AGROFORESTRY PLANNING AND DESIGN IN TANZANIA

DEVELOPING AN AGROFORESTRY PLAN FOR KILIMO TIMILIFU

OUTLINE

- Project Background
- Planning and Design Framework
- Developing the Plan:
  - Information Gathering
  - Brainstorming ‘Best Bets’ for Agroforestry
  - Develop agroforestry designs
  - Detailed Agroforestry plans
  - Updates from KT
  - Lessons learned
  - Conclusions

PROJECT BACKGROUND

- 2015: Agroforestry Online MS degree program through The University of Missouri
- Project search: Kilimo Timilifu (KT) Farm in Tanzania
- Concept: Assist with developing an Agroforestry Plan
- Early 2017: plans to travel to Tanzania
- August 2017: in Tanzania for 1 month

OBJECTIVES FOR THIS PROJECT

1. Facilitate a collaborative planning process with the KT staff
2. Develop an agroforestry plan for KT
3. Apply my agroforestry studies

KILIMO TIMILIFU (KT)

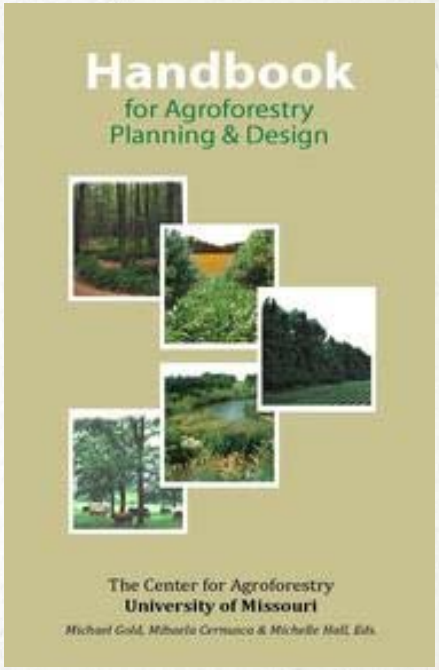
- Registered in Tanzania as a not-for-profit company since 2013
- KT Vision
  - Promote Holistic Farming in Southern Coastal Region of Tanzania
- Mission:
  - Provide conservation agriculture internship opportunities to Tanzanians
  - Support local farmers through value-adding and farm cooperative

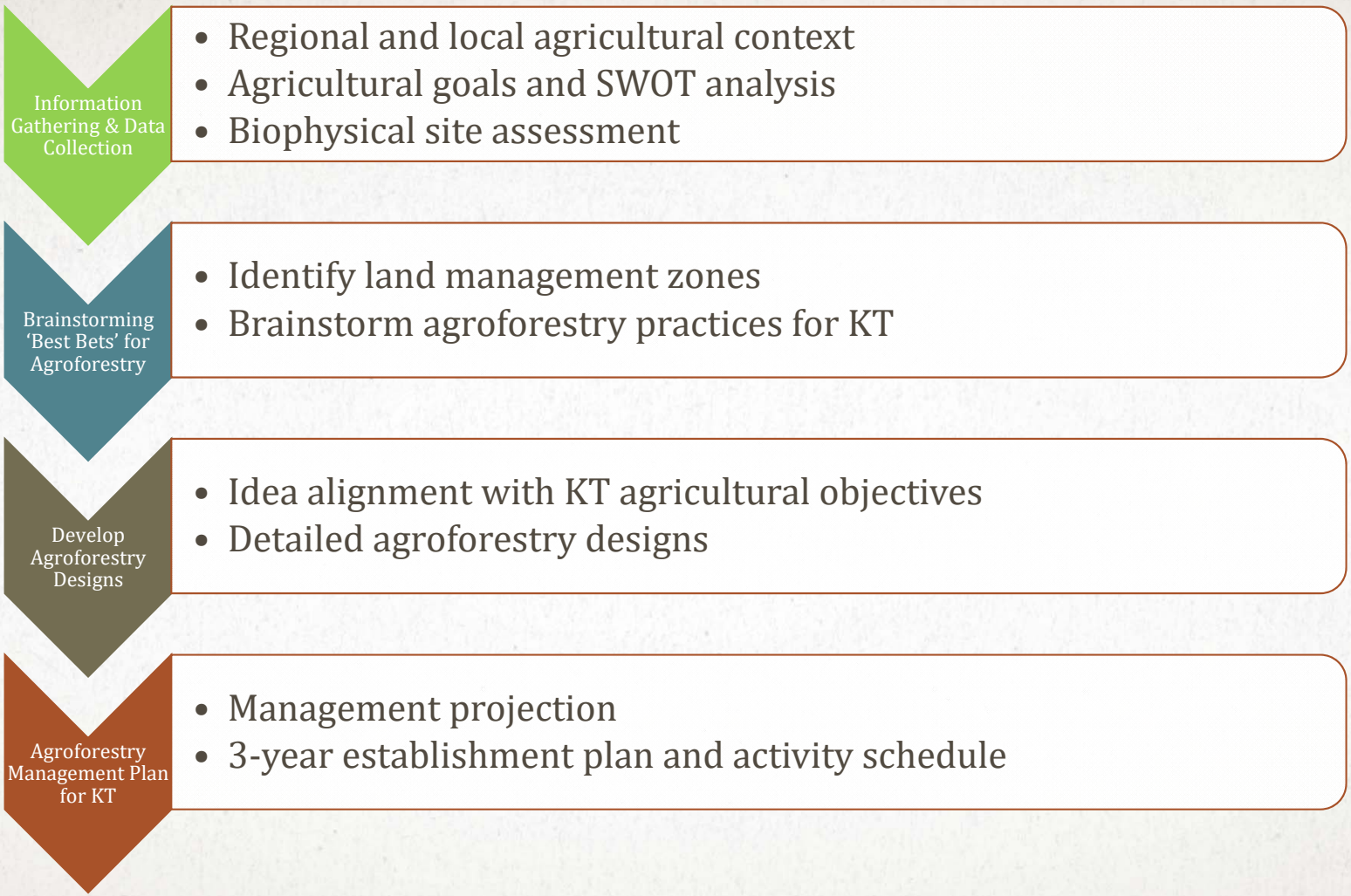
AGROFORESTRY

- “Land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land-management unit.” (Leakey, 1996
- Agroforestry is practiced globally.
- Agroforestry has the potential to provide a wide range of benefits.

PLANNING AND DESIGN FRAMEWORK

- Handbook for Agroforestry Planning & Design (Gold et al., 2007)
  - Adapt planning process to the KT context
- Individuals:
  - Roland Bunch—agricultural consultant and author of *Two Ears of Corn*




Information Gathering & Data Collection
Regional and local agricultural context
Agricultural goals and SWOT analysis
Biophysical site assessment
Brainstorming 'Best Bets' for Agroforestry
Identify land management zones
Brainstorm agroforestry practices for KT
Develop Agroforestry Designs
Idea alignment with KT agricultural objectives
Detailed agroforestry designs
Agroforestry Management Plan for KT
Management projection
3-year establishment plan and activity schedule

REGIONAL AND LOCAL AGRICULTURAL CONTEXT

SOUTHERN COAST OF TANZANIA —LINDI REGION

- One of the poorest regions
  - "Forgotten corner of the country"
  - Lagging behind
- Agricultural Practices:
  - Shifting cultivation
  - Cashew *shambas*
- Major crops:
  - Sorghum, cassava, pigeon pea, sesame, and maize.
- Challenges:
  - Soil degradation, loss of soil fertility, erosion.
  - Crop failure during drought years.

FARM VISITS & AGRICULTURAL RESOURCE CENTERS

- World Agroforestry Centre, Dar es Salaam
- Mikocheni Agricultural Research Institute, Dar es Salaam & Bagamoyo
- Sokoine University of Agriculture (SUA), Morogoro
- Sustainable Agriculture Tanzania (SAT), Morogoro
- Tanzania Starch Company, Lindi & Mtama
- Cashew nursery, Nyangow
- John Julius Sunflower Pressing Company, Masasi
- Mchinga local farm visits: Baba Soni, Mzee Hamadi

OBSERVATIONS-KEY TAKEAWAYS

- Agroforestry is common along the coast.
- Water is a major limiting factor.
- High cost of soil fertility inputs.

Opportunities: soil conservation practices, reduced tillage, soil coverage, N-fixing trees and fertilizer trees, rainwater catchment.

AGRICULTURAL OBJECTIVES AND SWOT ANALYSIS

KT DEVELOPMENT GOALS AND PROGRAMS

DEVELOPMENT GOALS

1. Rural communities are physically transformed through the implementation of CA principles.
2. Tanzanian farmers are fully equipped to engage in profitable, sustainable agricultural enterprise
3. Tanzanian farmers are empowered to become agents of change in their communities

PROGRAMS & STRATEGIES

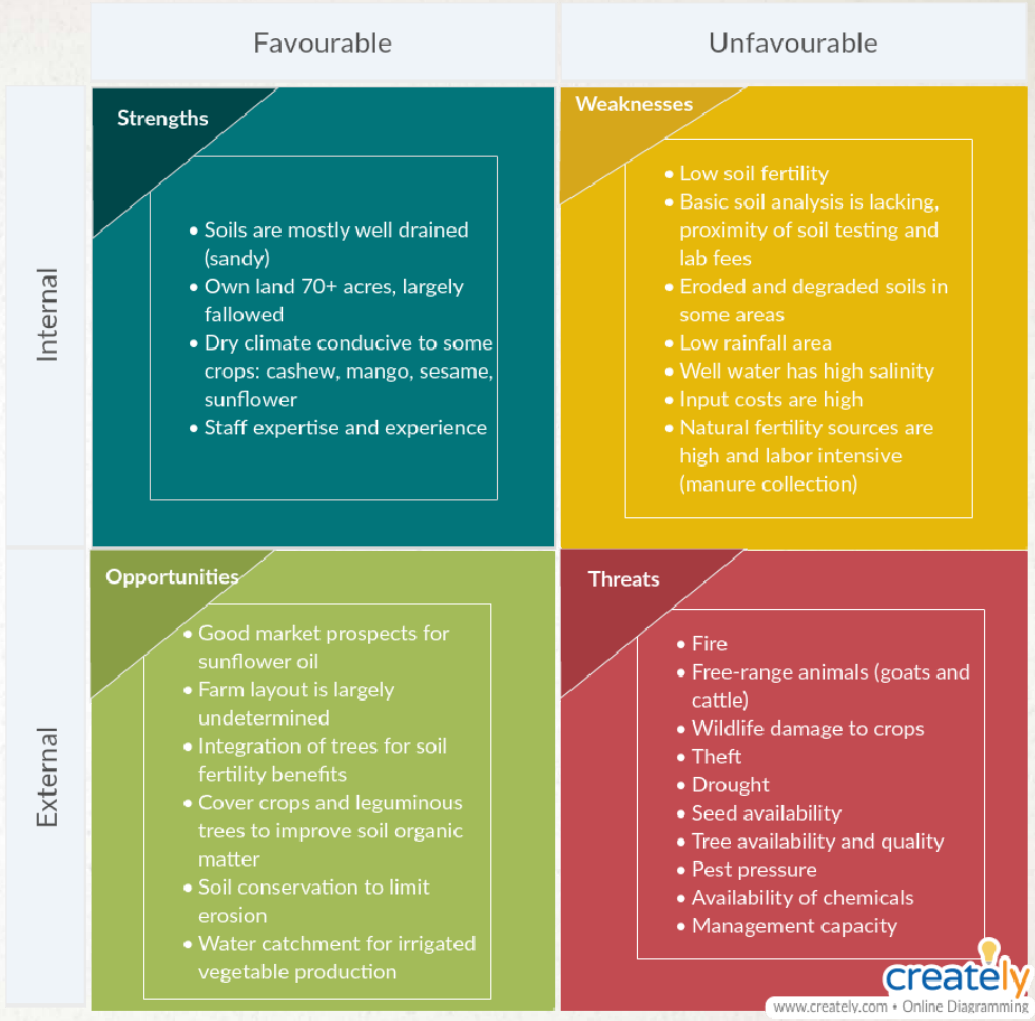
- One-year internship program for Tanzanian nationals
  - Prepare Tanzanians for agricultural success in southern coastal Tanzania
- Oil pressing Enterprise and Farmer Cooperative Program
  - Improve market access for farmers
  - Create value adding opportunities
  - Build extension network for coops

KT AGRICULTURAL OBJECTIVES

1. Establish a baseline assessment of the KT farm site: soil, climate, vegetation, and maps.
2. Implement rainwater catchment and capacity for irrigation.
3. Conserve and improve soil resources by establishing erosion control practices and improve water infiltration.
4. Design farm layout to maximize production as well as efficient movement, access, and security.
5. Establish intern field cropping shambas with intercropped fruit and nut trees, leguminous fertilizer trees, and other multipurpose tree species.
6. Establish a fruit and vegetable production area for interns.

SWOT ANALYSIS OF AGRICULTURE AT KT

- Observations:
  - Soils are infertile and prone to erosion
  - High cost of manure and fertilizer
    - Trees can be integrated to address soil fertility and erosion issue
  - Low rainfall, high variability of rain
  - High salinity well water
    - Water catchment is needed for irrigation



BIOPHYSICAL SITE ASSESSMENT

KT FARM SITE ASSESSMENT

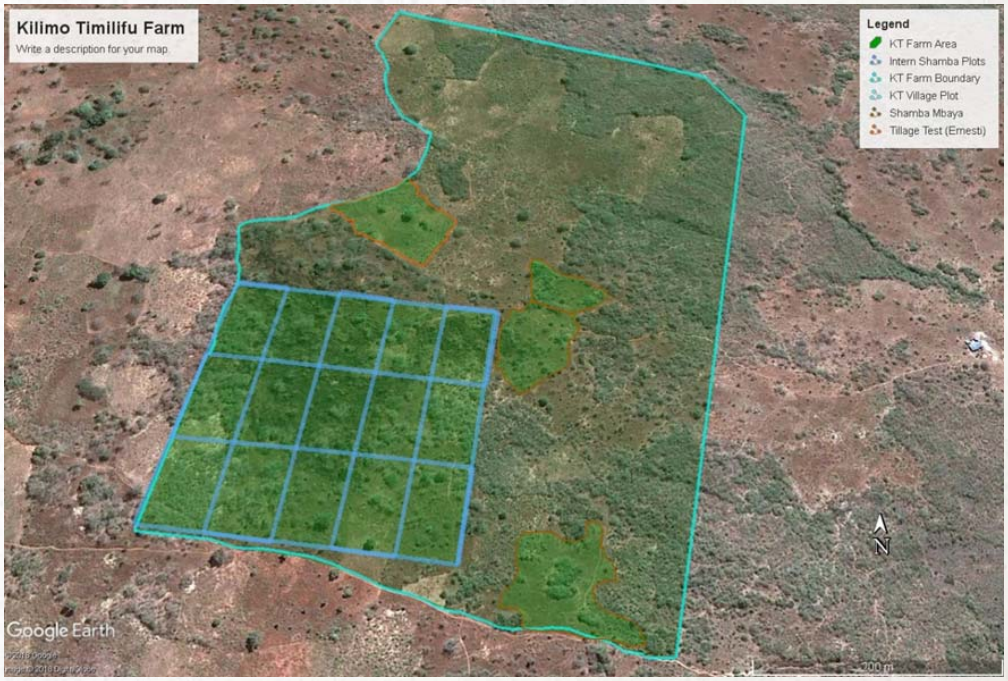
- Major Components:
  - Land Area
  - Topography
  - Climate
  - Water
  - Soil
  - Vegetation
- Data collection in Tanzania and follow-up research afterwards.

KT FARM LOCATION AND LAND HISTORY

- Located on the Indian Ocean; Lindi District; village of Mchinga
- 70 acres (28 ha)
- History:
  - Cleared for charcoal, then farmed
  - Fallowed in recent years
  - Some fires along ridge

KT FARM PLOTS

Table of KT Farm Areas:	ha	acre
KT Main Farm Site:	28.3	70
Intern Field Plots:	6.3	15.4
Tillage Plot:	0.75	1.8
Abasi Plot:	1.3	3.2
Shamba Mbaya	0.8	2
Shamba Njia	0.6	1.5
Vegetable Garden	0.1	(1095 m^2)



TEMPERATURE, RAINFALL, AND WIND

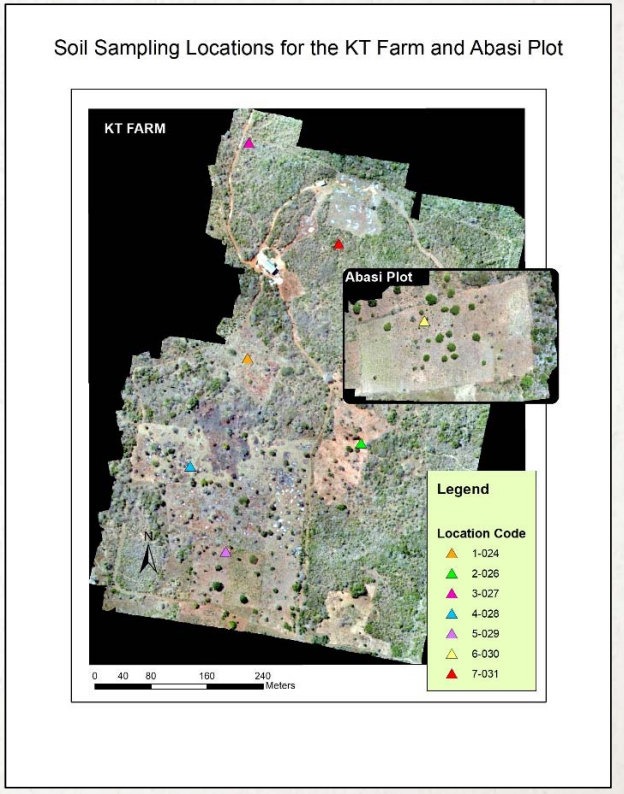
- Temperature: hot and humid from Nov-March, cooler and dry from June-August
- Average Temperatures:
  - Mtwara: T_{max} 30 °C and T_{min} 21 ° C (1975–2017)
  - Lindi: T_{max} 30.5 ° C and T_{min} 21.7 ° C (1935-1955)
  - Gridded Reanalysis data for inland Mchinga: T_{max} of 30 ° C and T_{min} of 22 ° C
- Rainfall:
  - Annual rainfall means for KT: **1012mm**, Lindi: **917mm**, and Kikwetu Estate: **909mm**
- Wind:
  - Generally our of the east and southeast

WATER RESOURCES

- KT has attempted to drill for water 3 times without success
- Bore hole well in Mchinga
  - KT well water is considered **highly saline**
- Rainwater Catchment:
  - 1” rain event = 10,043 Liters, future storage capacity goal of 140,000 L
- KT Reservoir:
  - 45 acre catchment area, estimated capacity of 12 million Liters

SOIL

- 7 sample locations—lab analysis Dar es Salaam
- Sandy clay loam
- pH was elevated in most sites-presence of limestone
- Organic Carbon (OC) was low for most sites
- Soil Life CO_2 Test:
  - Two sites showed ‘ideal soil activity’
  - Most sites had moderate to low soil respiration



VEGETATION—TREES

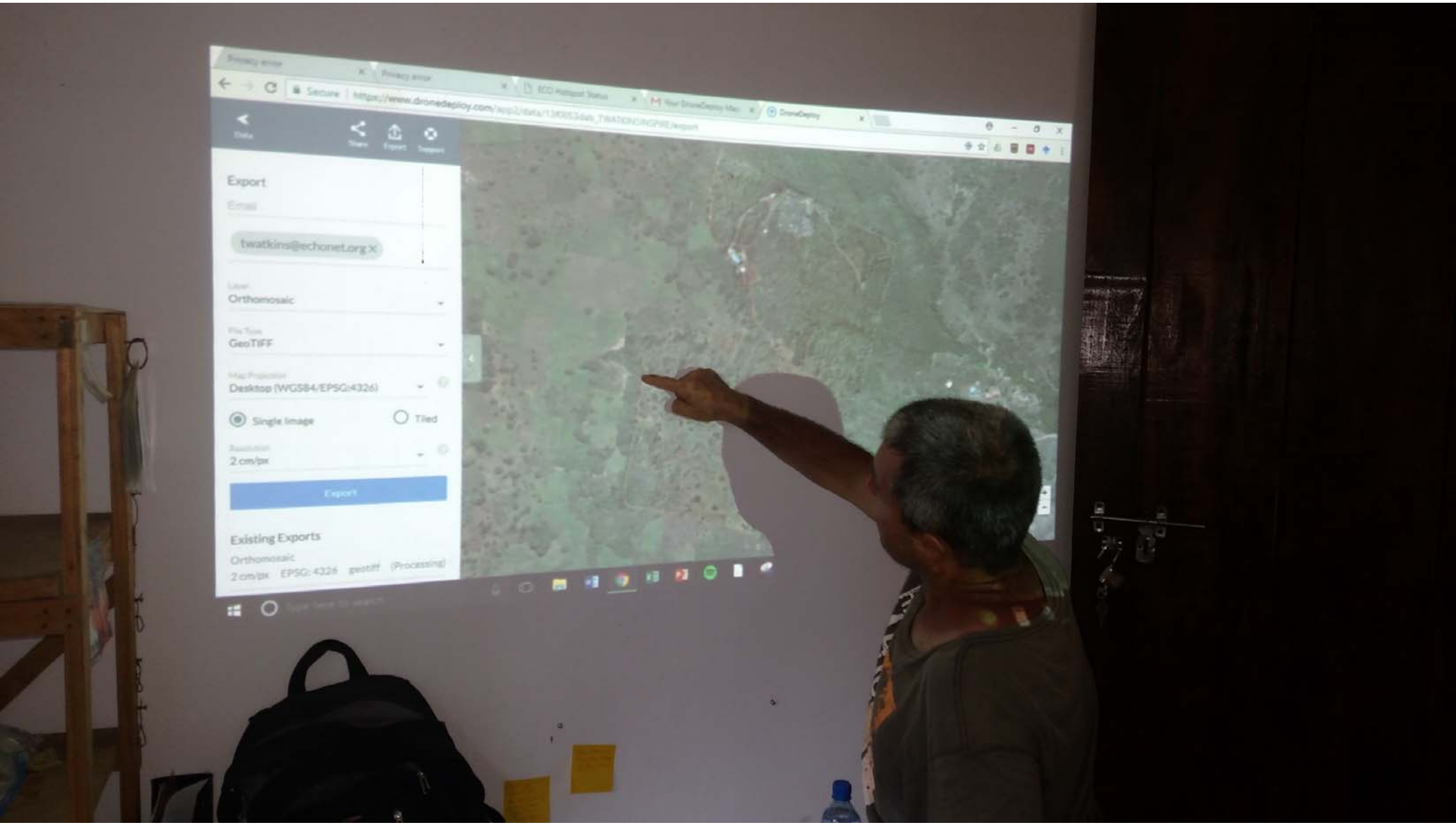
- Acacia spp. (*A. senegal*, *A. senegal*, *A. nilotica*, *A. polyacantha*)
- *Commiphora africana*, *Markhamia lutea*, *Dalbergia melanolxylon, Grewia sp.*
- Coconut palms common Mchinga but become rare inland.
- Large Baobab (*Adansonia digitata*)
- Fruit Trees: cashew, mango, tamarind, sugar apple, citrus

INSIGHTS FROM SITE ASSESSMENT

- Minimize tree-crop competition for moisture
- Build organic matter content
- Plant Nitrogen-fixing trees to improve soil fertility
- Produce biomass for field mulching or compost
- Plant tree hedges on contours for soil conservation
- Practice no-till or minimum tillage
- Keep the soil covered with vegetation and crop residues
- Selected drought tolerant and deep rooted tree species

Brainstorming ‘Best Bets’ for Agroforestry

KT LAND MANAGEMENT ZONES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Management Zones

Intern Slashes: 20 acres SW quadrant
- Dispersal shade, 30m fruit trees
- intern 1 acre plots

North Entrance:
- contour berms → cut lines into scrub save Acacia - big trees
* Seed Processing Bldg
* Catchment Area

South Ridge:
- Open areas → Contours: Gliricidia Vetiver
- Timber off (hardwoods) Micro catchments / Pothules: trees in low areas

KT Lake Zone: Home gardens
- Irrigated Bustan: → treadle powered irrigation? (NOT Petrol) Pump
- fruit trees
- coconut, citrus [Rube Soni:] System * Catchment
- contour beams

Abasi Zone: 3 acres (2 acres - best land)

Ridge Building Zone:

Land Purchasing: "down the road"
- # of interns, 3 acres / intern Or 5 acres/intern

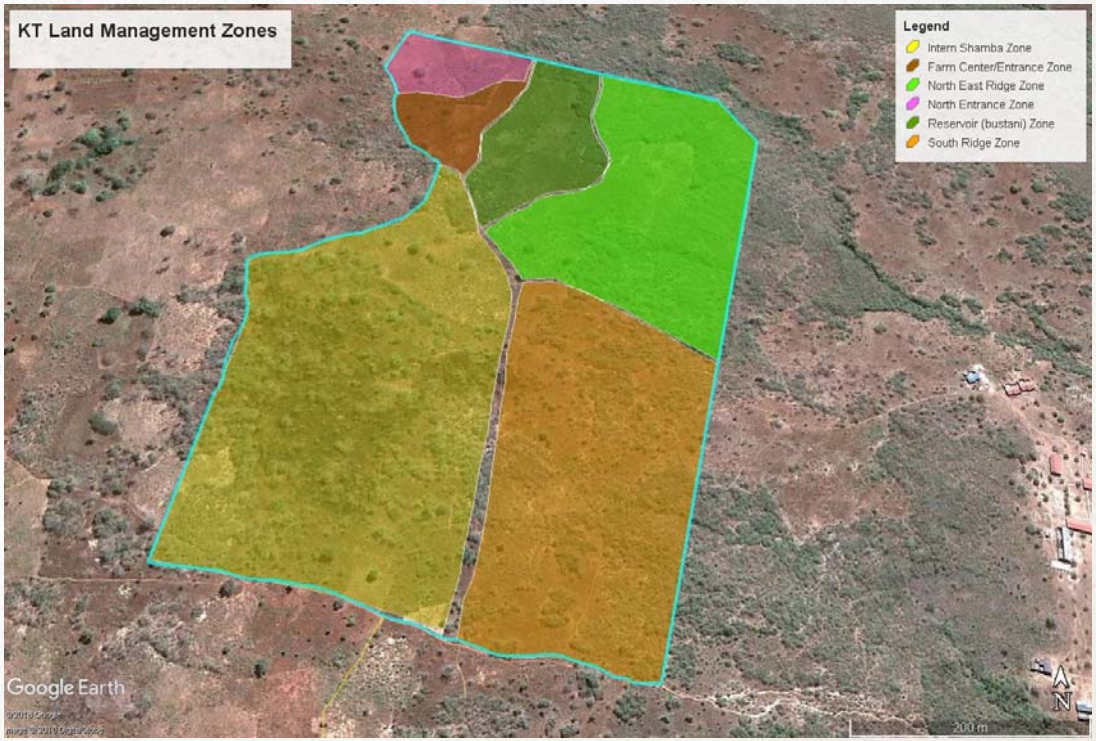
Structures:

current: 1) Office - Seed Bank - Shop
2) Store Room

Future - planned:
3) Seed Oil Processing + Storage

KT LAND MANAGEMENT ZONES

- North Entrance Zone
- Farm Center Zone
- Reservoir Bustani Zone
- Northeast Ridge Zone
- Intern Shamba Zone
- South Ridge Zone

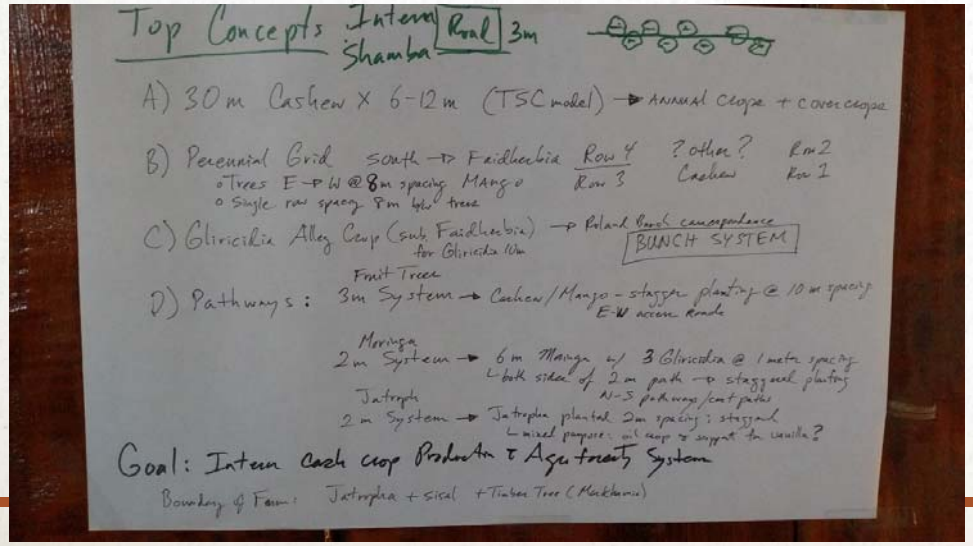


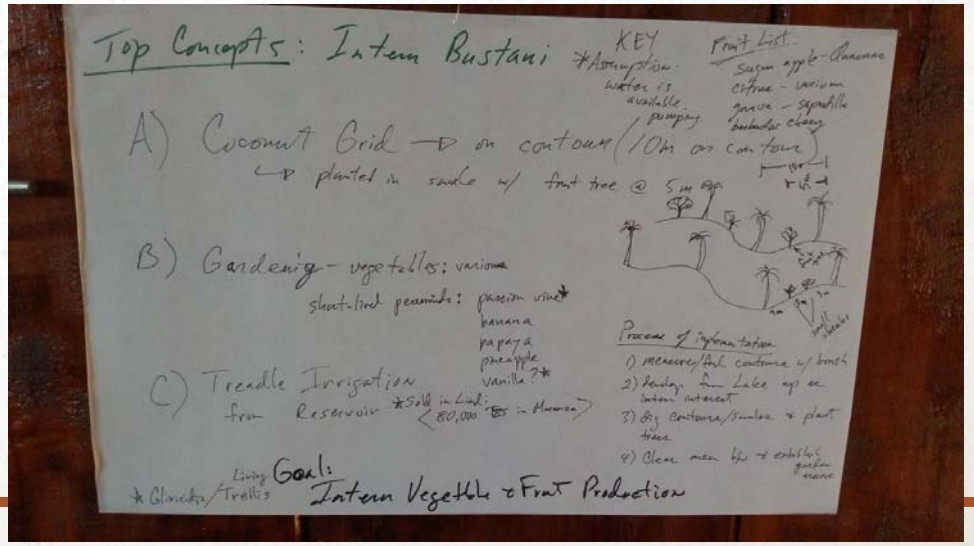
Brainstorming ‘Best Bets’ for Agroforestry

BRAINSTORM AGROFORESTRY PRACTICES

TOP CONCEPTS

- Narrowed ideas to top concepts for various zones





TOP CONCEPTS FOR INTERN SHAMBA ZONE:

1. Cashew and mango alley cropping/intercropping with conservation farming (CF).
2. Alley cropping system based on faidherbia and gliricidia with CF.
3. Field border plantings of multipurpose trees: gliricidia, moringa, and jatropha.
4. Farm boundary plantings of sisal and timber trees and living fence species.

TOP CONCEPTS FOR SOUTH RIDGE ZONE:

1. Contour hedgerows of closely spaced N-fixing trees, such as gliricidia and/or leucaena with faidherbia at 10 meter spacing, planted in a shallow swale along contour
2. Conservation farming approach between hedgerows with dispersed trees.
3. Improved fallow for soil restoration, planting pigeon pea within alleys.

TOP CONCEPTS FOR THE RESERVOIR BUSTANI ZONE:

1. Multi-strata garden: Coconut intercrop with compact fruit trees and grasses on contour at 1 meter elevation intervals, plant contour bunds with vetiver grass on the downhill slope and stones on soil bunds.
2. Biomass production with mucuna and tithonia for use in compost production for vegetable beds.
3. Napier grass bank around reservoir for soil stabilization and fodder production.

Develop Agroforestry Designs

IDEA ALIGNMENT WITH KT AG OBJECTIVES

KT AGRICULTURAL OBJECTIVES

1. Establish a baseline assessment of the KT farm site: soil, climate, vegetation, and maps. **Biophysical Assessment**
2. Implement rainwater catchment and capacity for irrigation. **KT Project**
3. Conserve and improve soil resources by establishing erosion control practices and improve water infiltration.
4. Design farm layout to maximize production as well as efficient movement, access, and security.
5. Establish intern field cropping shambas with intercropped fruit and nut trees, leguminous fertilizer trees, and other multipurpose tree species.
6. Establish a fruit and vegetable production area for interns.

AGROFORESTRY PRACTICES → KT AG OBJECTIVES

Intern shamba zone: The primary goals for this area are cash crop production for income generation, tree integration for soil fertility and annual crop benefits, and multi-purpose trees for the production of value added products.	**Agriculture Objective**
Practice #1: Cashew and mango alley cropping **Practice #2: Alley cropping system with faidherbia and gliricidia** **Practice #3: Border planting with multipurpose trees** **Practice #4: Boundary planting-living fence**	**4 & 5** Efficient farm layout & crop production

AGROFORESTRY PRACTICES → KT AG OBJECTIVES

South ridge zone: Goals were identified as erosion control, soil restoration and rehabilitation, as well as timber production	**Agriculture Objective**
Practice #5: Contour hedgerows of Nitrogen-fixing trees **Practice #6: Improved fallow with pigeon pea**	**3** Conserve and improve soil resources

AGROFORESTRY PRACTICES → KT AG OBJECTIVES

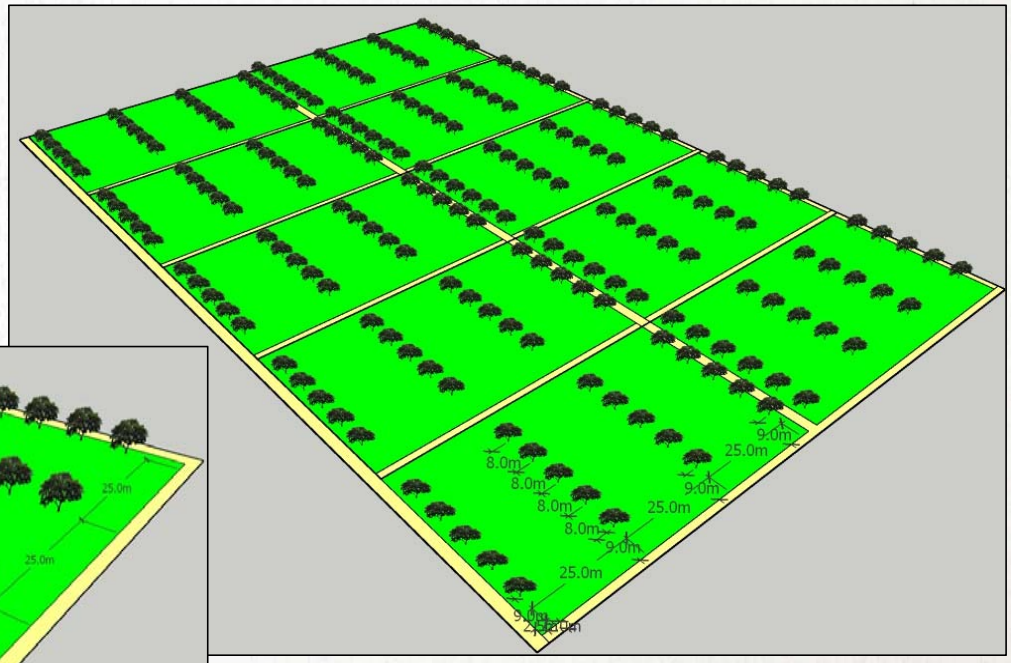
Reservoir bustani zone: Vegetable and fruit production for interns, biomass production for composting, and utilization of appropriate irrigation methods	**Agriculture Objective**
Practice #7: Coconut-Fruit Tree hedgerows	**6** Establish a fruit and vegetable production area

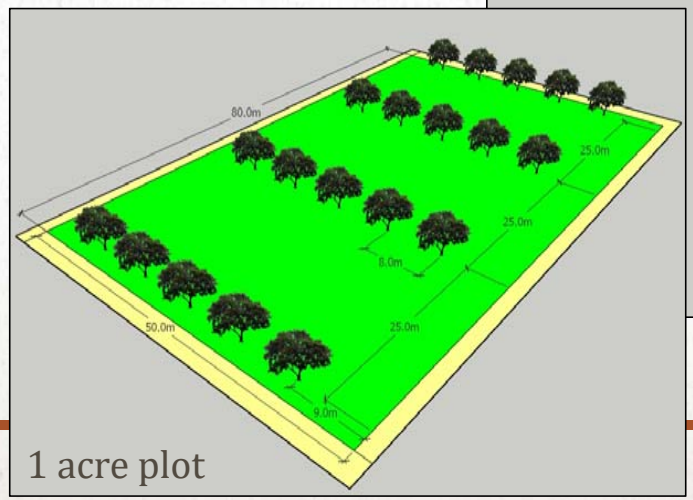
Develop Agroforestry Designs

DETAILED AGROFORESTRY DESIGNS

PRACTICE #1: CASHEW MANGO ALLEY CROPPING

- Based on observations of Tanzania Starch Co.
- Widely spaced cashew and mango
- 25 m x 8m spacing
- Field cropping in alleys

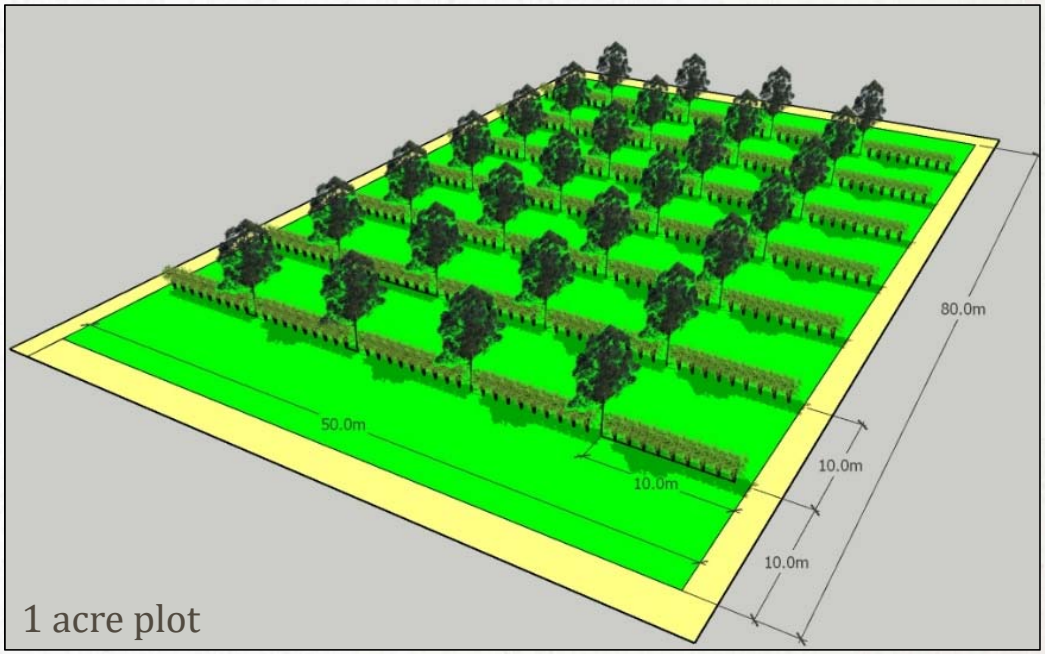




1 acre plot

PRACTICE #2: ALLEY CROPPING WITH GLIRICIDIA AND FAIDHERBIA

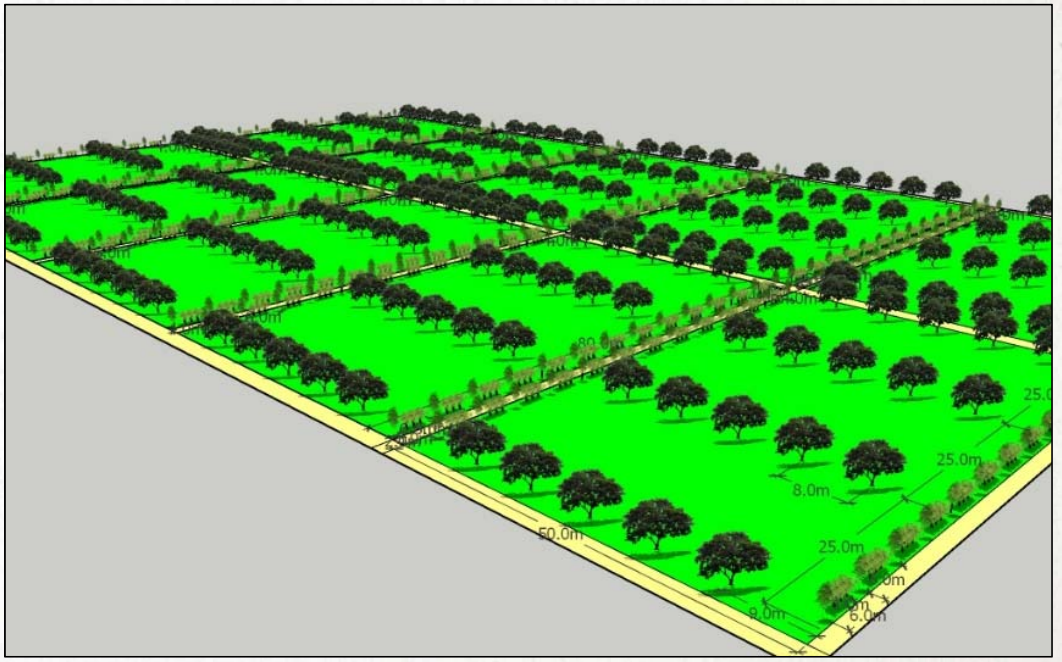
- 10 m x 10 m grid of *Faidherbia albida*
- Hedgerows of *Gliricidia sepium* 1m spacing
- Field cropping in alleys
- Leave select native trees as dispersed shade



1 acre plot

PRACTICE #3: BORDER PLANTING WITH MULTIPURPOSE TREES

- Moringa or jatropha 6 m spacing
- Gliricidia 1m spacing between
- Planted either side of pathways

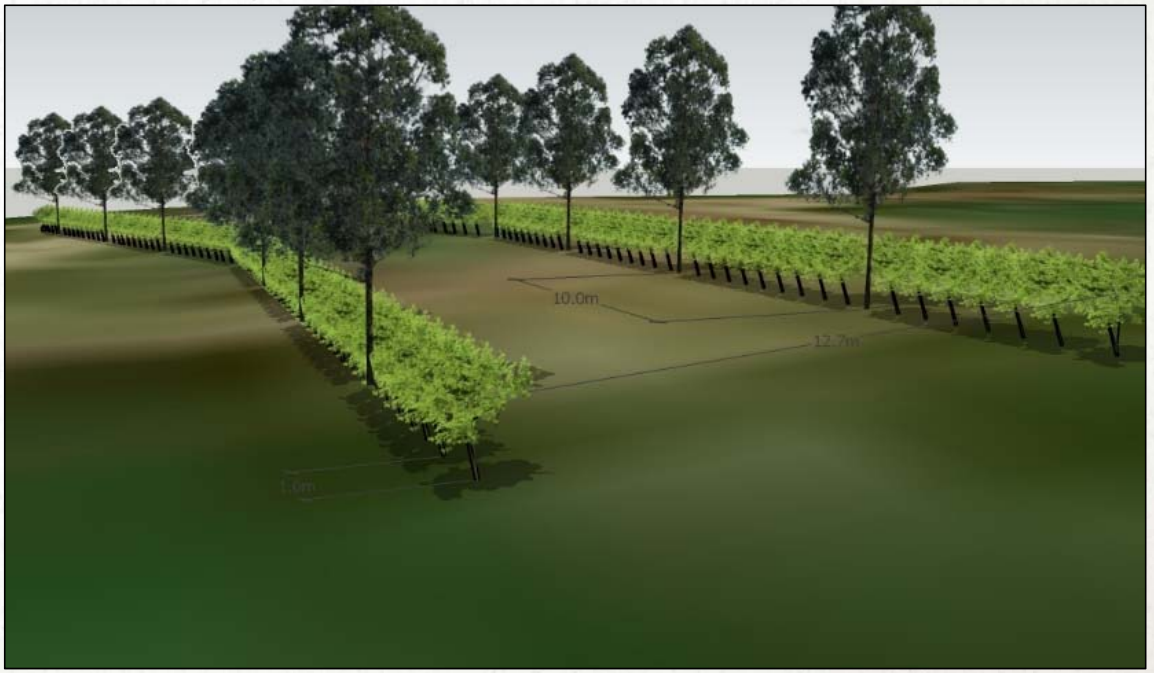


PRACTICE #4: BOUNDARY PLANTING-LIVING FENCE

- Tightly spaced sisal plants
- Timber trees (*Markhamia lutea*) 10 m
- Living fence species (*Commiphora sp.)*

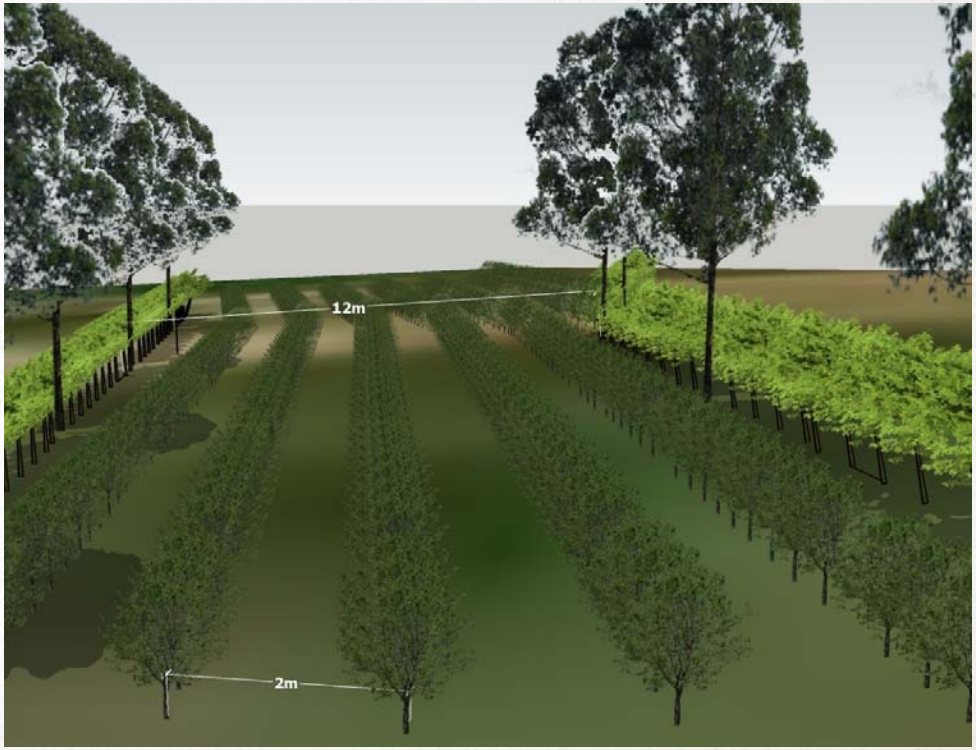
PRACTICE #5: CONTOUR HEDGEROWS OF NITROGEN-FIXING TREES

- Establish contour swale-soil bund
- Gliricidia and leucaena alternating 1 m spacing
- Faidherbia 10 m spacing within row
- Alleys 15-20 m wide along slope



PRACTICE #6: IMPROVED FALLOW WITH PIGEON PEA

- Medium and Long duration pigeon pea planted 30 cm spacing
- 2 m row spacing, in alleys between contours of N-fixing trees



PRACTICE # 7: COCONUT-FRUIT TREE HEDGEROWS

- Coconut palms at 10 m spacing
- Larger fruit trees 5 m between coconuts
  - Citrus
  - Mango
- Smaller fruit trees ~3 m spacing
  - Guava
  - Sugar apple

Agroforestry Management Plan for KT

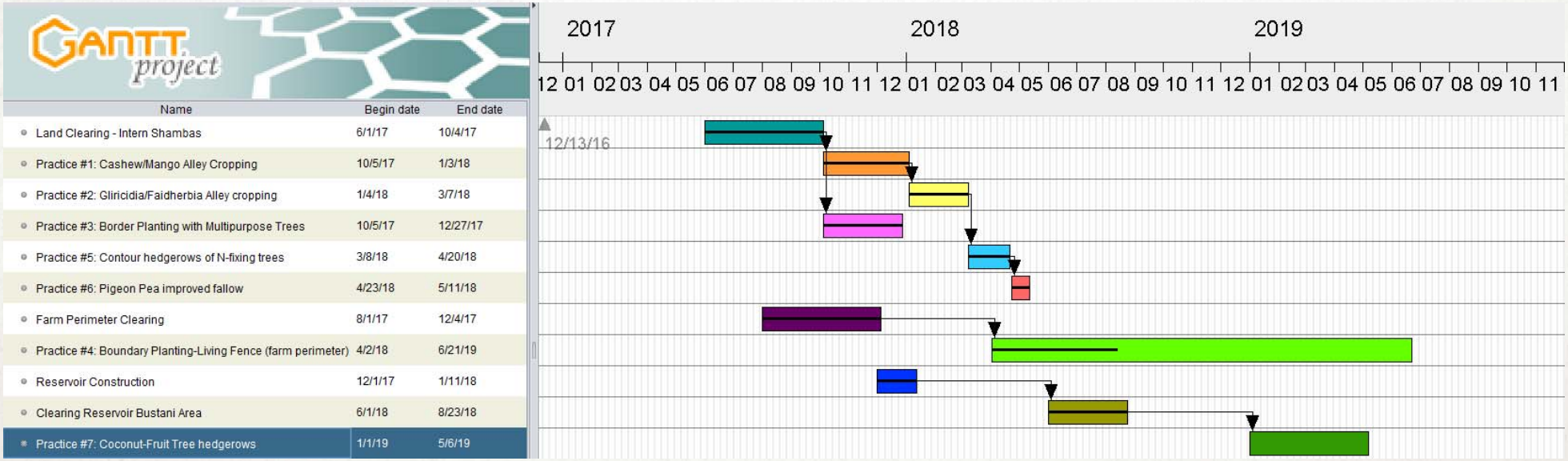
MANAGEMENT PROJECTION AND YEARLY ACTIVITY SCHEDULE

MULTI YEAR MANAGEMENT PROJECTION

	Agroforestry Practice	size of area	Year	Management Objective	Assumptions
Practice #1	Cashew/Mango Alley Cropping	10 acres	2017	Clear land, plant trees	trees are available
Practice #2	Gliricidia/Faidherbia Alley cropping	5 acres	2018	Clear land, plant trees	trees are available
Practice #3	Border Planting with Multipurpose Trees	15 acres (2400 m)	2017	Plant trees	trees are available
Practice #4	Boundary Planting-Living Fence (farm perimeter)	2668m	2018	Clear and plant 1000 m of live fence	trees and sisal available
Practice #5	Contour hedgerows of N-fixing trees	6.7 acres	2018	Install contours and plant trees	trees available
Practice #6	Pigeon Pea improved fallow	3.5 acres	2018	plant pigeon pea	seed available
Practice #7	Coconut-Fruit Tree hedgerows	2.4 acres	2019	clear area and install contours	1) intern program initiated 2) water available

IMPLEMENTATION PROGRESS

- Land clearing was underway in mid 2017
- Several agroforestry plantings were established in late 2017



YEARLY ACTIVITY SCHEDULES

- Detailed plot diagrams
- Tree requirements
- Nursery recommendations (production goals, timing)
- Planting recommendations (fertilization, timing)
- Maintenance requirements (weeding, irrigation, pruning)

EXAMPLE: CASHEW AND MANGO ALLEY CROPPING

Year 1: Land clearing and tree establishment.

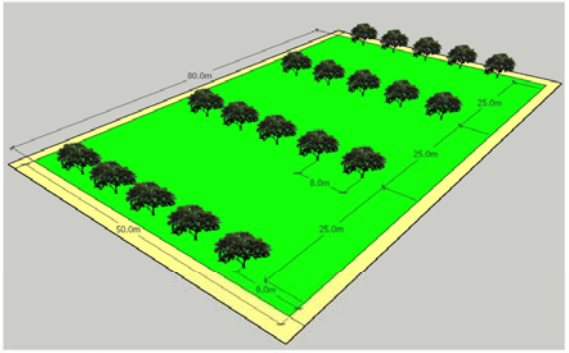
Year 2: Tree care and maintenance.

Year 3: Tree care and maintenance.

- Activities: Clearing land, marking planting locations, planting, raising seedlings or purchasing trees, etc.

11. Establishment Plan and Yearly Activity Schedule

Practice #1: Cashew and Mango Alley cropping: Intern Shamba Plots—Rows 2 & 3



Year 1: Land clearing and tree establishment.

a. Clear rows 2 and 3 of the Intern Shamba plots (10 acres total) removing all large trees and stumps. (All plots should be ready for planting in November)
b. Mark out planting positions based on diagrams provided.
c. Tree Planting: Water trees thoroughly at planting and mix 1 L of compost or decomposed cow manure in with soil that is returned to the planting hole.
    1. Plant grafted mango 8 m apart and triangulated at 8-9 m between rows 2 and 3 (see diagram).
    2. Plant grafted or seedling cashew trees at 25 m x 8 m spacing (see diagram).
d. Monitor rainfall for dry spells and water trees with 20 L of water if there is no rain for 1 week.

UPDATES FROM KT

IMPLEMENTATION OF THE AGROFORESTRY PLAN

TREE NURSERY

- Tree nursery late 2017
- Shelter for raising tree seedlings
- Trees are started in shaded conditions
- Seedlings are hardened off before planting in the field

TREE PLANTING JANUARY 2018

- Cashew-Mango Alley cropping:
  - 90 Grafted and seedling cashew trees
  - 100 mango trees: 25 'Kent', 25 'Keit', 25 'Apple', 25 'Ngowe'
- Gliricidia and faidherbia alley cropping planted on 3 acres
- Border planting:
  - Moringa and gliricidia planted every 2 meters along pathways
  - 30 custard apple and 30 soursop (Annona sp.)
- Farm boundary planting:
  - Sisal and *Commiphora africana* planted on half of farm perimeter (1300 m)
- Contour berms (meters planted):
  - Shamba mbaya 250 m, Abasi plot 175 m, Shamba njia 200 m
- Improved fallow:
  - Pigeon pea ratoon planted on south ridge fields and Abasi plot
- Reservoir:
  - 30 moringa and vetiver strips planted around the reservoir for erosion control

MANGO & CASHEW TREES

GLIRICIDIA AND LEUCAENA

TREE REPORT—NOVEMBER 2018

- Leucaena trees planted in 2018 largely failed—due to drought stress.
- Gliricidia trees grew vigorously and are now well established.
- Jatropha failed in the nursery and in the field.
- Grafted cashew trees failed to establish—many died in the field.
- *Markhamia lutea* seed failed to germinate
- *Commiphora africana* established well-other species failed

FIELD BOUNDARY FIRE

RESERVOIR PROJECT

- Reservoir was constructed in January 2018
- A large rock prevented the contractor from achieving the full volume
- Clay was sourced locally to help seal the bottom of the reservoir

LESSON LEARNED—CONCERNS

- KT staff were isolated in their management of the KT farm and program
- Drone images were extremely helpful for planning
- National staff participation could have been greater
- The success of KT rests on 2 key assumptions;
  - Interns can support their families on 3 acres of land
  - The oil-pressing-value adding program will generate a profit

CONCLUSIONS

- Agroforestry has great potential to help meet KT's agricultural objectives.
- Good design and planning is critical for success.
- A planning framework can help guide the process.
- The KT staff already had the ideas, experience, and goals but lacked the space and time to clarify goals and refine ideas into a concrete plan.
- KT staff felt significant ownership in the plan and implementation began immediately.

THANK YOU