Learn mobile course. Each chapter corresponds to one course module and reproduces every lesson in full, including the key takeaways. Read a lesson in the app, then revisit the same text here to revise; the structure and headings match the in-app lesson reader. After finishing a module, take the module quiz in the app (60% to pass), and after all modules, the final test (80% to pass) to earn your verified ACLA certificate of completion.

Module 1: The Science of Trees & Forest Ecosystems

Why trees succeed or fail starts long before planting — in ecology. This module covers what trees do for climate, water and soil, and how African forest landscapes actually work.

5 lessons · 14m

1.1 What Trees Actually Do: Carbon, Water and Climate

The multiple jobs of a single tree

A standing tree is a piece of climate infrastructure. Through photosynthesis it absorbs carbon dioxide and stores the carbon in wood, roots and soil — a mature tropical tree can hold roughly a quarter of a tonne of carbon in its trunk alone, and the soil beneath intact forest holds even more. Through transpiration it pumps moisture from soil to atmosphere: a large tree can move hundreds of litres of water on a hot day, cooling the air and seeding clouds. Through its canopy it shades soil, moderates temperature extremes, and breaks the force of raindrops so water infiltrates instead of running off.

Four ecosystem services that matter for restoration design

- **Carbon sequestration.** Different species and systems store very different amounts. Fast-growing plantation species accumulate quickly but often store less long-term than diverse natural forest; agroforestry trees store less per hectare but cover vastly more area when integrated into farmland.
- **Water regulation.** Forested catchments moderate floods in the wet season and sustain base flows in the dry season. On hillsides, tree roots stabilize slopes and reduce landslide risk.
- **Soil restoration.** Leguminous trees fix nitrogen; deep-rooted trees pump nutrients up from below the crop root zone; leaf litter rebuilds organic matter and soil life.
- **Biodiversity and livelihoods.** Trees provide fruit, fodder, fuelwood, medicine and habitat — the "co-benefits" that make restoration economically survivable for rural communities.

A tree that stores carbon but provides nothing to the community that tends it will not be tended for long.

Why this science drives planting decisions

Ecology sets the constraints for every later technical choice in this course. Species choice determines growth rate, carbon storage, water use and products. Spacing determines whether trees compete or complement each other. Mismatching any of these to the site is the root cause of most planting failures — a eucalyptus planted on a dry hillside may grow fast elsewhere but will drink the water table dry; a thirsty species near a seasonal stream can desiccate it.

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Key takeaways

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✓ Trees deliver four core services: carbon storage, water regulation, soil restoration, and biodiversity/livelihoods.

✓ Species-site mismatch — not poor planting — is the deepest cause of tree mortality.

✓ Restoration design must balance carbon goals with community benefits to survive socially as well as biologically.

1.2 Forest Ecology Essentials for Planters

Succession: forests build themselves in stages

Ecological succession is the sequence by which bare ground becomes forest: pioneer grasses and herbs arrive first, then pioneer trees (fast-growing, sun-loving, short-lived), which create shade and litter that allow longer-lived climax species to establish. A planter who fights this sequence — planting slow-growing climax species into bare, exposed ground — often loses. Working with succession means using pioneers as "nurses" for the species you ultimately want.

The three growth forms you will handle

- **Pioneer species** — grow fast in full sun, live short (e.g. *Markhamia*, *Trema*, *Sesbania*). They quickly shade out grass competition.
- **Climax/late-successional species** — slow growing, shade tolerant, dense wood, high value (e.g. *Prunus africana*, mahoganies, *Milicia excelsa*).
- **Intermediate/generalist species** — flexible, often fruit or fodder trees that perform across conditions (e.g. *Grevillea robusta*, *Faidherbia albida*).

Niches: why forests are layered

A natural forest has vertical layers — canopy, sub-canopy, shrub layer, ground layer — and root systems that occupy different soil depths. Planting one species at one spacing ignores these layers; mixed plantations that combine a tall canopy species with an under-storey fruit tree use sunlight, water and nutrients more completely and resist pests better. Diversity is not decoration; it is risk management.

Facilitation and competition

Trees interact underground through fungal networks (mycorrhizae) that trade nutrients and carbon between species, and through root competition for water. Dense grass competition — especially from invasive grasses like *Chromolaena* — is the single biggest early killer of planted seedlings in African savanna restoration, which is why site preparation (Module 3) focuses so heavily on grass control.

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Key takeaways

✓ *

- ✓ Succession works in stages; use fast pioneers to prepare conditions for valuable climax species.
- ✓ Mixed, layered plantings use resources better and carry less pest and disease risk than monocultures.
- ✓ Grass competition is the leading early killer of seedlings — plan for it.

1.3 Reading the Site: Climate, Soil and Water

The five site factors that decide species choice

1. **Rainfall** — annual total, but more importantly its *reliability and season length*. A 700 mm zone with a dependable 6-month wet season suits different species than a 700 mm zone with erratic 3-month rains.
2. **Soil** — texture (sand/silt/clay), depth, drainage, pH, salinity and fertility. Compacted or waterlogged soils kill trees that would thrive metres away.
3. **Water table and drainage** — seasonal waterlogging suits species like *Balanites*; others rot in the same spot.
4. **Aspect and slope** — in the tropics, slope affects soil depth and moisture more than sun angle; valley bottoms stay wetter than upper slopes.
5. **Existing vegetation** — the weeds, grasses and remnant trees tell you more about the real site conditions than any instrument: what already grows well, grows well for a reason.

Simple field tests every planter should know

- **Ribbon test for texture:** moisten a handful of soil and try to roll it into a ribbon. Long ribbon = clay; none = sand; intermediate = loam.
- **Infiltration test:** pour water into a ring 10 cm across and time how long it takes to drain. Slow infiltration on a planting site means roots will sit in water during storms — and drought-stress anyway in the dry season if the water runs off rather than in.
- **pH kit or probe:** extreme acidity (below 4.5) or salinity will exclude whole species groups; both are common in semi-arid valley soils.

Climate matching beyond the planting site

The old rule "plant what grew there before" is being rewritten by climate change: rainfall zones are shifting, and a species that thrived on a site in 1990 may fail there by 2040. Modern practice seeds trees from slightly warmer, drier provenances so the planting is pre-adapted to the climate it will grow old in — a technique called *assisted gene flow*.

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Key takeaways

✓ *

✓ Five factors — rainfall pattern, soil, water table, slope, existing vegetation — determine species choice.

✓ Simple field tests (ribbon, infiltration, pH) cost nothing and prevent expensive failures.

✓ Under climate change, collect seed from slightly warmer/drier provenances than the planting site.

1.4 African Forest Landscapes and Where Your Trees Fit

Africa's restoration opportunity

Africa holds the world's largest restoration opportunity — an estimated 700+ million hectares of degraded land considered suitable for mosaic restoration (mixes of forests, woodlands, grasslands and farms). The continent's flagship commitments — **AFR100** (the African Forest Landscape Restoration Initiative, restoring 100 million hectares by 2030) and the **Great Green Wall** across the Sahel — create real funding and institutional pathways for local tree planting projects to plug into.

The major landscape types you may work in

- **Humid forests (Congo basin, West African coast):** high rainfall, aggressive weed growth, valuable hardwoods; restoration mostly means enriching degraded forest or establishing community forestry.
- **Miombo woodlands (south-central Africa):** Brachystegia-dominated dry forests; strongly seasonal; best restored through natural regeneration protection and enrichment planting.
- **Savanna parklands (Sahel, East Africa):** trees scattered across farmland — *Faidherbia*, *Balanites*, baobabs; here "reforestation" mostly means agroforestry and farmer managed natural regeneration (FMNR).
- **Afromontane forests (highlands):** water tower catchments; high value for downstream cities; species like *Podocarpus* and *Juniperus*.
- **Mangroves (coasts):** specialized tidal planting with its own techniques and enormous carbon value.

Matching your project to the landscape

A tree planting project succeeds when it picks the right *intervention* for the landscape: in a dry savanna, protecting natural regeneration costs 10–20× less and survives better than planting; in a humid degraded site, enrichment planting works; in farmland, agroforestry species that produce food and fodder beat conservation plantations. Technology follows purpose.

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Key takeaways

✓ *

✓ Africa's restoration commitments (AFR100, Great Green Wall) provide funding and policy pathways for local projects.

✓ Each landscape type — humid forest, miombo, savanna parkland, afro-montane, mangrove — calls for a different intervention.

✓ In drylands, assisted natural regeneration often beats planting on both cost and survival.

1.5 Choosing Species: A Practical Framework

Purpose first, site second, species third

Species selection fails when it starts with a species ("we have grevillea seedlings") instead of a purpose and a site. The correct order: define the objective (fruit? fuelwood? timber? catchment protection? carbon?), confirm the site factors, then filter species.

The species filter checklist

A candidate species must pass **all** of these:

- **Ecological fit:** rainfall range, soil tolerance, drought behaviour match the site; provenance from a comparable or slightly harsher climate.
- **Purpose fit:** it actually delivers the intended product or service at a useful rate.
- **Non-invasiveness:** it does not escape and invade (a fatal flaw of several introduced plantation species).
- **Availability:** seed or seedlings can be obtained in quantity, legally, at realistic cost.
- **Community acceptance:** local people know it, value it, or can be convinced of its value.

Indigenous vs exotic — a practical, not ideological, choice

Indigenous species are usually better adapted, support more biodiversity, and carry fewer pest risks, but their seed handling and nursery requirements are often poorly documented. Exotics like **Grevillea robusta** or **Gmelina** have well-understood silviculture and fast early growth but can disappoint long-term (poor firewood, weak biodiversity value) and a few have become invasive. Best practice in African community planting: a majority indigenous mix with a minority of well-tested multipurpose exotics.

High-performing African multipurpose species worth knowing

- ****Faidherbia albida**** — the "fertilizer tree": sheds leaves in the wet season (so it doesn't shade crops), fixes nitrogen, pods feed livestock.
- ****Vitellaria paradoxa**** (shea) — carbon, fruit, and the shea butter economy in one tree.
- ****Baobab**** (*Adansonia*) — food, fibre, water storage, cultural keystone.

- ***Markhamia lutea*** and ***Warburgia ugandensis*** — fast indigenous timber/medicine trees for humid highlands.
- ***Acacia senegal*** — gum arabic income on Sahelian degraded land.

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Key takeaways

- ✓ *
- ✓ Select in the order purpose → site → species, never seedling-first.
- ✓ Every species must pass the five-point filter: ecological fit, purpose fit, non-invasiveness, availability, community acceptance.
- ✓ Favour a mostly indigenous mix with a few proven multipurpose exotics.

Module 2: Nursery Establishment & Seedling Production

Every successful plantation begins months before planting, in the nursery. This module covers seed collection, nursery design, propagation and the hardening-off that decides field survival.

5 lessons · 15m

2.1 Seed Collection, Processing and Storage

Seed quality is genetic quality

The seed you collect determines the ceiling of everything that follows. Collect from **phenotypically superior parent trees** — straight trunks, healthy crowns, good fruiting — that are not isolated (isolated trees give inbred seed). Collect from at least 25–30 unrelated mother trees to keep genetic diversity, and label every collection with species, location, date and mother tree.

Reading seed behaviour

- **Orthodox seeds** (most acacias, grevillea, markhamia) tolerate drying and cold storage — the easy majority.
- **Recalcitrant seeds** (many tropical hardwoods like shea, and most figs) die if dried; they must be planted fresh within days.
- **Dormancy** is common and broken by specific pre-treatment: **hot water soaking** (pour just-boiled water over acacia seed, soak overnight) for physical dormancy; **scarification** (nicking the coat) for hard seeds; **cold stratification** rarely needed in the tropics.

Processing and storing

Clean seed of pulp (ferment soft fruit briefly, wash, dry in shade), winnow away empty seed, and cut-test a sample to estimate the filled fraction. Store orthodox seed in sealed containers with a desiccant, cool and dark; a simple rule — **temperature in °C plus relative humidity in % should stay below 100** (e.g. 15°C + 60% RH is safe; 30°C + 80% is not).

Germination testing

Before sowing the main batch, germinate 100 seeds on moist paper. Germination percentage × filled-seed fraction tells you how much seed you actually need — the difference between a 95% and a 40% lot is the difference between meeting and missing your planting target.

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Key takeaways

- ✓ *
- ✓ Collect from many (25+) superior, non-isolated mother trees and label everything.
- ✓ Know whether seed is orthodox or recalcitrant before you plan storage; recalcitrant seed must be sown fresh.
- ✓ Run a germination test on every lot before committing nursery space.

2.2 Designing a Working Nursery

Match the nursery to the mission

A backyard nursery producing 5,000 seedlings needs shade, water and a fence. A community nursery producing 100,000 needs layout, logistics and labour planning. Decide the target (species mix, numbers, planting date), then work backwards — African nurseries typically plan **8–12 months ahead** of planting season.

The six essential zones

1. **Seed store:** cool, sealed, rodent-proof.
2. **Germination beds/boxes:** close-planted seed raised under fine shade until prick-out.
3. **Pricking-out and potting area:** a waist-height table transforms daily work speed and quality versus ground-level work.
4. **Seedling stands:** raised benches or graded ground, arranged so every seedling gets light — beds about 1 m wide allow reaching the middle without stepping on plants.
5. **Shade structure:** lath, grass matting or shade net at 50–70% shade for young stock, progressively removed.
6. **Water and compost:** a tank or reliable source, and a compost pile — buying seedling media is rarely viable at scale.

Root control: the technology most nurseries get wrong

A seedling with a deformed root system is a tree doomed years later — **root coiling** in the pot produces trees that snap in wind at 8 years old even though they looked perfect at planting. Modern nurseries use:

- **Containers with vertical root ribs and air-pruning holes** (e.g. lay-flat tubes, "book" systems) that train roots downward instead of circling.
- **Root trainers / deep cells:** one seedling per cell with internal ribs; more expensive per unit but dramatically better root architecture.
- **Under-cutting / root wrenching:** periodically slicing beneath beds or wrenching seedlings loose to prune taproot tips and stimulate fibrous roots.

Watering discipline

Water deeply, then let the surface dry — constant shallow watering breeds surface roots and disease. Morning watering beats evening (leaves dry, less fungal infection). In the last weeks before planting, water less — that is hardening-off, covered later in this module.

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Key takeaways

- ✓ *
- ✓ Plan nurseries 8–12 months before the planting date.
- ✓ Root-pruning containers or wrenching prevent the fatal hidden defect of coiled roots.
- ✓ Water deeply and intermittently, in the morning, not constantly.

2.3 Propagation: From Sowing to Vegetative Methods

Sowing and pricking out

Sow germinated or pre-treated seed densely in germination boxes at a depth of roughly twice the seed's diameter. At the two-leaf (cotyledon) or first true-leaf stage, **prick out** seedlings into individual containers — handle by the leaves, never the stem, and never squeeze the stem; crush damage invites damping-off disease. Water in immediately and hold under heavier shade for a week while roots recover.

Vegetative propagation — when and why

Some species seed poorly or vary too much; elite clones multiply only vegetatively:

- **Stem cuttings:** strike semi-hardwood cuttings with a node into free-draining media under mist or humidity cover; rooting hormone (IBA) speeds difficult species. *Warburgia* and many fruit species root this way.
- **Air layering (marcottage):** girdle a branch, wrap with moist medium until roots form, then cut and plant — used for difficult-to-root fruit trees like some mango and guava cultivars.

- **Grafting:** the standard for fruit species — a stem (scion) of a proven variety joined onto a vigorous rootstock. Grafting turns a 7-year wait for fruit into 3. Every community nursery that includes fruit trees should master wedge and side-veneer grafts.
- **Live stakes:** some species (*Gliricidia*, *Erythrina*, figs) regrow from cut metre-stakes pushed into moist soil at the start of rains — zero-nursery propagation used widely in agroforestry.

Media and hygiene

A good potting medium drains freely yet holds moisture: common recipes mix forest topsoil, compost and sand, or use composted bark/coffee husk with sand. **Hygiene is the nursery's invisible technology:** sterilize media with solarization (moist media under clear plastic in full sun for weeks), clean benches, and never reuse unsterilized containers — damping-off (*Fusarium*, *Pythium*) is the top seedling killer and travels in dirty trays.

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Key takeaways

- ✓ *
- ✓ Prick out at the first true leaf, handling seedlings by leaves only.
- ✓ Cuttings, grafting and live stakes let you multiply elite plants and fruit varieties.
- ✓ Sterilize media and containers — damping-off fungi are the main seedling killer.

2.4 Seedling Care, Grading and Hardening Off

Daily nursery culture

Consistent small actions — watering, shade adjustment, weeding containers, rotating stands — produce uniform stock. Watch for the early warnings: yellow lower leaves (nitrogen hunger), purple tinge (phosphorus or cold), white crust (saline water), webbing (mites). A weekly nursery walk with a checklist catches problems while they are still cheap.

Grading: cull ruthlessly

Before hardening, grade the crop and discard any seedling that is: root-collapsed or coiled, stem-damaged, diseased, or more than ~30% off the mean height. Planting weak stock wastes field costs on trees that were already dead. A nursery that plants only its best 85% beats one that plants 100% of mixed quality — the field survivors tell the story.

Hardening off — the survival technology

A lush nursery seedling is a greenhouse child. **Hardening** progressively converts it into a field-ready plant:

- **Reduce shade** stepwise to full sun over 2–4 weeks (leaves thicken, cuticles wax).

- **Reduce watering** frequency — mild stress trains stomata to close efficiently and roots to explore the whole root ball.
- **Stop fertilizing** (especially nitrogen) — lush soft growth is the first to die in the field.
- Optionally apply a mild potassium feed, which supports drought readiness.

The field-ready specification

Target specifications vary by species and climate, but a robust general standard for African conditions: root-collar diameter at least 3–5 mm (diameter predicts survival far better than height), a firm woody stem, a root ball fully holding together when lifted, and visible mycorrhizal fine roots. Height matters less than toughness — a 25 cm stocky seedling routinely out-survives a 60 cm leggy one.

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Key takeaways

- ✓ *
- ✓ Grade and cull before hardening; only strong, uniform stock goes to the field.
- ✓ Hardening = progressively more sun, less water, no nitrogen — toughness before planting.
- ✓ Root-collar diameter, not height, predicts field survival.

2.5 Mycorrhizae and Biological Seedling Enhancement

The hidden partnership

Most tree species depend on symbiotic root fungi — **mycorrhizae** — that dramatically extend the root's effective absorbing surface, mine phosphorus from soil, and improve drought tolerance. Nursery-grown seedlings in sterile media often lack these partners and transplant poorly into poor soils. Inoculating seedlings is among the highest-return, lowest-cost nursery technologies available.

Practical inoculation

- **Soil-based inoculum:** a few grams of topsoil gathered beneath healthy adult trees of the same (or related) species, mixed into potting media or watered in as a slurry. This traditional method transmits locally adapted fungi and their associated microbes.
- **Commercial inoculum:** available for some groups (especially ectomycorrhizal products for pines and some acacias); quality varies, so test before scaling.
- **Whole-culture approaches:** "biorational" nurseries simply grow seedlings in soil-based, biologically active media from the start, trading sterilization's disease control for biological richness, with net gains in field survival.

Rhizobia and nitrogen-fixing trees

For legumes (acacias, *Faidherbia*, *Sesbania*, *Gliricidia*), effective **rhizobium** inoculation can multiply early growth on nitrogen-poor sites. A simple test tells you if inoculation worked: dig a seedling and look for pink-to-red nodules on the roots (active) versus green/white (ineffective).

Biochar and other amendments

Small doses of finely ground biochar in potting media improve water holding and cation exchange and can carry nutrients; compost tea applications add beneficial microbes cheaply. These fit the same philosophy: **grow seedlings with a functioning soil ecosystem, not in a sterile medium**, so they hit the ground already adapted to real soils.

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Key takeaways

- ✓ *
- ✓ Mycorrhizal inoculation (even simple local soil inoculum) measurably improves field survival on poor sites.
- ✓ Check legume seedlings for pink nodules to confirm effective rhizobia.
- ✓ Biological media (compost, biochar, living soil) produce tougher transplants than sterile media.

Module 3: Site Preparation & Planting Technology

From pit to drone: preparing sites properly, planting at the right time with the right technique, and using modern tools from GIS to direct seeding.

5 lessons · 16m

3.1 Site Assessment and GIS Mapping

Map before you dig

Every serious planting project now starts with remote data. Free and low-cost tools put satellite imagery, historical maps and terrain models on any laptop or phone:

- **Google Earth Pro / Earth Engine:** free imagery back through decades — compare a site's tree cover in 2005 vs today to see how it degraded and what used to grow there.
- **QGIS:** the free, professional desktop GIS; combine imagery, elevation (SRTM/ALOS DEMs) and your own GPS points into a planting plan.
- **Collect Earth / Collect Earth Online:** FAO tools built exactly for restoration assessment, walking systematically through sample plots on satellite imagery.
- **Field apps (KoboToolbox, ODK, Survey123):** turn any smartphone into a geo-referenced data collector for nursery records, planting lines and survival plots.

What the map should answer

A planting map must settle: where the boundaries are (and who owns what — a leading cause of project failure is unclear tenure), where water moves and pools, where soils change, where existing valuable trees and natural regeneration already stand (protect them — do not plant over them), and where access for planting crews, water and later monitoring is realistic.

Sampling the site

Ground-truth the map on foot. Walk transects, dig soil pits every few hundred metres where the map shows change, photograph and GPS-reference each. A \$30 phone GPS is accurate enough for block edges; planting lines can be laid out with string and measuring tape — technology should reduce labour, not add it.

From map to plan

Overlay what you learned into a simple planting design: blocks or lines by species mix, firebreak placements, access paths, and the "leave-alone" zones of natural regeneration. This plan is the master document for budgeting plants, people and timing — and the baseline for the monitoring in Module 4.

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Key takeaways

- ✓ *
- ✓ Free tools (Google Earth, QGIS, Collect Earth, ODK) cover the whole mapping workflow at project scale.
- ✓ A planting map must settle tenure, water flow, soil variation, existing regeneration and access.
- ✓ Ground-truth with transects and soil pits; GPS-tag everything as your monitoring baseline.

3.2 Land Preparation and Fire Management

Beat the grass, not just dig the hole

Across African savanna and farmland restoration, grass and weed competition kills more seedlings than drought. Land preparation exists mainly to give each seedling a competition-free zone for its first two seasons:

- **Spot preparation:** clear a 1–1.5 m circle (or 1 m strip along a planting line) of all grass and weeds. Cheap, targeted, and preserves soil structure between spots — usually the best option.
- **Line preparation:** rip or hoe continuous lines along the contour on compacted or crusted soils; the slit captures rain and lets taproots penetrate plough pans.
- **Full cultivation:** reserved for intensively managed woodlots and fruit blocks; risky on slopes (erosion) and costly.

Pitting — dimensions and timing

Dig pits **before** the rains: 30 × 30 × 30 cm is the minimum standard, 40–50 cm on hard or dry sites. Backfill loosely (break clods), and always separate topsoil to go back in last, around the roots. Pre-season pitting means planting happens the day rains saturate the soil, and dug soil mellow over the dry season. Add a handful of compost or manure where available; on acidic soils, lime.

Fire

Late dry-season fires destroy young plantations across Africa annually. Fire management is planting technology: cut and burn (or stack) firebreaks 4–10 m wide around every block before the fire season, coordinate with neighbours on early controlled burns, keep blocks small and separated, and choose fire-resistant designs (fruit trees near homes, broad breaks, lower fuel loads by grazing grass early where appropriate).

Water harvesting into the planting spot

On drylands, shape the micro-catchment so the seedling harvests runoff: a crescent-shaped micro-basin (demi-lune), an eyebrow bund, or a "Zai"-style pit with manure. These Sahelian techniques can double early survival at almost no cash cost.

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Key takeaways

- ✓ *
- ✓ Grass control around each seedling (spot preparation) matters more than pit size.
- ✓ Pit and prepare before the rains; plant into saturated soil on day one of the season.
- ✓ Micro-catchment shapes (zai pits, demi-lunes) harvest runoff and double dryland survival.

3.3 Planting Technique: The Day and the Details

Timing is a technology

The single highest-leverage decision in planting is **when**: at the first sustained soil saturation of the rainy season, not the first shower. A false start plants seedlings into soil that dries before roots escape the root ball. Practical rules: wait until the soil is wet beyond 30 cm (test with a bar), and target planting in the first third of the season so roots have maximum time before the dry season returns.

The planting sequence, step by step

1. **Transport seedlings shaded and watered**, planted within a day or two of leaving the nursery — desiccation in transit silently kills root tips.
2. **Remove the container fully**. Planting a tube seedling "sleeve and all" or letting a polythene sleeve constrict roots causes invisible strangulation.
3. **Cut or straighten any circling roots** found on the root ball.

4. **Set the seedling at collar depth** — the root collar (where stem meets root) exactly at soil surface. Deep planting buries the collar and rots the stem; shallow planting exposes roots to air. On sandy soils err a finger's width deep; on heavy clay, a finger's width high.
5. **Backfill with topsoil, firming in layers** with fingers (not stamped boots — compaction kills infiltration), leaving no air pockets.
6. **Shape a watering basin** and apply 5–10 litres where water is available.
7. **Mulch** the basin with grass, straw or stones — moisture conservation plus gradual nutrients.
8. **Stake only where needed** (exposed sites, tall stock) and label a sample of seedlings for monitoring.

Spacing by purpose

Dense timber spacings (2 × 3 m or even 2 × 2 m) force early crown closure and self-pruning; agroforestry spacings (widely scattered, e.g. 10 × 10 m in parkland style, or in rows 4–10 m apart between crops) minimize competition with food production; fruit blocks typically 5–8 m depending on species. Mixture patterns (alternating in rows vs small groups) trade pest benefits against management simplicity.

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Key takeaways

- ✓ *
- ✓ Plant at the first true soil saturation — a week late is survivable, a false start is not.
- ✓ Full container removal, collar-depth planting, layered firming, mulching: each detail moves survival by real percentage points.
- ✓ Spacing follows purpose: tight for timber, wide and rowed for agroforestry.

3.4 Direct Seeding, FMNR and Assisted Natural Regeneration

Planting without planting

Nursery seedlings are expensive — typically several times the cost of seed. For hardy species and large areas, three no-nursery approaches can outperform them:

Direct seeding

Sow pre-treated, large-seeded species (acacias, balanites, shea) directly into prepared spots at 2–3 seeds per station, early in the rains. Costs a fraction of seedling planting, scales fast, and avoids transplant shock; the trade-off is heavy early losses to rodents, insects and drying — hence over-sowing and site selection matter. Successful African programs seed tens of thousands of hectares this way when species fit.

Farmer Managed Natural Regeneration (FMNR)

The Sahel's most celebrated restoration method. Instead of planting, farmers select and prune the stumps and root systems that already exist underground — most African dryland trees resprout vigorously when cut.

Each season, keep the 3–5 strongest stems per stump, prune the rest, and cultivate around them. Zero nursery cost, species are automatically site-native, and survival is inherently high. Niger's farmer-managed regreening across millions of hectares began with this single technique.

Assisted Natural Regeneration (ANR)

The forest-landscape version: suppress weeds and fire around existing wildings and seed rain, and enrich only where natural establishment fails. ANR typically costs 10–50% of conventional planting and often regenerates more biodiverse forest faster — because the forest's own seed bank and dispersers do most of the work.

The cheapest tree to establish is the one already growing. Planting is the tool for where nature needs help, not the default.

**

Key takeaways

- ✓ *
- ✓ Direct seeding suits large-seeded hardy species at scale for a fraction of nursery cost.
- ✓ FMNR regrows dryland forests from existing stumps — no nursery, native species, high survival.
- ✓ ANR suppresses competition around natural seedlings and costs 10–50% of planting.

3.5 Drones, Seed Balls and Emerging Planting Tech

What technology actually does well

The planting-tech boom (drones, seed balls, AI mapping) solves specific bottlenecks — it does not replace ecology or community ownership. Use it where it fits:

Drone seeding

Heavy-lift drones fire seed capsules or seed balls into prepared ground at rates of hectares per hour in terrain crews cannot easily reach (steep slopes, post-fire landscapes, mining spoil). Success hinges on the same old factors: site-species match, seed pre-treatment, and enough over-sowing to survive rodent and drought losses. Best current practice: drones for pilots and hard access, people for precision blocks — and honest survivorship monitoring, since the industry's failure cases are under-reported.

Seed balls and encapsulation

A simple ancient technology industrialized: seed inside a clay/comcast capsule waits for rain, protected from rodents and sun. Massively scalable by hand (school and community seed-ball programmes across Kenya make millions annually), and effective for pioneering species. Encapsulation with additives (hydrogel, mycorrhiza, rhizobia) is an active research frontier improving field performance.

Smart monitoring stack

- **Drone photogrammetry** generates centimetre-resolution maps for survival counts.
- **Satellite time-series** (Sentinel-2 free every 5 days) tracks canopy establishment across whole projects.
- **AI/ML classifiers** detect planted versus naturally regenerated trees and estimate survival remotely — a 2020s breakthrough enabling honest reporting at scale.
- **Field sensor networks** (soil moisture at seedling depth) close the loop between survival and site treatment.

The honest checklist for adopting tech

Does it reduce a real bottleneck (access, labour, counting)? Can it be maintained locally? Is its performance independently verified? Technologies passing all three (ODK forms, drone photogrammetry, satellite monitoring) belong in every project's toolkit; those that fail them become expensive demos.

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Key takeaways

- ✓ *
- ✓ Drones and seed balls genuinely scale access and labour-limited planting for pioneer species.
- ✓ The free satellite + AI monitoring stack makes honest large-area survivorship reporting possible.
- ✓ Adopt technology only when it passes the test: real bottleneck, locally maintainable, independently verified.

Module 4: Monitoring, Survival & Landscape Restoration

The difference between planting trees and growing forests is what happens after. Post-planting care, survival monitoring with field and remote methods, community engagement and restoration finance.

5 lessons · 17m

4.1 Post-Planting Care: Years One to Three

The aftercare gap

Most funding and energy concentrate on planting day; most mortality concentrates in the 30 months after it. The trees that survive to "establishment" (root systems escaped the root ball, crowns above the grass layer, generally 2–3 years) are usually safe for decades. Budget accordingly — plan aftercare costs at 30–50% of planting costs.

The maintenance calendar

- **Year 1, each dry season:** water where feasible; re-mulch basins; collar-up sand-drifted stems; replace dead stock (blanking) at the next rains so the stand stays uniform.
- **Every wet season start:** re-clear grass within 1 m of each stem — release the seedling from competition until its crown shades its own basin.
- **Every dry season before fire:** cut and maintain firebreaks; brief communities; coordinate early burns with neighbours.
- **Continuous:** guard against livestock browse during the first years (fences, thorn branches, or social agreements with herders — agreements usually work better than wire).

Formative pruning and singling

For timber and fruit objectives, years 2–4 are when quality is set: remove basal shoots and competing leaders (singling FMNR stems), prune the lower third of the crown with clean cuts that heal — never strip branches flush with heavy unclean tools, and never top trees. Pruning dosage rule: never remove more than ~25% of live crown in a year.

Learning loops

Keep simple permanent sample plots (flag a fixed 50–100 trees per block). Each season: count survivors, measure a sample of heights, photograph each plot from a fixed point. After two years these plots tell you which treatments, species and sites to scale — turning your project into its own research programme.

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Key takeaways

- ✓ *
- ✓ Establishment (years 1–3) is when mortality happens; budget aftercare at 30–50% of planting cost.
- ✓ The maintenance calendar: release weeding each rains, firebreaks each dry season, blanking, browse protection.
- ✓ Fixed photo-plots and survivor counts turn the project into its own learning loop.

4.2 Survival Monitoring and Field Measurement

Measure what funders and trees both need

The two numbers every project must know honestly: **survival percentage** (live ÷ planted, by species and block) and **growth** (height and root-collar diameter of a sample). Industry-recognized thresholds: below ~40% overall survival at year 3 signals replanting; 60%+ is a healthy African dryland outcome; 80%+ in humid zones.

Field protocol that scales

- **Systematic sampling beats walking impressions.** Count every tree along fixed transects (e.g., every 5th planting line, 100% of the line), or use circular plots (e.g., radius 5.66 m = 100 m²) on a grid.
- **Record by species and treatment** — survival always differs sharply by species and by micro-site, and that difference is your management information.
- **Photo-monitoring:** repeat photos from permanently marked points each season — the cheapest, most honest evidence of landscape change.
- **Digital field forms** (ODK/Kobo) capture counts straight to a database with GPS and time stamps; paper tally sheets remain a fine backup.

From counts to maps

Upload plot data into QGIS, join with your planting map, and produce survival heat-maps by block. Managers instantly see which corners of which blocks need blanking, which species to drop, where water harvesting worked. This same layer feeds your remote-sensing calibration in the next lesson — ground truth is what makes satellite AI honest.

Reporting honesty

Report survival the way a scientist would: sample size, method, date, and confidence. Round numbers ("100% survival!") and un-dated claims are red flags to any serious funder — and meaningless for management. Honest partial numbers build more credibility than inflated perfect ones.

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Key takeaways

- ✓ *
- ✓ Track survival (%) by species and block plus sample growth — with fixed transects or plots, not impressions.
- ✓ Map survival by block to steer blanking, species choice and site treatment.
- ✓ Report with method, sample size and dates; honesty is a competitive advantage with funders.

4.3 Remote Sensing and Tech-Enabled Monitoring

The satellite layer

Free Sentinel-2 imagery (10 m, every ~5 days) and Landsat (30 m, since the 1980s) let any project watch canopy green-up and loss across whole landscapes. Standard workflows: compute a vegetation index (NDVI or the tree-focused woody cover indices), compare season-matched images year to year, and flag areas of gain and loss. QGIS and Google Earth Engine both run these analyses free; Earth Engine processes entire districts in the cloud.

Drones: your own survey instrument

A consumer drone flying 100 m altitude produces orthomosaics where individual trees are countable. Fly the same blocks each year, count crowns in the mosaic (manually or with AI assistance), and you have audit-grade survival data without walking every row — and a before/after visual no funder forgets.

AI classification

Machine-learning classifiers trained on your field plots can distinguish planted trees from crops and natural regrowth across thousands of hectares. Emerging global products (e.g., tree-cover mapping at 1 m resolution from commercial constellations, and FAO/REDD+ platforms) increasingly let small projects borrow state-of-the-art detection without building it.

Ground truth discipline

Remote numbers are only as honest as the field plots behind them: calibrate every season with measured plots, keep the GPS discipline, and archive raw imagery. The stack — **field plots → drone mosaics → satellite indices** — is now the recognized monitoring architecture for serious restoration reporting (and for carbon and AFR100 reporting obligations).

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Key takeaways

- ✓ *
- ✓ Sentinel-2 + vegetation indices track canopy change free at landscape scale.
- ✓ Annual drone mosaics give audit-grade, per-tree survival evidence.
- ✓ Calibrate imagery with fixed field plots — the three-layer stack is the reporting standard.

4.4 Communities, Ownership and Restoration Economics

Tenure and benefit-sharing decide survival

Across African restoration, the technology works; it is insecure land tenure and absent local benefit that kill projects. Before scaling any planting: who owns and who uses the land (formally and customarily)? Who guards young trees from livestock and fire — and what do they gain? Projects structured around clear, written benefit-sharing (fruit rights, thinnings, payments, employment) consistently outsurvive those structured around external targets.

Designing the benefit package

- **Product streams:** fruit, fodder, fuelwood from pruning, honey (apiaries among flowering trees), gum, medicinal bark — timed so communities earn before timber decades arrive.
- **Paid community roles:** nursery teams, planting crews, monitoring enumerators — local wages convert neighbours into guardians.
- **Agreements in writing:** simple MOUs on who harvests what, when, and how revenue splits — renegotiated openly rather than assumed.

The economics of a planted hectare

Cost structure: nursery (seed, media, tubes, labour), site prep and pitting, planting day labour, and — the forgotten line — aftercare. Rough African program figures: community agroforestry with natural regeneration can restore a hectare for tens of dollars; seedling-based dryland planting runs in the hundreds; intensive fruit orchards higher still. Revenue: carbon payments (next lesson) plus product sales plus ecosystem-service contracts (water funds paying upstream catchment restoration). A project that models both sides of this ledger, honestly, is fundable; one that models only costs is not.

Women and youth as restoration managers

Programmes that put women in lead roles (nursery management, fruit marketing) and youth in tech roles (drones, monitoring data) consistently show stronger maintenance discipline — the daily attention young trees need — and more durable local institutions after external funding ends.

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Key takeaways

- ✓ *
- ✓ Clarify tenure and put benefits in writing before scaling — governance, not botany, is the usual failure point.
- ✓ Combine product streams, paid local roles and MOUs so guardians gain from survival.
- ✓ Model costs AND revenue per hectare; include the aftercare line.

4.5 Carbon Finance and the Future of Tree Planting

Trees as a climate asset class

Carbon markets pay for verified, additional, permanent emission removals — and tree restoration is one of the few proven routes. For African projects the practical entry points:

- **Voluntary carbon standards (Verra/VCS, Gold Standard):** the frameworks under which restoration projects issue carbon credits. Requirements: additionality (trees would not exist without the project), permanence (typically 20–40 year commitments with buffers for fire and drought risks), measured baselines, and independent audit.
- **Certification pathway:** land tenure evidence → baseline survey → planting and monitoring → verification audit → credits issued → offtake agreements with buyers. Realistic timelines run 3–5 years before first significant issuance; project developers who promise faster are selling something.
- **New soil and ARR methods** (Afforestation, Reforestation and Revegetation) under Article 6 and compliance markets are widening demand for African restoration credits; sovereign programs (e.g., jurisdictional REDD+) allow landscape-scale participation.

The honest caveats

Carbon revenue is real but modest relative to tree-product value in most community projects; treat it as one income stream, never the sole rationale. Integrity scrutiny of forestry credits is intense — over-claimed baselines and "phantom" credits have damaged the whole sector — so projects aligned to transparent measurement (your monitoring stack from the previous lessons) are the ones that survive due diligence. Non-carbon finance (biodiversity credits, water funds, restoration bonds, AFR100-linked grants) is growing alongside.

Where tree planting goes next

The discipline is consolidating around: **right tree, right place, right purpose, right people** — enforced by satellite verification and buyer scrutiny; diversification beyond carbon into biodiversity and water payments; and genuine technology integration from seed-tracking (some programs now barcode seed lots) to AI survivorship reporting. Practitioners who master both ecology and honest measurement — the content of this whole course — are exactly who this industry now lacks.

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Key takeaways

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- ✓ Carbon finance requires additionality, permanence and audit — plan a 3–5 year pathway through VCS/Gold Standard.
- ✓ Treat carbon as one income stream among products, water and biodiversity payments.
- ✓ The field's future is right-tree-right-place discipline enforced by transparent measurement — which you now practice.

Final Assessment & Certificate

The final test draws on questions from every module. The pass mark is 80%. When you pass, Tapi Learn issues a certificate of completion bearing your name, the course title, your final score, a unique certificate number and the signature of the CEO of the Pan African Network for Climate Action (PANFCA). Each certificate carries a verification URL (acla.io/verify/<number>) so employers and partners can confirm its authenticity. You can download the certificate as a PDF directly from the app at any time, and your progress and certificates are backed up to the cloud under your email address.

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