Alphonso by the Lake
Design Document

2021

ANANAS

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Contents

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Document Overview

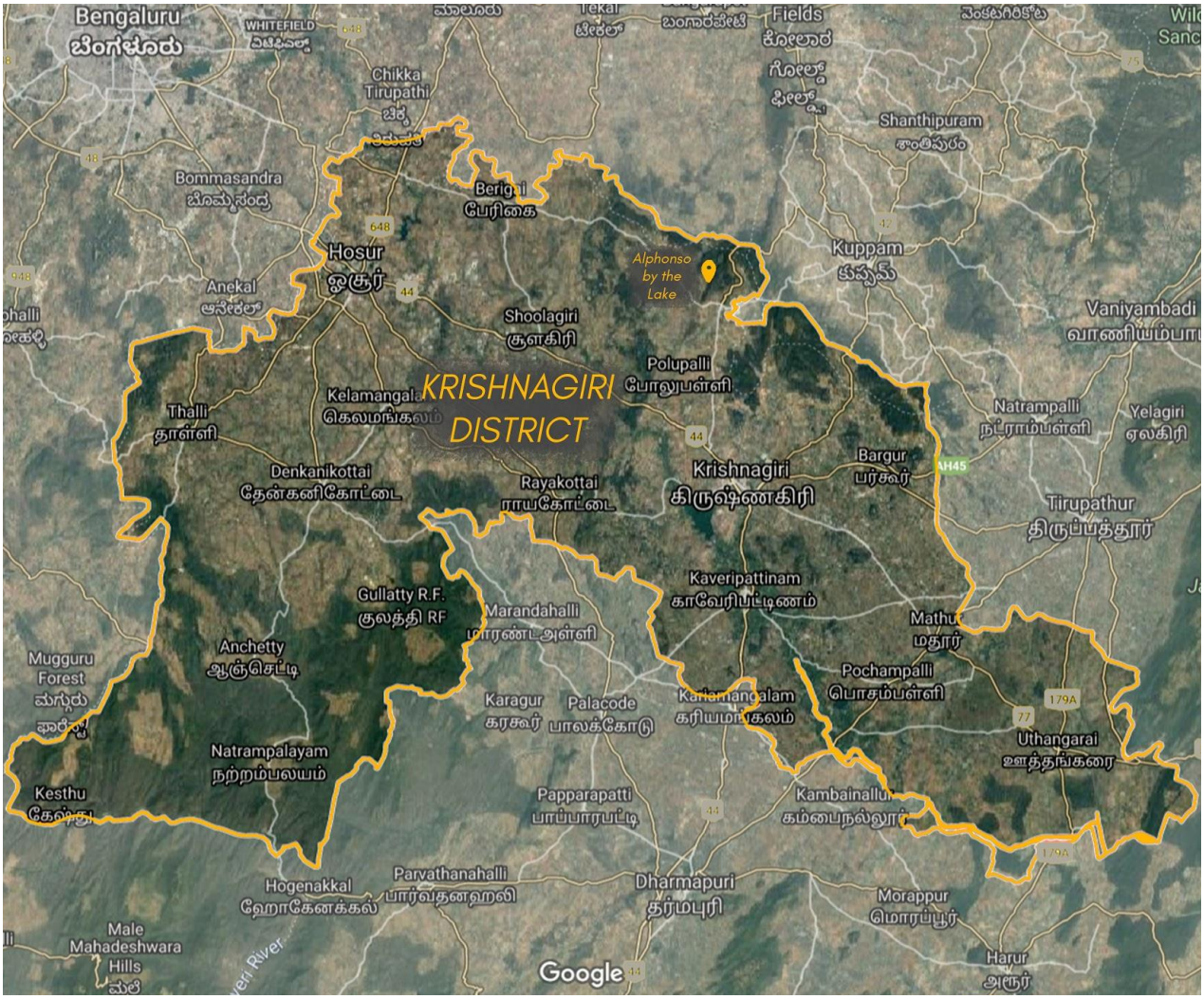
What is a design document?

This is a documentation of our masterplan, elements, functions and relationships of the whole systems design created for Alphonso by the Lake.

What is its purpose?

- To provide a vision for what is possible, and how the vision for the project is to be realised through on ground interventions.
- To guide and equip those working on the land and associated with the project with the information they need to set it up and run it.
- To provide a template for others to replicate. The methods of regenerative design thinking and whole systems planning for land restoration and livelihood generation discussed here can be replicated in South India and beyond.

Location Map



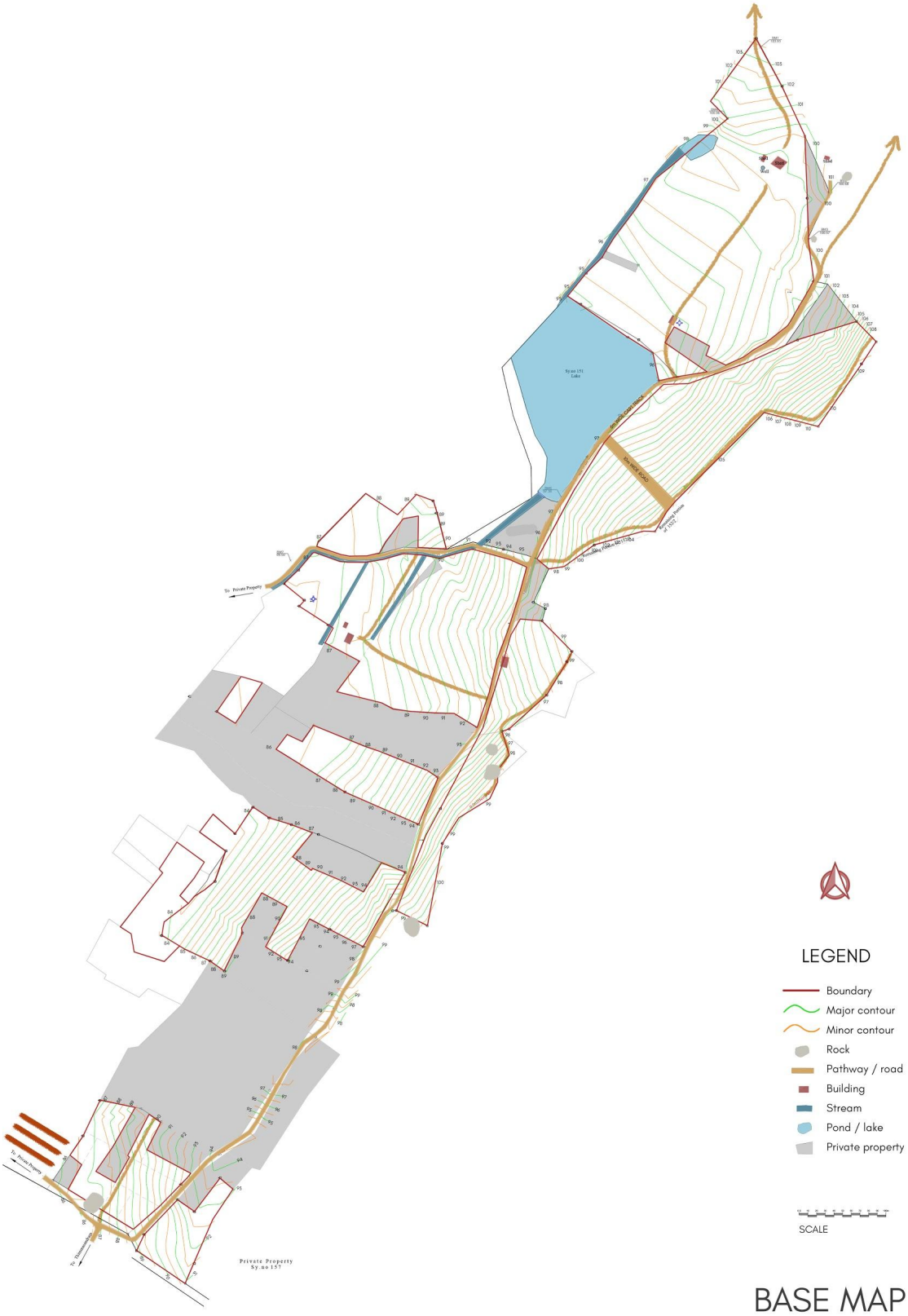
Site Location:
Chinnathammandrapalli, Veppanapalli,
Krishnagiri district, Tamil Nadu

Coordinates:
12.736217963993429, 78.18305004224177

Elevation:
583 m

Total Area:
68 acres (as of June 2021)

Base Map



BASE MAP

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Base Map

Satellite

LEGEND

- Boundary
- Rock
- Building

SCALE

BASE MAP
WITH SATELLITE IMAGE

Masterplan

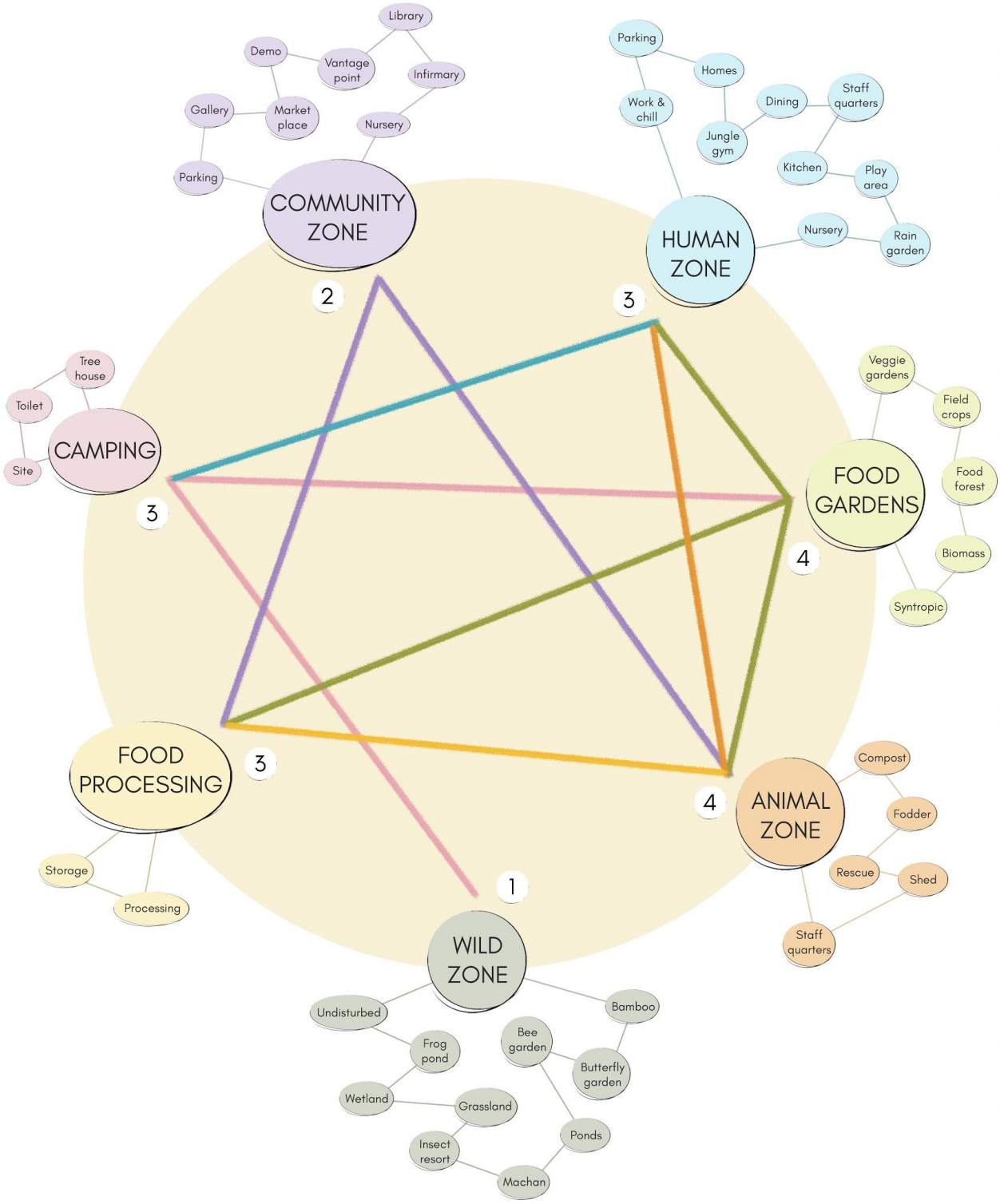
Masterplan


ROAD DRAINAGE
U-DRAIN / BIO-SWALE
RAISED PATHWAY DETAIL
BOOMERANG BERMS
BOUNDARY PLANTING PLAN (all rows)
BOUNDARY SECTION
MANGO SYNTROPIC
SYNTROPIC AGROFORESTRY
Lake
NURSERY
Community zone
Community forest
Orchard with house
YET TO ACQUIRE
Habitation zone
Avenue planting
Wild zone
Syntropic agroforestry
Animal systems & staff quarters
Mango syntropic with boomerang berms
Banana circle
Composite
Buffer planting / wild zone
Watering hole
Kalyani
Tree rows
Field crops
Paths
Biomass rows
LEGEND
Boundary planting
Machan
Potential well
Tank
Pond (perennial)
Pond (seasonal)
Boundary
Pathways
Bioswale / u-drain
Stormwater drain / channel
Basin / wetland
Boomerang berms
Avenue planting
SCALE
ALPHONSO GAIA MAP

ANANAS

Elements & Linkages

Elements & Linkages



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Elements & Linkages

Elements and linkages is a process by which we arrive at networks of all relationships between all the elements, which are derived from the vision and purpose of the project.

Relationships between any two elements are established based on their interactions with and influences on each other, and dictate their relative **placement**.

Determining these relationships is an exercise done first on paper with the team to figure out parameters such as proximity, access, frequency of use and its general connections with respect to the other elements. The network of relationships thus formed is then subject to refinement over discussions and iterations.

This exercise is essential for us to further the design through zoning, relative placement and master planning.

The numbers on the elements attests a value of importance to that element. It signifies the frequency of use of that particular element and therefore plays into the relevance of that in the larger scheme of things.

This exercise is followed by **zoning** - which involves planning the site into zones and assigning design elements a *relative placement* - based on sectors & flows, plus elements & linkages. The zones are usually numbered 0 to 5, and their positions depend upon the usage, needs and interactions of the zone/elements.

Zoning

Zone Map

ZONING & ELEMENTS

Water Systems

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Water Needs and Sources

As part of the water strategy and design, we start by assessing the site's projected water demands, while also assessing what the appropriate water sources to meet those demands could be.

The Water Demand Map

The map on the following page depicts the projected **annual water needs** of the site (in kiloliters / thousands of liters or KL in short) **activity-wise as well as zone-wise**.

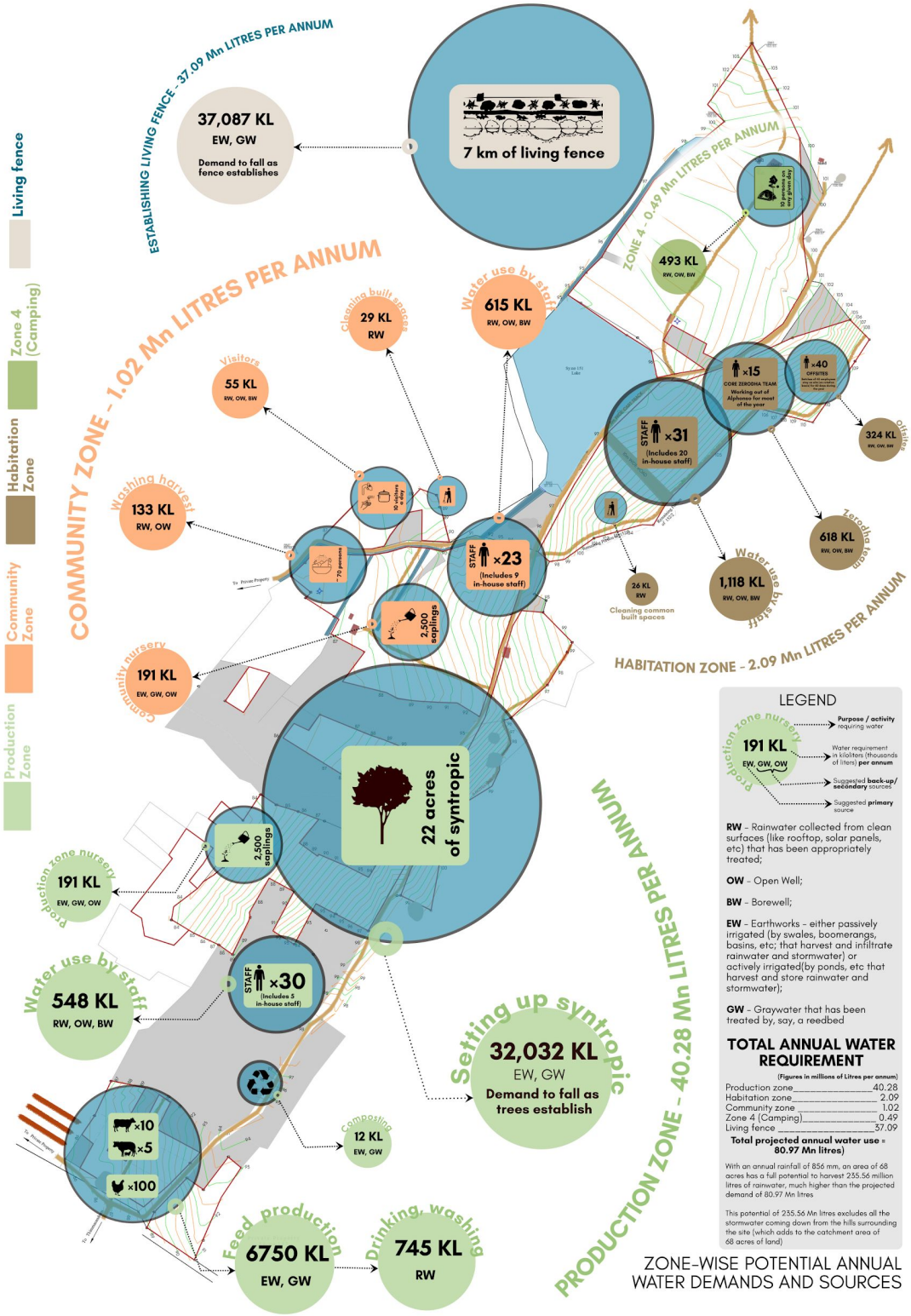
Each activity requiring water is tagged with **primary** as well as **secondary / backup water source(s)** that would be appropriate for that activity. For example, the site's highest quality rainwater - typically runoff from relatively clean roof surfaces, solar panels, etc (abbreviated as **RW** on the map) - can be used as the primary source for domestic consumption by the site's residents and staff members. Open well (**OW**) and borewell (**BW**) water are secondary / backup sources for the residents when the primary source falls short.

On the other hand, stormwater from less clean surfaces such as earthen slopes, streets, etc that are harvested by the earthworks (EW) can be directed and utilized for various types of irrigation on site. Greywater (GW) generated by the site's human residents can also be directed for irrigation.

Note - *The projected annual water demand has been worked out on the basis of the level of activity we anticipate on site in each zone in the longer term, the number of human residents the site would support and also staff that may be required to run operations on site, etc. It is very important to review these assumptions / bases, since the projected water needs depend on them. Water needs would also have to be reassessed every time you foresee any change in plans as regards to the site.*

As far as planning water goes, while it would be best to keep the long-term vision in mind, we could take a staggered approach where we slowly build on water capacities, infrastructure and redundancies over time as our long-term vision materializes.

Water Needs and Sources



ZONE-WISE POTENTIAL ANNUAL WATER DEMANDS AND SOURCES

Water Needs and Sources

Source-wise water needs / demands

While the map depicts water needs by activity that are grouped into zones, it would also be helpful to look at the water needs by source, so as to understand what quantity of water we expect from each source and if such expectation is realistic:

Volumes in millions of litres per annum

Water sources	Production	Habitation	Community	Camping	Living fence	Total
Clean (RW, OW, BW)	1.29	2.09	0.83	0.49	-	**4.70**
Less clean (EW, GW)	38.99	-	0.19	-	37.09	**76.27**
Total	**40.28**	**2.09**	**1.02**	**0.49**	**37.09**	**80.97**

The demand for water from clean sources represents only ~ 6% of the projected annual water needs. We also need to match the quality of water being harvested with the strategy used to store it. For example, while it would be appropriate to store rainwater collected from clean surfaces in tanks, it would be more appropriate to store / infiltrate storm water in earthworks. It is more cost-effective to store water in the soil / earthworks when compared to tanks (which are more expensive). **In our case, we would need to invest in tanks to meet only 6% of our total water needs.**

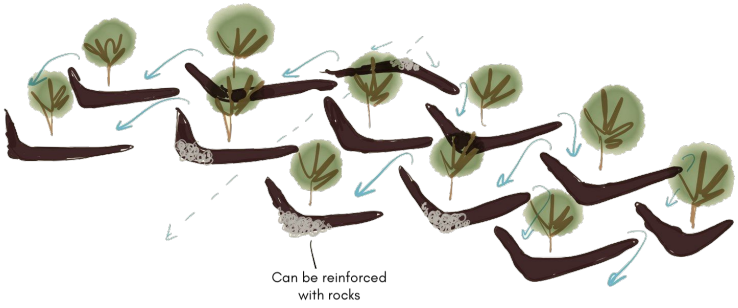
Let's understand how to read the table above by considering the projected annual water needs at the habitation zone of ~ 2.09 million litres. Since these projected needs pertain to domestic consumption by the residents and staff, the entire demand needs to be met from clean sources as indicated in the table (namely, rainwater harvested off clean surfaces, open wells and borewells). Considering the habitation zone has a roof footprint of 24,524 sq. ft. (~ 2,278 sq. m), there is a potential to harvest ~ 1.76 million litres of rainwater in an average year (considering a roof runoff coefficient of 0.9). This means that rainwater can meet almost 85% of the water needs at the habitation zone, and if we are able to harvest this full potential by investing in well-planned storage capacity, we would have to depend on open wells / borewells (secondary / backup sources) only for 15% of the total needs. This will ensure our groundwater extraction rates are far below what we replenish each year through the combined action of our earthworks and trees and we have a net positive impact on regional water resources, so we can make groundwater sources more dependable in drought years.

Earthworks Masterplan

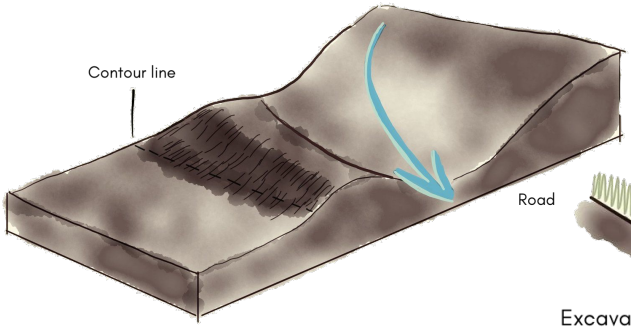
Details and Description

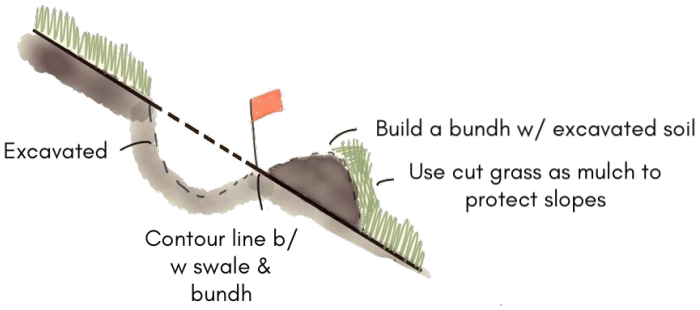
We have designed several earthworks for the property to slow, stop, store and save water flowing on the land.

Swales, boomerang berms, basins, ponds, diversion berms, diversion swales, gullies, gully plugs, french drains are planned across the site based on the required function and the form of the land itself.

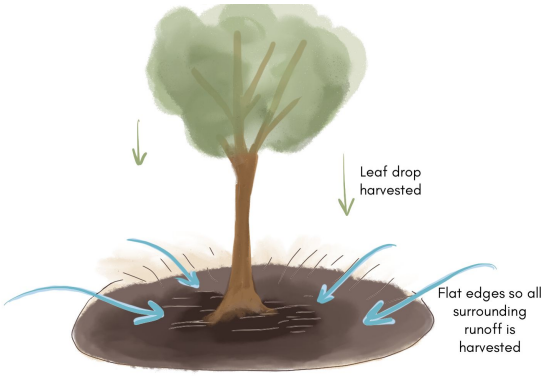


Boomerang berms (above) here are raised bundhs designed to retain sheet flows and disperse channel flows of water. At Alphonso these are done around the existing mango trees and in steeper areas.





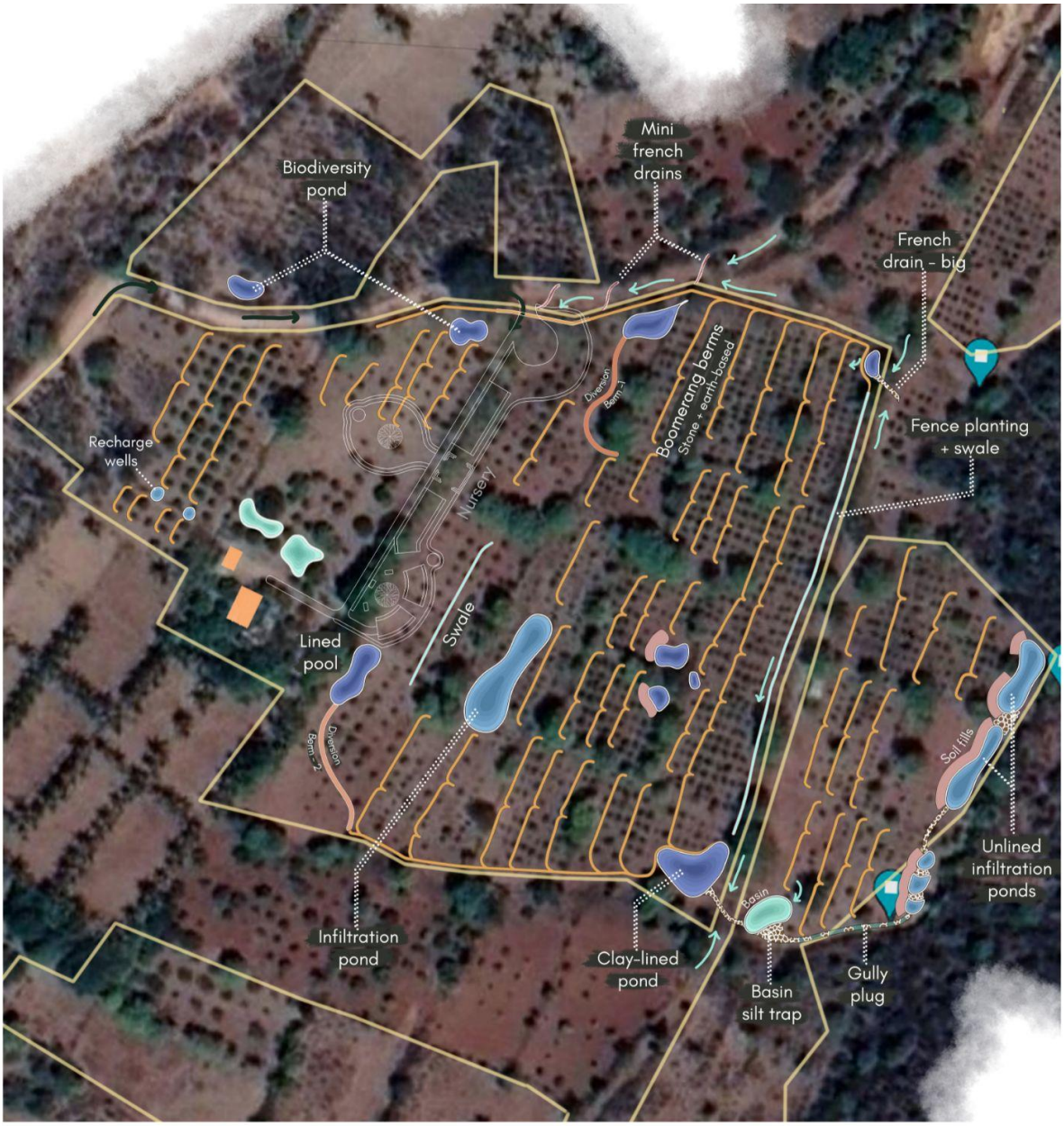
Diversion berms (above) are done to intercept water flowing on roads and to direct it into vegetative spaces. In other words, these are speed breakers for water.



Swales (above) are much talked about trenches that are done along the contour. These intercept sheet flows, harvest organic matter and reduce erosion..

Infiltration basins (left) or planted basins are shallow pools of water created to infiltrate water on flatter lands.

Earthworks Map - Nursery Area



LEGEND

- Boomerang berm (1m wide)
- Unlined infiltration pond
- Soil fill (3m wide)
- Basin
- Swale (1m wide)
- Lined pool
- Rock channel / gully
- Diversion swale

0 10 20 30 40 50 60 70 80 90 100m

Scale

EARTHWORKS PLAN
NURSERY AREA

Earthworks Map - Habitation Zone

LEGEND

- Building
- Pond
- Basin
- Swale (2.5m wide)
- Mud pathway
- Main pathway
- Lined / unlined
- Earth boomerang
- Rock boomerang
- French drains in pathways

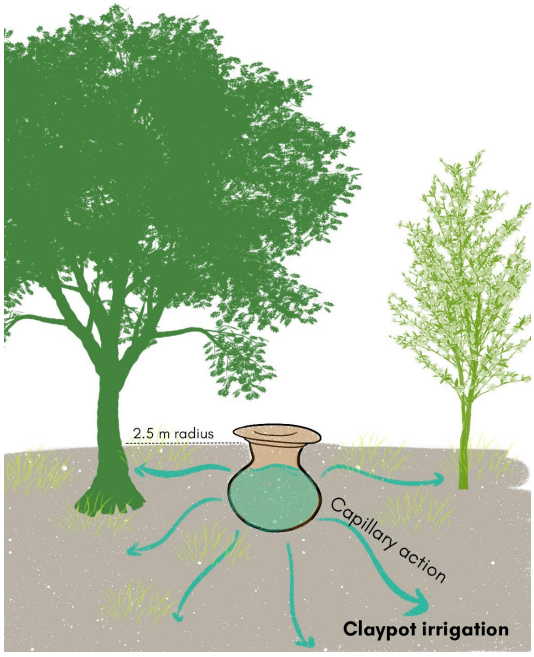
10 50m
0 20
Scale

HABITATION ZONE EARTHWORKS

Irrigation Strategies

Irrigation

- The main goal when it comes to irrigation is to use the least amount of energy and resources to water saplings for the first two years, after which they will thrive on their own with rainfall and soil moisture.
- **Passive irrigation**: Monsoon months will need no direct irrigation, **earthworks** like Boomerangs, Swales and Ponds will infiltrate maximum amount of stormwater that would otherwise run off the site. **Soil building** will help hold the moisture inside for longer, along with **support planting** like windbreaks and biomass species for mulch which prevent evaporation from direct sun and wind..
- **Direct irrigation**: Clay Pot irrigation is an ancient method of irrigating dry lands. A closed lid clay pot filled with water can irrigate saplings within upto a 3 metre radius without any loss of water through evaporation. Hand watering in this way also ensures those working on the land regularly observe the plants and can address problems as soon as they arise. Clay pots that suit this purpose are produced by the potters living in CT Palli and neighbouring villages. The clay pots last for around two years, by which time the root systems of the saplings will be established enough to manage on rainfall and passive irrigation from earthworks.



Irrigation Strategies

Irrigation plan

The main source of water for irrigation in the summers is going to be **open well wate**r (new wells that are going to be dug) and in the monsoons each water tank is supported by a sealed perennial pond which will collect **filtered storm water** to be pumped into tanks.

Tanks with 6,000 litres capacity, raised by 5-7 ft above ground level, are placed on the higher slopes so that the water in the **primary and secondary pipelines** can flow with **gravity**. The secondary pipes have **valves** every 50 metres where **hose pipes** can be connected to fill in the clay pots. The existing bore well water connected to the nursery can be used in case of emergencies for the nursery only. The pipes and tanks can also be shifted to a new area when they are no longer needed.

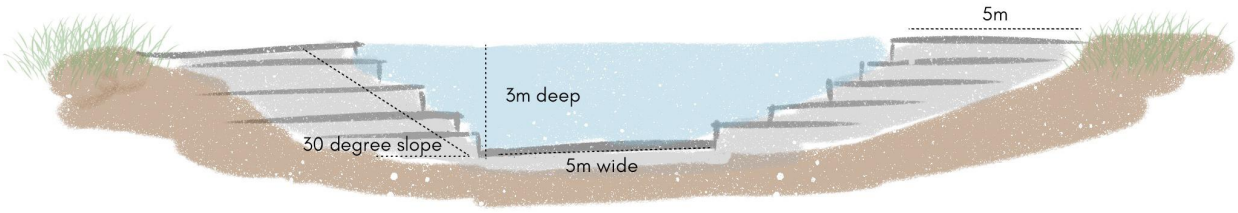
Wild Zone Earthworks

Due to the shrinking water tables, many natural ponds and wetlands dry up leaving wild animals struggling to find access to fresh water during the summers.

Elephants were seen to be breaking pipes near the kitchen to access fresh water. As lake water dries up during the dry season, turbidity levels go up making the water undrinkable. **Artificial watering holes**, that double up as perennial ponds for human use have been designed for easy water access to these animals.

Different techniques can be experimented with for sealing the ponds: cement, clay and lime, gel membrane liner, stones and some can even be left alone for elephants to seal. Smaller constructed watering holes sealed with cement can be added all across site which can be topped off with excess water in the summers until our ponds seal themselves and become perennials sources.

The Kalyani to the north of the habitation zone is an area where the elephants spend a lot of time. This can become an elephant Kalyani, designed with very gentle sloping steps, and which is, on the overall, very wide and shallow so that young animals can easily access the water and make their way out.



Elephant Kalyani

Lake Restoration

The lake at Alphonso is perennial but dries out by 80% during peak summers. The lake remains to be **the main water source for groundwater recharge for CT Palli**. The lake was last dredged in 2019, but there are some other interventions that can take place along with desilting in the next phase

- Lake water seems to be biologically **contaminated**. Those who have drunk the water or swum in it have fallen mildly sick. It is important to direct all the streams around Inlet 2 to allow for maximum inflow of stormwater, and facilitate the formation of **wetlands** here for further filtration of this water. [For a list of wetland species please see Appendix VI.]

- Water infiltrates and evaporates very quickly as temperatures get higher, introduction of **floating macrophytes** like lilies and lots of **trees** for shade along with wetland plants will increase the water holding capacity of the lake.

- The edges of **bundhs** along the lake are very steep. This not only restricts easy access to the lake for wildlife, it also prevents the formation of an **edge ecosystem** which thrives when submerged reeds establish along shallower section of the lake. This perform various functions for the lake like erosion control, fodder, food, nesting site for birds and recycling nutrients and toxins in the water. Therefore, these shores can be smoothened to make **gentle banks** that can be planted with reeds.

- Goats and cattle will be less dependent on foraging the forests if there is more food available at the lake. With some planting efforts and better management of water, the lake can have **fodder parks** along the bunds for domestic animals as well as wildlife. A combination of perennial fodder trees as well as grasses and shrubs can be introduced into the existing edge ecosystem.

- Keeping the eastern side fairly open (for unobstructed views of the lake from the habitation zone), the rest of the lake can be planted densely, especially the southern outlet wetland area following a **dense wild zone** where wildlife can spend time without feeling exposed.

- A **private entry** to the lake on the north eastern corner near inlet 2 with a **Machan** has the best views of the lake. This is a good non-intrusive spot for bird watching and wildlife sightings during the day and at night.

Lake Restoration

Greywater Strategies

Greywater (**GW**) is the wastewater produced from sinks, baths, or clothes-washing; it does not include toilet water, which contains potentially harmful pathogens. Kitchen water can be considered 'dark' greywater due to its high biological content and benefits from one or two additional levels of treatment. As a general rule, if greywater is held or stored for more than 24 hours it becomes blackwater.

Creating a **tight local cycle** through the use of secondary water sources such as greywater enables one to support a **lush landscape year-round**, while using less energy and infrastructure and reducing or eliminating the need for irrigation with potable water.

There could be up to **600 KL*** of greywater produced each year at Alphonso. If treated, this would be enough to propagate **15,000 saplings** in the nursery per year.

Containing organic nutrients such as phosphates, and nitrates as well as bacteria and other organisms, greywater is a **rich source of fertility**. Plants and microorganisms consume and filter these organic materials and utilise them for their growth.

Greywater can either be **sent directly into the landscape** or be **treated in constructed wetlands** to increase its potential use. Both approaches are described in more detail below. But first, some thumb rules need to be followed.

Thumb Rules for Greywater Management:

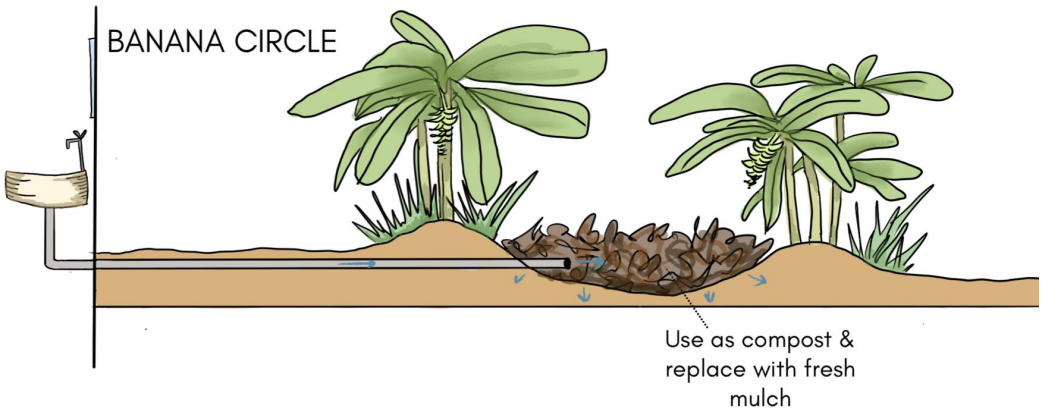
- Untreated greywater should not be drained into deep pits or open wells where it will **contaminate groundwater** sources.
- Only **natural soaps** and detergents should be used for bathing and washing clothes and utensils.
- Greywater must not come into contact with **edible portions** of food crops i.e. avoid using greywater to irrigate root crops or low-growing salad greens that touch irrigated soil.
- Greywater should therefore not be distributed through **sprinklers** unless it has completed tertiary treatment.
- Greywater **should not be concentrated** in areas where it can pool and water log soil.

** Assuming an upper end population of 50 full time residents, 50 part time residents (60 days/year) and 60 day visitors/workers*

Greywater - Direct to Landscape

Direct to landscape systems are usually very simple, the main aim being to ensure the greywater is directed to the **primary root zone of perennial plants**. It can be infiltrated in a mulched pit, swale, basin or can be sent through a planted gravel channel and allowed to infiltrate gradually as it moves through the landscape.

One common system for landscape GW management is a **banana circle**. A dish shaped pit, approximately two meters in diameter and down to 1 meter deep in the middle, filled with mulch (banana leaves, cardboard, paper, twigs, logs, straw etc). The greywater from the house is directed into the circle, where it will go on to feed all the plants. The outer rim of the hole is an bundh made of the earth dug out from the pit. On this bundh, Banana and Papaya trees are planted at 60 cm intervals. Along with these, edible and aromatic perennials such as Lemongrass, Citronella, Tree Spinach, and ornamental Gingers and Heliconias can also be planted. Both Bananas and Papayas are gross feeders and thrive on nutrients from the decaying organic matter in the central hole. Banana circles also make fantastic **compost** heaps.



Another option is to create a **mulched infiltration basin** or **rain garden**. This is a level-bottomed, relatively shallow depression dug into the earth that intercepts and infiltrates rainfall, runoff and/or greywater in the planting basin it creates. This technique works best on flat landscapes where it will have no bundh, so all surrounding runoff can drain into it. Multiple small ones can work just as well as one large one.

Greywater - Constructed Wetlands

To treat greywater so that it is clean enough to be stored in a tank or a pond and be used more widely for irrigation, washing and so on it must be processed by passing it through microbes and plants in an **artificial wetland**, which would remove and detoxify contaminants. Wetlands are nature's way of purifying and recycling water (more about that on page 60).

Domestic wastewater treatment with artificial wetlands involves the following steps:

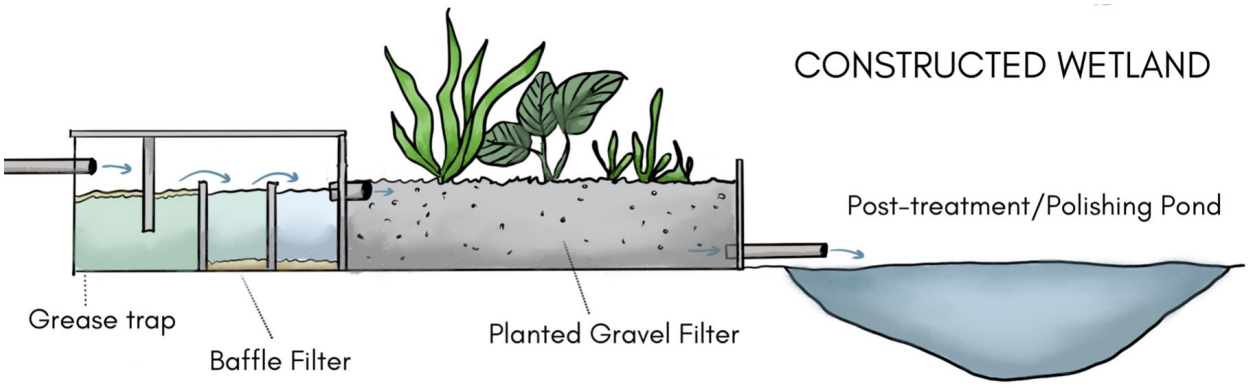
- **Inspection Chamber/Grease Trap**: Generally used to remove larger solids and floating matter if the water is coming from the kitchen or bath. The floating scum is held back by the raised baffle wall, while the clean water flows underneath.
- **Baffle Filter**: The water from grease trap goes to the baffle filter. Each baffle chamber functions as a treatment unit by promoting anaerobic decomposition and removing solid matter and scum in the process.
- **Planted Gravel Filter**: The water then passes through a gravel bed in which wetland plants are rooted. Selected species have a relatively rapid growth rate and are tolerant to nutrient rich feeds. Nutrients are removed through absorption by the plants' roots. Pathogens are removed and eliminated through natural die-off, UV-exposure, antibiotics released by microbes and sedimentation and adherence to the gravel bed. In general 5-7 m^2 of bed area is recommended for every 1000 litres of wastewater. The treated water should be used within 24 hours for garden and cleaning purposes. Excess water is sent to polishing ponds for stabilization.
- **Post-treatment**: This final section of treatment receives the treated wastewater from the planted gravel filter. A polishing pond is where oxygen is dissolved in the water to neutralize smells, while removing remaining pollutants by oxidation and through UV exposure, making the water quality compatible with desired standards. Aerobic ponds are usually between 0.5 to 1.5 m deep with a retention time of 15 to 20 days. If used in combination with fish this type of pond is effective at removing a majority of nitrogen and phosphorus from wastewater. From here the water can be used for washing animal pens or other outdoor surfaces, for irrigation or be sent to a tank for storage.

Greywater - Constructed Wetlands

The constructed wetland must be located **downhill** from the building's greywater outlet (so that it can be gravity fed). It should be constructed to hold at least **3 days** of greywater volume.

Wetlands can be any shape. However, nooks and crannies can result in stagnation, and should be avoided wherever possible..

This kind of system is necessary for **high volumes** of greywater, at the community kitchens and within the habitation zones for example, which would quickly become difficult to manage were they are sent directly to landscape.



See Appendix VI for a list of species and more detailed information on phytoremediation (removal of contaminants by living plants).

Planting

Planting at ABTL

Alphonso is located in a region that has witnessed a tremendous ecological transformation in recent decades, with a loss of biodiversity and tree cover coupled with a drop in groundwater levels to the extent where the open wells have run dry and only borewell water is used for domestic as well as agricultural and industrial needs.

Keeping this in mind, the planting here needs to be aimed at building resilience, having a low demand on existing resources and creating an **ark of floral biodiversity** that will have a knock on effect on fauna as well as the community and culture of the surrounding villages.

The strategy employed here is to create a strong vegetal foundation that requires minimal inputs and maintenance and within a relatively short period of time begins to support all activity on site including habitation and production.

In this section, explore:

- **The Nursery**
- **Boundary Planting**
- **Forest Gardens**
- **Wild zones**

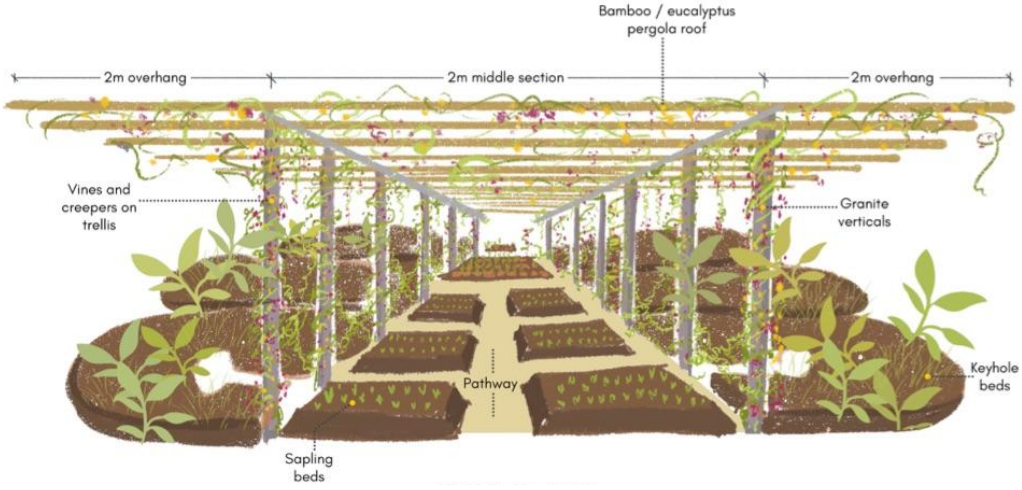
The Nursery

The nursery and seed bank are usually one the first things one sets up on any land regeneration project. The idea being that the project becomes, as early as possible, **independent of external vendors for seedlings and saplings**, thereby reducing costs and embodied energy. Having one's own nursery also allows one to propagate seeds, cuttings and other propagules of **native and naturalised species** - many of which are collected in and around the site and are rarely available for purchase - and plant them with minimum stress or damage.

Conventional nurseries are often a source of plastic waste in the form of grow bags, shade net etc. The aim of the nursery here is to go entirely **plastic free** and act as a new model of how nurseries can be run.
All the materials used are either from the farm or have been sourced from the local area. The structures are designed to be durable without requiring high energy inputs to set up or maintain.

Nursery Set Up

- The first nursery is located in the **community zone**, the reasons being:
  - It is one of the primary hubs of activity (Zone 1)
  - It is close to the entrance and therefore will be visible to visitors
  - Its proximity to the entrance also allows easy transport of saplings in and out
  - Open well water can be piped here
  - Open land is available here, structures can be put in with minimal removal of existing vegetation
  - There is some existing shade from the avenue trees
  - There are protected areas with appropriate sunlight intensity for hardening off young saplings.
- Seeds will be germinated in **seedbeds** (1.2 m x 4 m, 10-15 cm deep) - these will be sunken beds to reduce evaporation losses
- From there seedlings will be transplanted into terracotta pots, arranged in similar sunken **container beds** to prevent toppling and allow for better moisture retention.
- Seedlings will be grown under **arched rebar trellises** and the more established saplings under a more sturdy **granite chappadi structure with a eucalyptus and coconut thatch roof**. These will also act as a support for perennial vines (i.e. Flat Bean/Avare, Sword Bean, Passion Fruit).
- The hardening off area is under existing mango trees and close to the road for easy access and transport.
- The nursery is also designed to house the **seed bank** and a **pottery yard** where potters from the local area can come in and, using clay from the lake, make pots



Nursery Operations

The following information can be used by the nursery head and to train the nursery team.

Planning and Scheduling

- The nursery requires a **species level nursery calendar** - each species has its own season of establishment hence the seed collection, sowing, transplanting and distribution of each species should be scheduled accordingly.
- Maintain **strict records** of sowing time, germination rates and dates.
- **Label** beds with species name & date of sowing
- Seeds should be sown early in the morning (7-9 am) or evening (3-5pm)
- Transplanting, watering, weeding & shifting needs to be done at **fixed intervals**.
- Hardening off & dispatch of seedlings should be done in the proper time
- Engage only **skilled labour** in nursery activities to ensure success

Process

1. ID plants on site from which seeds and cuttings can be collected.
2. Set up a seed bank on site
3. Collect, process, store seeds.
4. Create a list of species to be grown for your first phase of planting
5. Purchase seeds not available on site, from reliable sources
6. Find a nursery head and create a team on ground, ensure they are well informed of nursery procedures.
7. Set up the nursery
8. Propagate seedlings
9. Plant the seedlings come monsoon

Nursery team

Ensuring that the nursery operations run smoothly requires diligence and attention to detail. Ideally the nursery has a head who coordinates all nursery activities, follows the growing schedule, keeps records and communicates all requirements for materials to the project manager in good time.

Nursery Operations

In addition to the nursery head, a full-time team of gardeners is needed to do the daily nursery work, including: propagation (sowing, planting etc); watering; making the beds, transplanting, potting and de-weeding, with Ananas providing guidance on all of the above.

Possible errors

- Containers not filled properly, not upright
- Soil in germination beds not changed between each cycle
- Seeds sown too deep
- Seedlings wrenched out and/or exposed to air after lifting
- Bad or delayed transplanting
- Leaving air space around the roots of young seedlings after transplanting
- Improper pruning while transplanting
- Creating shaggy cuts when harvesting cuttings or pruning
- Neglecting or delaying the hardening off process
- Improper or inadequate labelling
- Carrying plants by the stem

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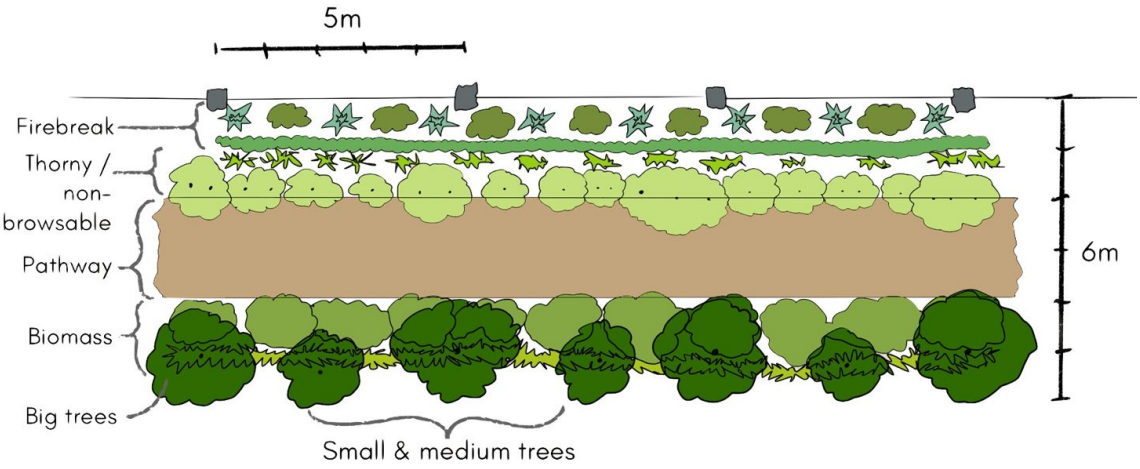
Boundary Planting

Planting the edges of the land with multifunctional fencing lays an important biological foundation for the farm. The living fence is a multi layered hedge that includes a diverse mix of native, hardy, pioneer species. Planned properly, they:

- **Deter** wildlife & people where necessary
- Provide **yields**:
  Short-term: biomass/mulch, poles, beauty, wildlife.
  Mid-term - food, increased soil humus.
  Long term - timber, shade.
- Provide **habitat**, **food**, and **shelter** for a diverse range of wildlife
- **Microclimate**
- **Privacy** (depends on zone)
- Provide **fire protection**
- Act as **windbreaks** (reduce soil drying, wind erosion and stress on plants and livestock, thereby increasing yields within and around the site)

Of course, the more diverse they are, the more you get in return. Multilayered, multifunctional planting like this provides edge habitat that supports ecological diversity. As more species (insects, spiders, toads, snakes, birds and mammals) find food and refuge in this habitat, **natural balances emerge**, yielding, for example, a reduction of rodents and crop-damaging insect populations.



The living fence at Alphonso has **four main layers** and, depending on the zone, either some or all of the layers are present. Which layers go where are illustrated in the map on the next page.

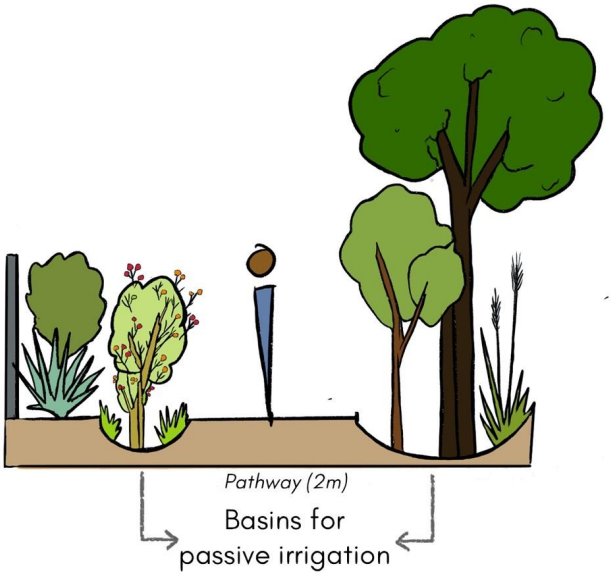
Boundary Planting

Boundary Planting

Features and Details:

- **Multiple rows** –
  - **Fire break**
  - **Thorny/non browsable**
  - **Biomass**
  - **Trees and shrubs**
- Integrated with **earthworks**, in the form of long shallow basins on contour (where possible), for passive irrigation
- Includes a 2m **pathway** for access, maintenance and for additional fire protection
- Should be grown from **self-propagated plants or sown directly** (saves cost, embodied energy, adapted to local conditions, employment)
- **Start in priority areas**
- **Plant all layers at once** (apart from the Tree row which may require saplings, this depends on water availability)
- **Ensure good access** to all layers for easy maintenance
- PVC **irrigation pipes** running along the main path with valves every 30 m to which hoses can be attached allow for easy irrigation. **Clay pots** buried in the beds further reduce water requirements.

For a list of species to use for boundary planting see Appendix II.



ANANAS

Firebreaks

Fire is a major risk at Alphonso, the hills with their dry grasses and lack of evergreens become tinderboxes in the dry season. The boundary of the land, the Western edge in particular, is the first line of defence against fires. In order to protect the farm, in addition to maintaining an observation log of local fire incidents, the following measures are to be taken:

- Sunken **basins** to retain moisture into the dry season
- 1-2 rows of local **fire resistant and retardant species** close to the fixed fence. Use what locals grow e.g. Agave, Milk Bush, Dodonea. When using short lived species, e.g. Dodonea (5 years), plan for succession.
- 2-3 m **road** all around the fence line
- After road, a wall of **evergreen species** to stop hot flow and catch embers
- Removal of **eucalyptus trees** within fire sectors
- Strict **firebreak maintenance** regime 2-3 times a year based on understanding of local incidents. Fire breaks need regular maintenance otherwise they become ineffective. Remove dead debris, water properly.
- Provision of appropriate **water storages** along fire sectors for quick dousing e.g. perennial ponds and tanks
- **Irrigation systems** to put out fires along the boundaries. One long PVC pipe running along the roads, with valves at 30-50 m intervals enable hoses to be attached and used to douse the first signs of fire along the edge.
- Plant species that provide a **yield** e.g. Aloe Vera, Vetiver, so that maintenance happens during harvest
- Create fire **resistant zones** using hardscaping, stone mulching and ground covers.

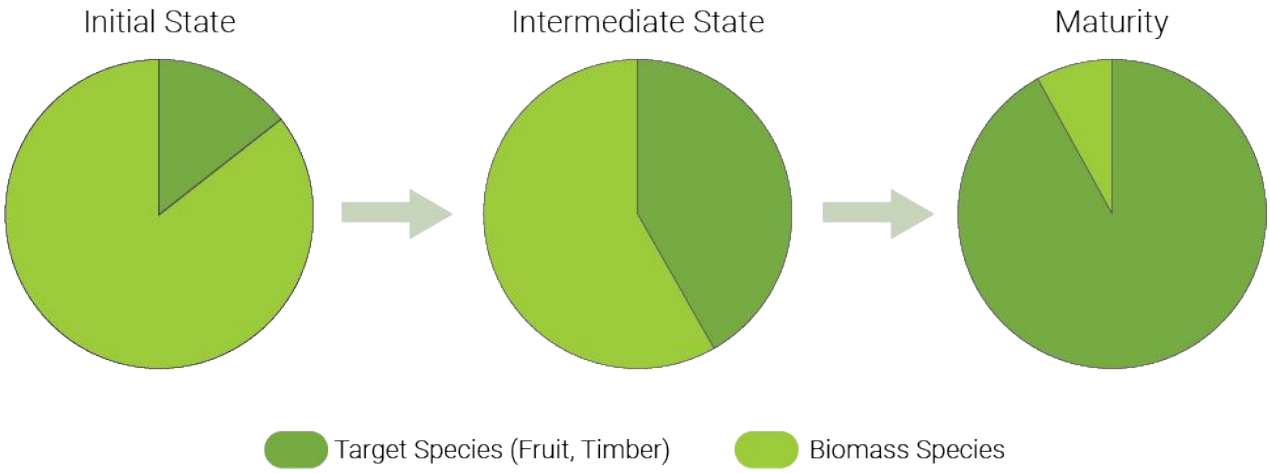
Forest Gardens - Syntropic Agroforestry

Syntropic Agriculture is a way of regenerative farming and rehabilitating land that utilises and accelerates "**natural succession**" - the phenomenon by which nature transforms a barren landscape into a densely vegetated forest.

Syntropic agriculture builds on complex cooperative relationships among members of the living system, facilitated by human stewardardship, in a way that benefits the system as a whole. It recognises the crucial ecological role played by specific plant species that have no direct use (yields) for humans and that are generally not accommodated in other, human-centric agri systems.

In this approach, non-useful/non-harvest species (called "**Biomass species**") are grown along with species useful to humans (e.g. fruit, timber, collectively termed "target species"). The nutrients, energy and mass accumulated by biomass species are subsequently used to aid a growth spurt in target species, via systematic pruning of the former.

This sacrifice of biomass species "hacks" the phenomenon of natural succession and accelerates the whole system's progression to a state of increased biodiversity, enhanced soil health, and domination by target species. Once mature, dominant "**target**" species start accumulating enough nutrients/energy to sustain the whole system, replicating a forest.



Forest Gardens - Syntropic Agroforestry

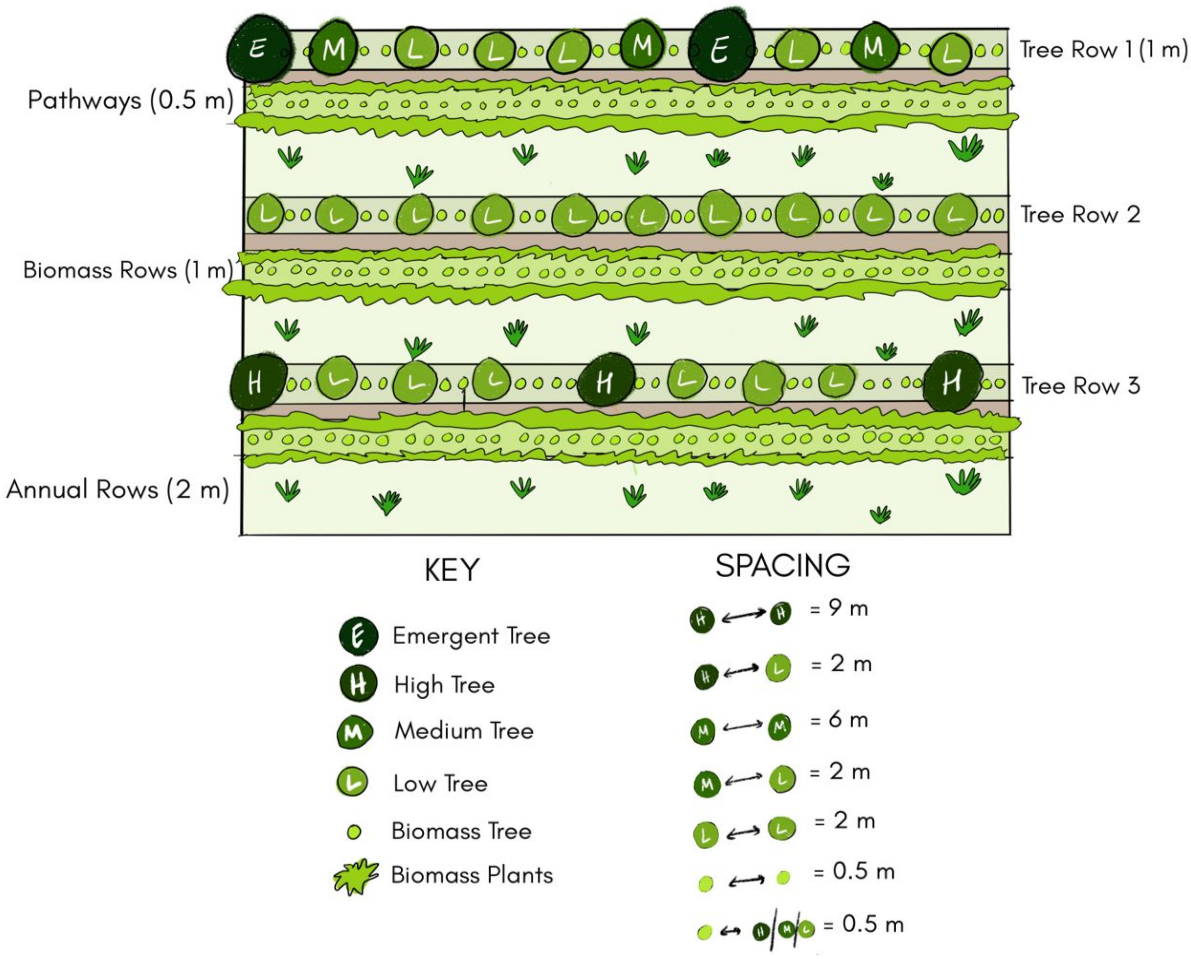
Sun loving annuals and fodder are grown in such a system until the perennial canopies shade out the ground. The nature of produce changes from annuals in the initial years to perennials at maturity.

Besides the year after year improvements in soil health after every cycle of crops, the syntropic forest garden offers a range of benefits:

- **Superior resistance** to disease and insect attacks owing to high biodiversity
- At maturity, the syntropic system **supplies its own fertiliser and irrigation**.
- Even though the perennial, “target” species can take time to mature, the syntropic forest garden can be **designed to produce waves of harvests right from the start**.
- Layered planting **optimises solar energy** thereby producing higher yields
- The **diversity** in vegetation leads to a range of yields in addition to food, including timber, fibre, medicinal and herbal plants, wildlife habitat and beauty.

Site appropriate biomass and target species can be found in Appendix III.

Forest Garden Planting Plan



Pictured above is the planting plan for the forest gardens on **open land** at Alphonso.

The spacing convention ensures that there is **minimal light competition** between tree canopies.

Linear planting allows for easy management, as the system matures the planting pattern will appear more natural. These can be grown along the **contours** of the land, which allow the raised pathways and sunken tree rows to act as earthworks and contribute to **passive irrigation** and **soil stabilisation**.

The spacing between rows allows for easy **annual integration**. If more production from annuals is required, Tree Row 2 can be removed.

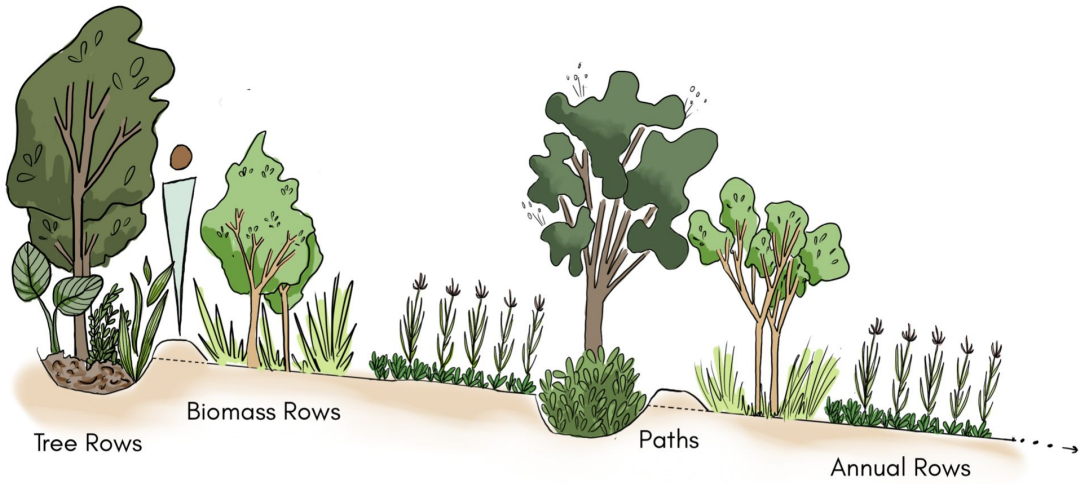
Forest Garden Succession

FOREST GARDENS - YEARS 1 & 2

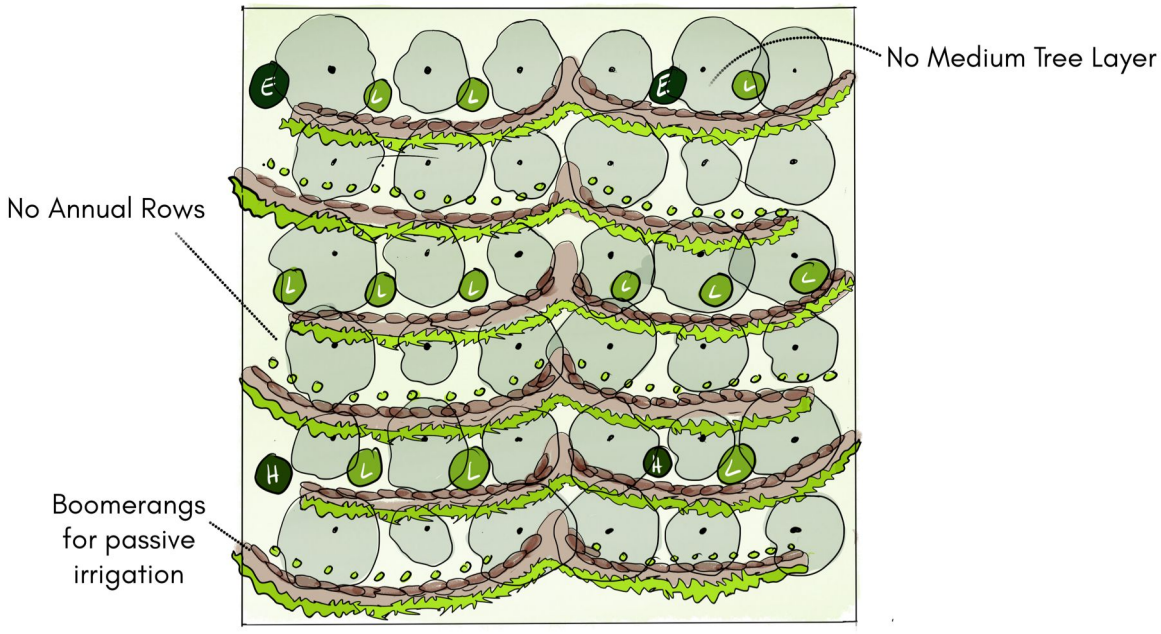
FOREST GARDENS - YEAR 5

Implementation

1. Mark tree rows, pathways and biomass rows on contour using lime or pegs and rope. In areas where wider pathways are required, the width can be increased to 1-1.5 m.
2. Dig out 0.3 m of soil from each tree row and place it on the pathways to create basins and raised pathways, leave the biomass and annuals rows at ground level
3. Divide saplings according to categories (E, H, M, L, BM)
4. Place tree saplings (starting with E and ending with BM), every Low tree is to be planted with either a Banana or Papaya sapling
5. Plant each sapling in a hole 2 times as wide and 1.5 times as deep as the root ball
6. Fill the pit with fresh and dry biomass as well as mature cow dung or any other manure or compost on hand.
7. Water the root ball and the hole before planting
8. Plant clay pots at 2.5 - 3 m intervals along the tree rows
9. Mulch the tree rows with a mulch layer at least 15 cm deep
10. Perennial vegetables should be planted in the tree rows after 3 - 6 months once the tree saplings have started to establish themselves and cast a light shade on the ground below.



Mango Syntropic Planting Plan



This syntropic approach to planting can also be applied in the **Mango orchards** at Alphonso. By adding more trees and biomass species we **increase their diversity, functionality and resilience**.

Here one major difference lies in the fact that the Medium Tree level is already occupied and there will be **no annuals/field crops** between the trees unless they are grown randomly as cover crops in the beginning. **Perennial vegetables** such as Turmeric, Ginger, Sweet Potato, Yams, Gourds and Pumpkins can however certainly be grown below and around the Mango trees.

The earthworks in this system also differ in that instead of linear pathways intercepting sheet flows, we have **boomerangs** to do the same job. In rocky areas, such as the land above the first nursery, the rocks will be used to stabilise the bundhs.

Forest Garden Management

Pruning

A major part of forest gardening involves the removal of parts of plants by pruning, weeding or thinning. Pruning serves the following purposes:

- Sunlight management
- Removing dead and diseased plant parts
- Removing undesirable plants and trees
- Ensure continuous fresh growth and prevent senescence
- Releases growth hormones below ground
- Adds biomass to the soil and creates a protective layer of mulch
- Maintains space between tree canopies
- Keeps plants at the right shape and height for easy harvesting

Biomass Trees can be pruned when they are about 3 m tall. A sharp tool must be used and the top of the tree can be cut at an angle at chest level. The leaves should be removed from the branches and the branches be put on the ground first before being covered by leaves. Wood is an important component of soil fertility as it encourages fungi. Throughout the year, the lateral branches of trees can be cut to ensure the annual rows receive the right amount of light.

The biomass grasses and herbs must be **chopped and dropped** regularly, as will the Banana and Papaya trees as and when they reach the end of their lifecycle. These provide a huge amount of moisture as well as nutrients.

The **heaviest pruning should be done at the beginning and end of the monsoons**. Pruning right before the monsoon and the subsequent rain would create the right window for trees to bounce back and grow. End of monsoon pruning would make sure that the ground is shaded and kept cool as the dry season advances.

Production from annuals

Annual crops will be grown in ‘alleys’ between rows of biomass plants on contour. Biomass rows also act as internal windbreaks and bring in wildlife for pest management. And also intercept and infiltrate water. Some thumb rules:

- **Alternate crops** to reduce pests - grow something different in that field the next time

Forest Garden Management

- Have **diversity** in the field - mix of pulses, oil seed, grains e.g. sesame and groundnut with ragi, sunflower. Depends on availability, of course, but the mix of textures, flower colours etc throws the pests off
- Ensure plenty of stones/boulders/dead wood etc are left around the fields as **habitats** for predatory insects.
- Use **rotational grazing** practices to increase soil fertility, reduce pest pressure and prepare the fields for the next crop.

Animal Integration

The problem

- Overgrazing leading to **desertification**.
- Decline of animal health and productivity due to **depletion of desirable forage and decreased nutrition**.
- Changes to the flora profile and soil structure results in **biodiversity loss and erosion**.
- **Lack of financial security** for the pastoralist community due to land degradation and increased ecological uncertainty.

Intensive rotational grazing & its benefits

- **Nutrient cycling** - ruminants and chickens invigorate grass growth, speed up decomposition and distribute nutrients evenly through manuring.
- Trampling and scratching create tiny earthworks, microclimates ideal for **seed germination.**
- **Increased fodder diversity** for livestock - annuals, perennials, trees.
- Increased **carbon storage** - Mulching is useful for building soil carbon but is ultimately unstable and used up rapidly. The most stable form of carbon cycling comes from growing and re-growing of plants coupled with planned grazing which encourages continuous, deep root growth.
- Encourages **water infiltration and retention in soils** - The growth and decomposition of roots results in a dense network of capillaries that facilitate water infiltration and storage underground.
- **Land preparation** for first crops or reseeding - reduces machinery cost
- **Conserves domestic animal biodiversity** and **indigenous knowledge.**
- Promotes **grassland regeneration.**

Animal Integration

Method

- **Meet with the pastoralists and understand**:
  - Current problems
  - Seasonal routines
  - Animal feeding habits, behaviours and preferred fodder species
  - Breeds - current, preferred, lost
  - Ethnoveterinary practices
  - Discuss rotational grazing and modify based on their inputs and recommendations

- Identify livestock keepers for rotational grazing **pilot project** at Alphonso.

- **Annual rows become paddocks** with the help of a temporary, movable fence.

- **Planned migration** - keep the animals moving. Leave them in paddocks for a day to two weeks depending on count and species, then move them on to the next paddock. Rest periods for regeneration of grasses is a key aspect of this system.

- **Mixed grazing** - graze the animals in sequence. Cattle, then chickens then goats. Or cattle, then chickens and goats together. Experiment.

- Ensure drinking **water sources** - In the syntropic forest gardens, irrigation lines will provide water. Ponds and swales can also be lined to create perennial sources of drinking water for the animals.

- **Dry season** - Cut and feed as well as open foraging. Ensure a diversity of food sources e.g. dry and cut grasses, *Acacia leucophloea* pods

Animal Integration

Challenges

- **Fencing** - since the animals will be within intensive production zones, they have to be contained. Temporary fencing can be moved and thereby reduces costs.
- **Labour and observation** - the animals require constant observation and the system itself will need be be continuously tweaked. This makes it labour intensive and means it might take a few years to arrive at a system that works.

Rehabilitation of existing grazing lands

Here we suggest that the animals be integrated into the forest gardens to increase fertility and reduce grazing pressure on the wild lands i.e. grazing in the forest does not have to come to a complete halt. In fact **well-managed pastoralism helps land regeneration**. Therefore, the wild zones and the forest itself can be used for rotational grazing. Following the completion of the pilot project at Alphonso, the scheme can be expanded to a village-level programme, with common lands being divided into paddocks and animals cycled through systematically.

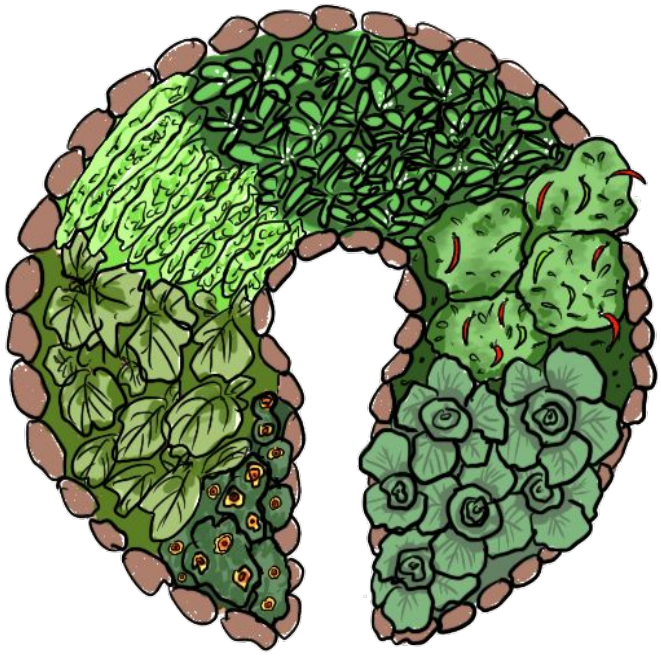
Kitchen Gardens

While the primary production spaces within Alphonso will be its forest gardens, the highly intensive zones of production, such as the Farmer's Quarters and the Habitation and Community Zones, will also contain **small-scale kitchen gardens**. These require **higher maintenance** than the forest garden, and consist of raised beds used for growing annual and perennial vegetables, herbs and flowers in **dense polycultures**.

Raised beds allow for easy access and quick soil building. They can be filled with organic matter and thereby create fertile soil on poor soils quickly; they also drain well.

We suggest creating **'keyhole'** beds (see image below) which allow for maximum growing area and minimum pathways. This means all parts of the round bed are within reach when standing inside the keyhole pathway leading to the middle. The beds can be up to 2 feet high (height being dependent on who uses it and the materials used to create the edges.) Bricks fall easily and absorb a lot of moisture. Sticks, logs and large rocks work well - but the idea is to **use whatever is at hand**. Clay pot irrigation works in raised beds too.

For a list of perennial vegetables, refer to Appendix III.



Wild Zones

Zone 4

This zone is **semi-wild**. Wild fruits, perennial vegetables and timber trees can be grown here. Accessed only for harvest of fruits or pruning of trees, this zone acts as a buffer between the actively farmed zones and the wild zones. Grazing and wild animals will have access to this zone once it is established. The function of this zone remains to be a **shared ecosystem** for humans and all wildlife, where we experiment growing food with minimal intervention, and to **change the habit of always actively extracting from all parts of the land**.

Marked below is the Zone 4 of ABTL, which will be planted with trees, grasses and food crops for all. This zone will have corridors for larger mammals like Elephants and Bears, as well as for ungulates and smaller mammals. The idea is to let them occupy this space freely between dusk and dawn and remain contained here. This zone is also important for the conservation of some endangered species like Antelopes and Bengal monitors that may find this space safe to rest and nest. This zone will only be passively irrigated, containing only resilient native species that will continue to thrive even during the long and dry summers. See Appendices IV & V for plant lists.

Wild Zones

Zone 5

This zone is left **completely wild**. Because it usually needs **no intervention**, nature thrives here with great biodiversity and achieves its own equilibrium over time. Birds and other wildlife disperse seeds here to allow for natural regeneration facilitating an organic exchange and influence between ABTL's restoration efforts and its forests and wetlands.

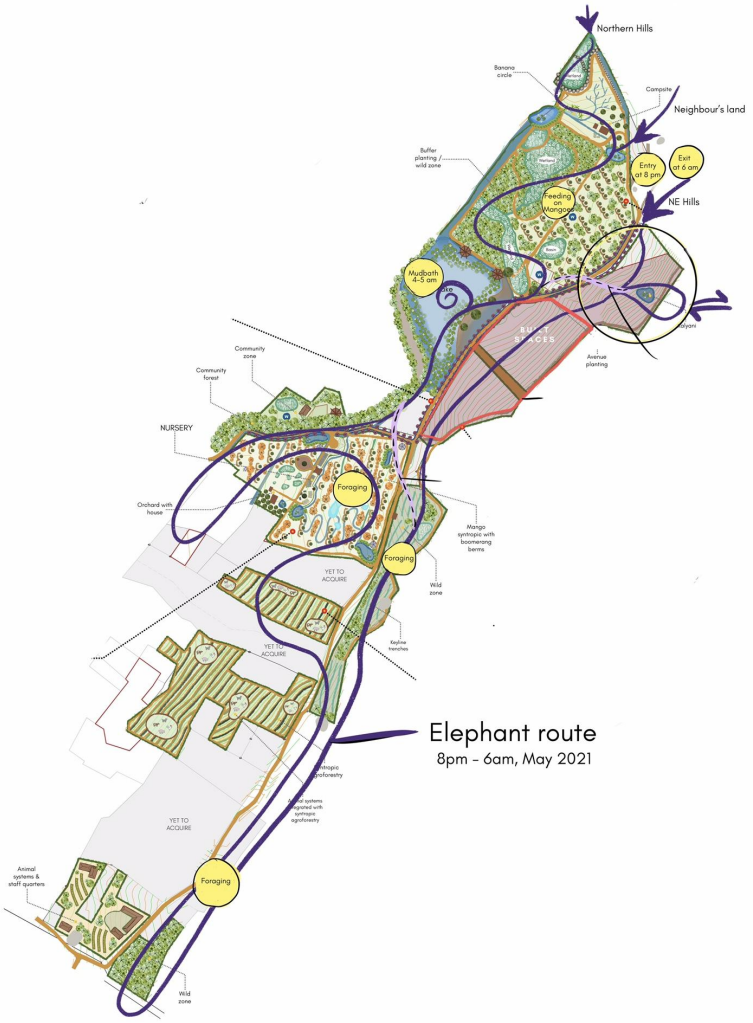
The main function of this zone is to allow for **observation** and **learning** from the wilderness, a space where we can observe how to mimic nature, which is one of the foundational principles of permaculture. Consisting of **water bodies**, **wetlands** and **forests**, this is home to all the native/naturalised flora and fauna in the region.

At ABTL, since the forests have been heavily extracted from, some (minimal) interventions are needed to allow the forest to mature. Introduction of endangered/missing species, education and awareness of better forest land management is needed. Some strategies for intervening holistically into these socio-ecological issues include, but are not limited to:

- **Awareness workshops** on soil, water and vegetation to help the villagers interconnect how trees are linked to climate and rain
- **Design and maintenance of fodder parks** in the lake and other common areas, and a **rotational grazing** programme, so the shepherds can follow seasonal and sustainable grazing patterns and also take part in regenerating the forest
- **Documentation of older pastoralist communities and their knowledge** on the upkeep of the forest health which seems lost on the youth now. If they can be persuaded to understand the ecological value of these rich ecosystems and their services they are more inclined to protect it instead of destroying it.
- Finding and creating **other forms of livelihoods** so people are not dependent on commercial farming activities alone.
- **Education/awareness programs on conservation and reforestation with the women and children**, aided with events revolving around planting drives on the hills done with the shepherds and farmers.

Design for Elephants

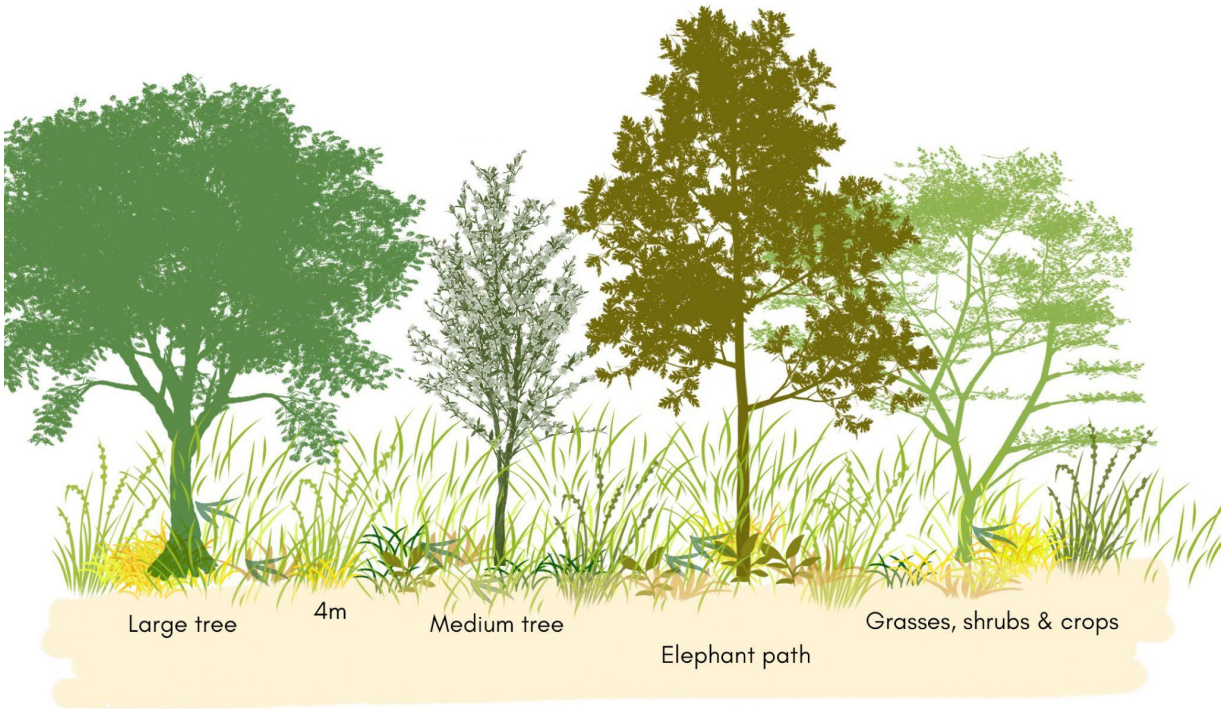
Elephants are generalists i.e. they feed on a wide variety of flora. They are both grazers and browsers, grazing mainly on tall grasses like Themeda and Cymbopogon species but also browsing on a variety of trees and bamboo in the Nilgiris region.
While they are known for depredation of crops grown by farmers, they are actually very intelligent creatures and play a **vital role as forest gardeners** in maintaining the health of these ecosystems. Studies have shown that they follow the same foraging patterns as they did centuries ago, but their habitats get fragmented and they end up having to stray into farms in search of food.
Two families of elephants were seen in ABTL in the month of May 2021, for the first time after years, feeding mainly on the ripe mangoes and some other foliage and barks of trees on site. The map below shows their movement and behaviour around the site.



Design for Elephants

Feeding behaviour

They are known to have **seasonal movement** with **optimal foraging strategy** that does not destroy the cycle of crops. They feed on grasses mainly during the wet season after they have matured, and restrict themselves to feeding on sedges and grasses growing along streams during the dry season. Browsing of leaves on trees is seen during the dry months, and when there is no foliage they feed on twigs and barks of trees. After the first rains, when the grasses are plenty, they feed on the new growth and are observed to feed on different parts of the grass through different seasons.
Feeding on cultivated crops shows similar behaviour, they selectively pluck the terminal portions of crops bearing inflorescence. Some crops like banana, sugarcane and coconut trees are uprooted and eaten as a whole. A **planted corridor** along all the elephant trails may contain them to zones 4 and 5, thereby preventing them from venturing into the forest gardens and habitation zones.



Elephant corridor

Design for Sloth Bears

Behaviour

The sloth bear is the most widespread of the 4 bear species found in India, ranging from the foothills of the Himalayas to the southern part of the western ghats. These bears have a distinctive shaggy fur, a strong sense of smell and long snouts that they use to suck up insects.
They rest in their dens (caves) throughout the day and come out at dusk to start foraging. They have been known to share dens with porcupines for reasons unknown. They mostly remain nocturnal, although they can rarely be seen during daylight hours. Sloth bear mothers find new dens to birth their cubs, and are known to do so closer to human habitats. The mother does not leave her den for 3-5 weeks, and young cubs hitch rides on their mothers' backs once they are ready to venture out.

These bears are not generally aggressive and will do everything to avoid contact with humans. They do get startled easily, in close quarter encounters, because of poor vision. When startled/threatened, they can get very aggressive, and are known to charge at and attack people. This behavior likely evolved as a survival mechanism against tigers, elephants and other large animals that they share their habitat with. Mothers with cubs are known to fight off and hold their ground against tigers twice their size, and against attacks by more than one tiger back to back.

Habitat loss and fragmentation owing to human activity has increased instances of Bear-Human conflict. They're poached, and are also victims of road kills, deaths at barbed wire fences in agricultural landscapes, wire snares and explosive food baits. The species is **listed as "vulnerable"** by the International Union for Conservation of Nature. For obvious reasons, they **perceive humans as a threat**, so it's important to respect their space.

Feeding

Sloth bears are omnivores, feeding on plants and insects. The composition of their diet depends on the density and type of forest, though in a majority of cases, their diet comprises fruits and insects. Meat is a small component of their diet. They're **opportunistic omnivores** (they eat meat only when they come across carrion).

ANANAS

Design for Sloth Bears

Guidelines

Sloth bears dwell in the surrounding hills of ABTL. They have been sighted near the kitchen, their scat observed on the campsite and all around the northern forests (including scratch marks on trees). Staff have also reported occasional bear grunting and huffing sounds on the eastern border in the mornings. Although there have been no reports of bear attacks in the area, including on shepherds that walk through the forests daily - one must follow these guidelines to avoid potential conflict.

- **Visits to the forest to be restricted** to peak daylight hours (9 AM - 4 PM) and always accompanied by a local who routinely does these walks. Encounters during day time cannot be ruled out.
- **Travelling in groups** is safer. Research indicates groups of 2 or larger are rarely attacked.
- **Making noises** with walking sticks or chatting will alert the bear to human presence and give it time to retreat. Bells/Phones can be used too.
- Food scraps disposed outside the kitchens and homes can attract them to enter human zones. This also invites a lot of other creepy crawlies so **good wet waste management** is essential.
- Bear-Human conflict witnesses an **uptick from December to Feb** (when cubs are born), and then again in **the summer months**. Mama bears will fight tooth and claw if they sense their cubs to be in danger, so it's important to **understand their mating and birthing cycles**.
- In the event you encounter a bear, if the it hasn't seen you, **retreat slowly from the scene. Walk backwards slowly while facing the bear.**
- If the bear sees you and attacks, fall to the ground, curl up into a ball and cover your face and neck. Research has shown that no deaths have been reported for people who fell to the ground and didn't fight back. Running away isn't as effective as a bear can outrun humans.
- If in a group, do not surround the bear. If given an safe route to escape, it will escape.

Wetlands

Mysterious, overlooked and undervalued, wetlands are ecosystems that provide **innumerable services to the maintenance of planetary health**. Hugely diverse ecosystems, wetlands can be found in many forms in every continent. From inland wetlands such as marshes, ponds, lakes and bogs, to coastal mangroves, lagoons, tidal flats and coral reefs; what they all have in common is that they provide a link between land and water. These kinds of edge habitats are hugely important, performing a range of essential services including water purification, soil stabilisation, flood control, carbon sequestration (absorbing upto eighth times more carbon than any other ecosystem) and supporting a wide diversity of animals and serving as nurseries for many species.

The design for Alphonso aims to prioritise the existing marshes in the Northwest and around the lake which have been been neglected and, at times, systematically removed over the past few decades. These intermittently flooded wetlands not only need to be protected, but also reshaped, expanded and extensively planted in such a way that ensures all trophic levels are represented.

The map on the right shows the **proposed wetlands** for the northern section of the site. The defining feature of these shallow basins is that they are dominated by plant species that are adapted to growing in seasonally or continuously flooded soils and are comfortable in the resulting anaerobic or low oxygen conditions. For a list of these plant species, please refer to Appendix VI

The wetlands along the western edge also act as **fire breaks** with the majority of the fire threat at ABTL originating in the western hills.

Wetland Regeneration

For details on how the wetlands are going to be regenerated in and around the **lake**, go to page 26. As for the on-land wetlands in the north and northeast, the procedure for re-establishment is as follows:

1. **Understand inflow and cascade**
    a. The wetlands capture sheet flow and erosion from the surrounding land, direct rainfall and overflow from the ponds in the northwest and northeast. This cascade needs to be understood clearly so as to allow a smooth flow from the highest point in the northwest corner down into the lake.

2. **Excavation and shaping**
    a. Mark the outline of the new wetland according to slope and vegetation density (select areas that require minimal disturbance and removal).
    b. Create a shallow basin by removing 3ft of top soil, this can be done by hand or with a JCB. The soil can either be placed around the edges to create a shallow bundh, be used to create an island or be taken away for other earthworks.
    c. Create the overflow points using a Bunyip, Dumpy or Auto level
    d. Finish the edges of the wetland by hand, ensure there is a very gentle slope around the whole basin. Animals should be able to walk in and out with ease.

3. **Seeding and planting**
    a. Plant the edges with grasses (e.g. Vetiver) and emergent macrophytes (e.g. Typha)
    b. The rest of the plants will self-seed and colonise the new basins from the nala

4. **Maintenance and monitoring**
    This is a crucial step in the management of a restored wetland, and when done well, the wetland will continue to be a vibrant natural habitat for many species of plant and animal life for generations to come. Maintenance involves:
    a. Reseeding and replanting
    b. Level adjustments based on observations
    c. Desilting

The Built Environment

Fencing

Fence ecology (the effect of fences on life forms) is a relatively new discipline.

Traditional, impermeable fences tend to restrict wildlife movement and many animals and birds get tangled in them while trying to cross them. Bats, owls, owlets and eagles are especially susceptible as they tend to dive down while hunting and notice the wires too late.

Besides individual fatalities, the presence of fencing over a large region can fragment a species habitat and isolate populations into small groups that cannot mingle and breed with each other. Eventually, this causes loss of genetic diversity and make them susceptible to local extinctions.

While no fencing is ideal in areas close to prime wildlife habitat, at Alphonso, fences are necessary to keep the grazing cattle out and rehabilitate the land. To maintain a balance between our requirement for a fence and that of wildlife in mind, we can design an outer, wildlife friendly fence that keeps the cattle out, while allowing other species to traverse through the landscape.

The fence design parameters we have arrived at are based on North American wildlife friendly fences (a new concept even on that continent), and based on inputs from Indian conservationists and wildlife rescue experts.

More **impermeable** fences can be erected around **residences/food forests/nurseries/veggie gardens** to keep them secure. These fences will lie inside the land and will seal off smaller patches of land.

The outer fence should be designed to provide wildlife free travel to important habitats and corridors, as well as access to water. **Wetlands and riparian habitats** are especially important for all wildlife.

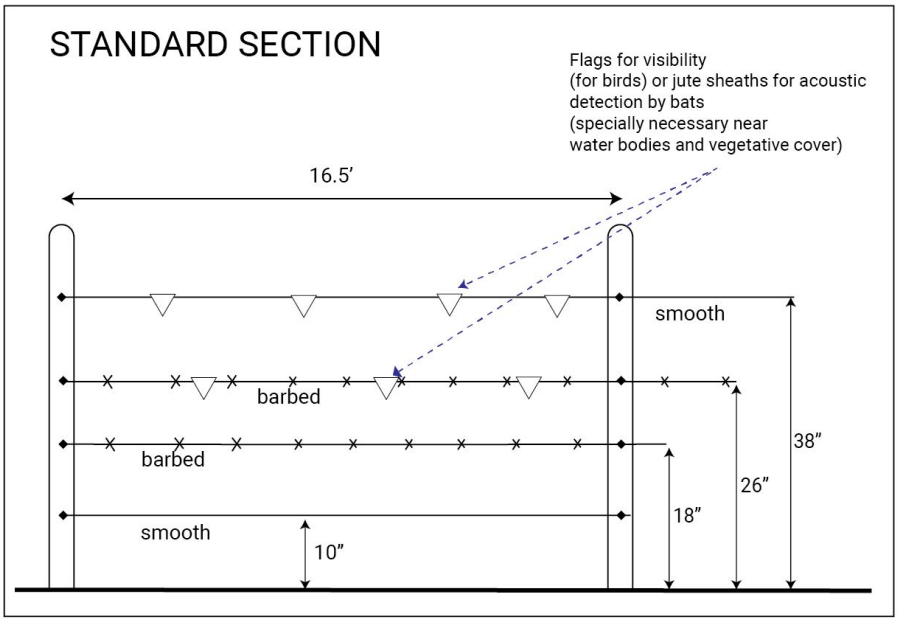
Fencing

For Alphonso, we recommend an outer perimeter fence with 2 different sections to achieve this. This would suffice for all animals except for elephants (discussed later).

Requirements:

1. The fence should be **highly visible** to running and flying fauna.

2. The highest and the lowest wires should allow wildlife species to either jump over or crawl under them. The standard section shown below will take care the first requirement while keeping the goats and cows from coming in.

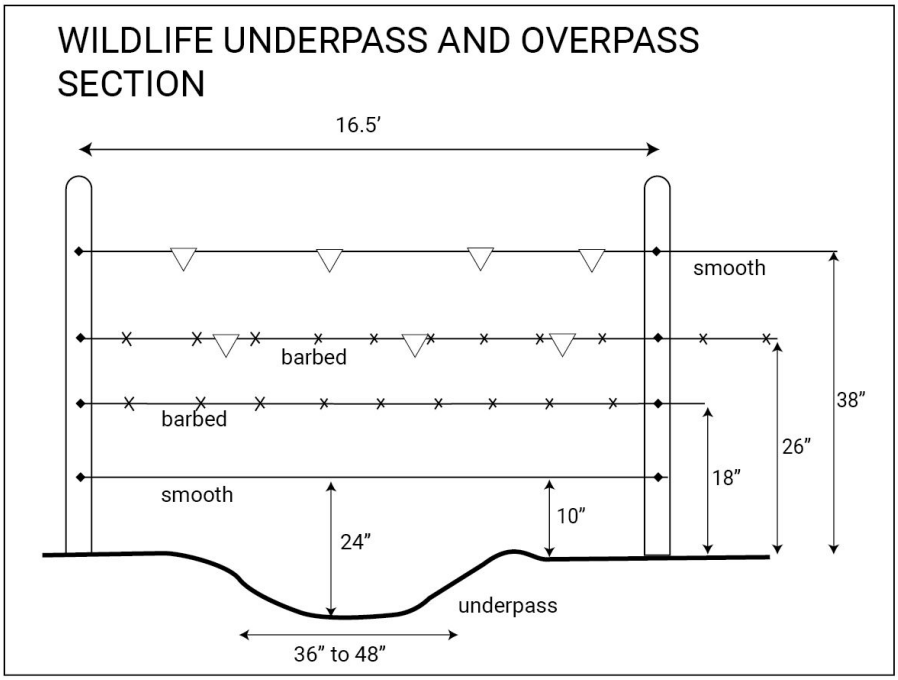


The distance between poles/posts is 16.5 feet.

It is important to use smooth, **barbless wires for the bottom most and the topmost strand**. A line of **bright white cloth flags** should be hung from the topmost wire for visibility (though this may not work for bats and nocturnal birds). Four flags for the topmost wire and 3 for one of the middle wire for every section (16.5 feet) is recommended.

A gap of 12 inches between the top two wires is also important to prevent foot entanglement if an animal hops over the fence.

Fencing



The wildlife underpass and overpass section **is a critical part of the wildlife friendly fence** that would allow larger species to traverse the land. The topmost wire will have a white flagline for visibility. And a depression will be created to allow a "hole" 24 inches wide. Alternately, the lowermost wire can be lifted and bound to the wire above (using a simple binding wire) to provide more space on the sides. Which method is ultimately deployed depends on the situation on the ground.

Location of this section:
The location of these sections will depend on our observations and understanding of sectors and flows (human, cattle and wildlife entry/exit points and movement) across Alphonso.

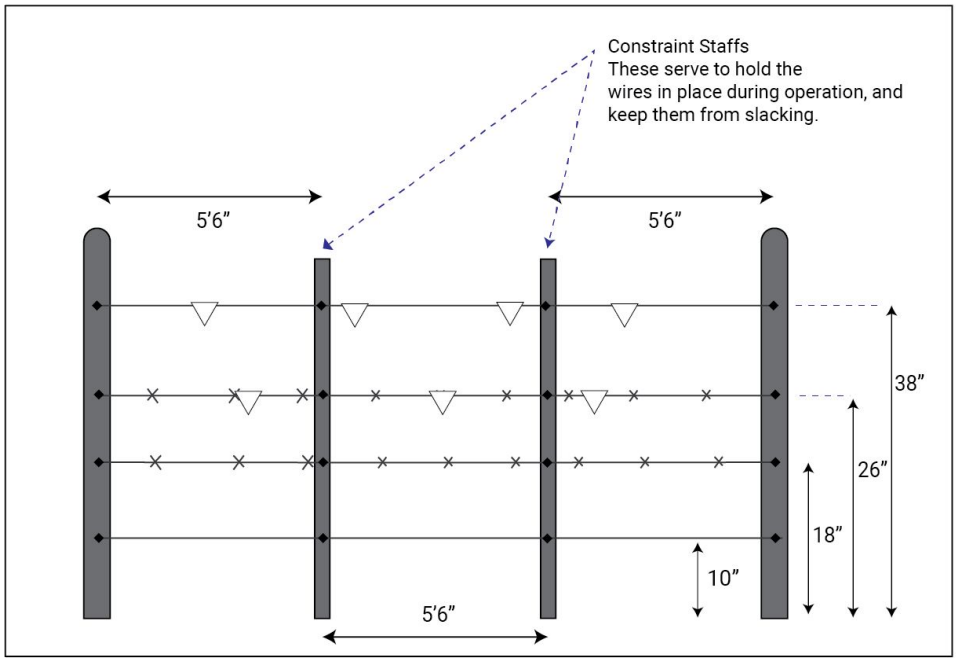
These will be closer to observed animal trails, streams, wetlands and forest edges. In addition, on a regular stretch of fence, a wildlife underpass/overpass section should be installed roughly every 400 feet. We'd also try to place these sections at perimeter corners/vertices, since certain animals are able to find openings/exits at corners.

We'd like to thank wildlife experts Dr. Arun A Sha, Dr. Prakash Mardaraj and Dr. Yoganand K for their inputs.

Fencing: Drop Down Sections

In light of the visits made by elephants in 2021, we will also be incorporating “drop down” sections in our fence. As the name suggests, these sections of the fence can be dropped or removed when needed.

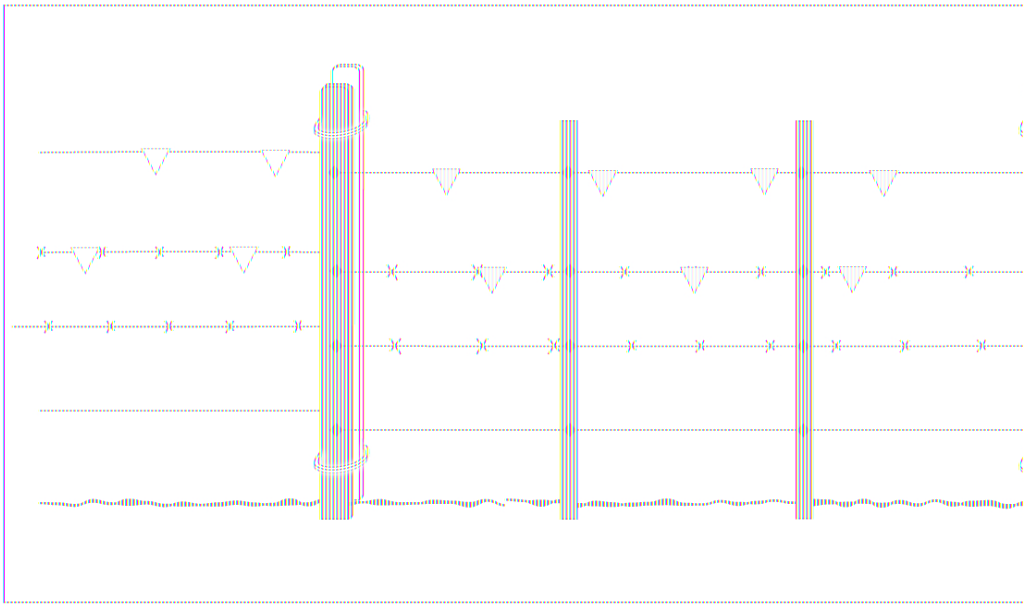
Carefully placed drop down fence sections will give the elephants an opening and would reduce the likelihood of their taking down the fence elsewhere in order to get in. After the animals have moved on from the area, the fence can be brought back up to keep the cattle out.



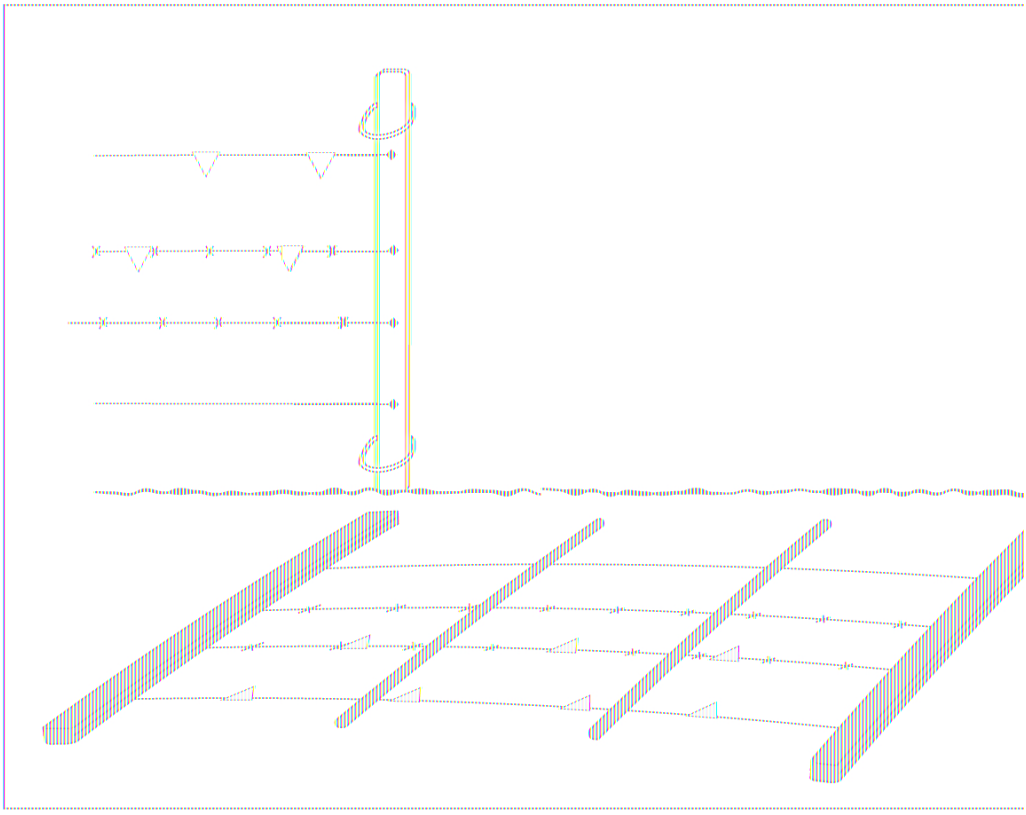
A drop down section. Wire types (barbed/smooth) and the gaps between them are the same as other sections. This section isn’t fixed to the ground. Two constraint staffs are provided to maintain wire gaps, which would otherwise be subject to distortion when the section is moved.

The next page explains how the drop down section fits in with the rest of the fence.

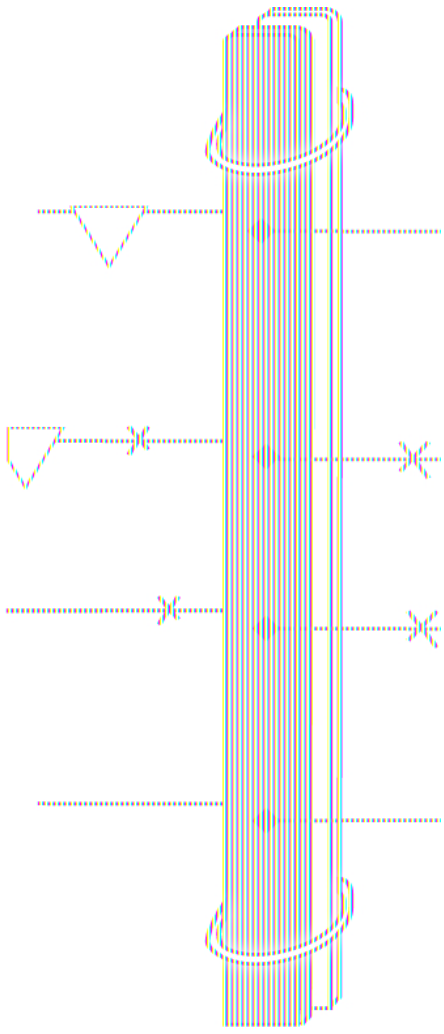
Fencing: Drop Down Sections



The drop down section (dark) is secured to the fence (light) using wire loops near the top and the base of the staffs.



Fencing: Drop Down Sections



The Base loop is permanently secured around the standard fence pole (light).

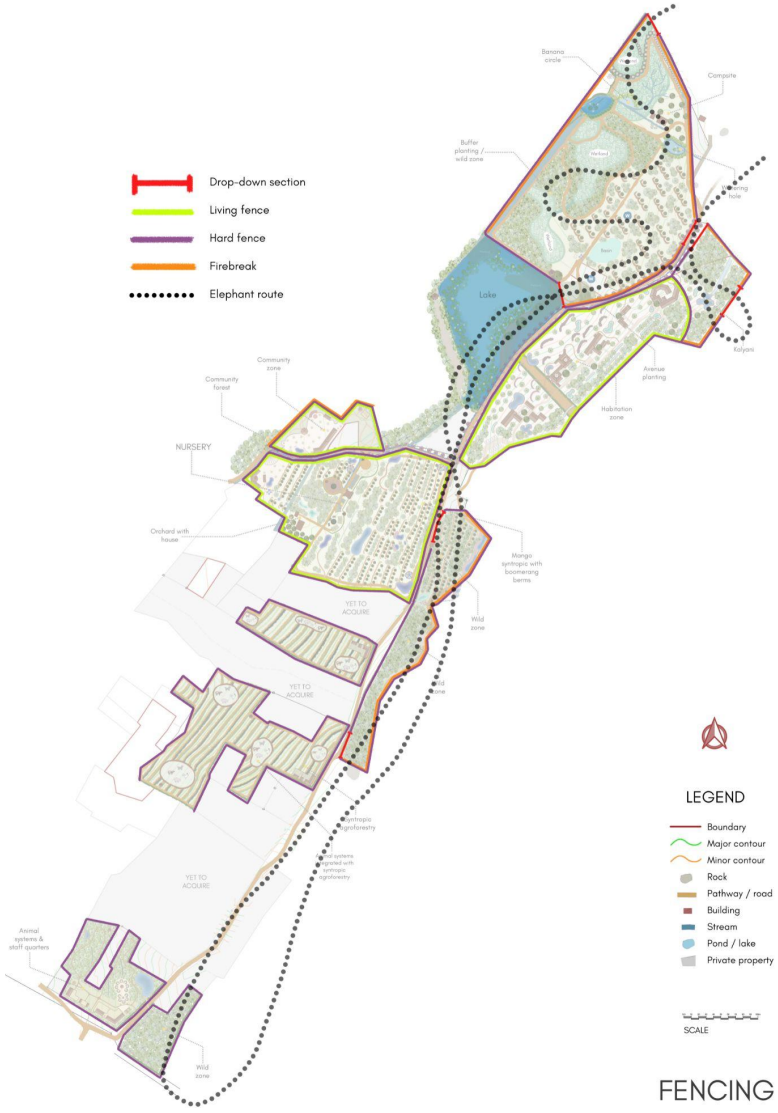
To erect the drop down section (dark), it is placed base first into the base loop, with both poles parallel.

The top loop is then flung over the two poles and is used to secure them.

To “drop” the section, the process is reversed. (1. Remove the top loop. 2. Pull out the drop down section. 3. Welcome the elephants in).

Location of Drop Down Sections

While our design is very **inclusive** and elephant movement generally does not cause any disturbance as they tend to avoid human habitats, it is best practice to avoid any surprise encounters with them while they are still exploring new routes for foraging at ABTL. The **non-browsable living fence** along with the hard fence will deter elephants from entering the farms and habitation zone. But while the plants establish themselves into a thorny physical barrier, the hard fence can be combined with bee boxes, minimal lighting (infrared triggered lights or dim solar powered lights through the night). We have marked some parts in red (in the map below) as drop down sections, where the hard fence can be temporarily removed or collapsed for free movement of these pachyderms.



Community Zone

LEGEND

- Building / shed
- Lined pond
- Swale (1.5m wide)
- Pathway
- Gazebo / machan
- Living fence
- C Compost
- E Entry

0 10 20 50m

Scale

COMMUNITY ZONE

Community Zone

The evolution of this zone will play a big part in the ecological, economical and social regeneration of Aphonso and the protection of its surroundings.The space will provide a safe haven where community can comfortably gather, exchange information, resources, earn an income and take back with them new thoughts and ideas which will empower them to live a synchronous lifestyle with their surrounding environment.

Here are some of the **important functions** of this zone.

1. **Open Ground / Marketplace:** This area will provide a common space where people of all ages residing nearby can come together throughout the year to relax, sell their goods at the boutique store, market their services to other people or seek expert advice in particular trades. Skills in all forms can be taught by the people themselves or understood from the regenerative systems on display i.e. Gardens showcasing companion planting, guilds, herb spirals demonstrating the functional use of space or different composting techniques. Local festivities, village gatherings, celebrations are all welcome here. Children can use this space to learn and play. Open areas can be used for drying of seeds.

2. **Infirmary:** A doctor or traditional healer could be present to administer general medicine to the community using locally grown flora.

3. **Kitchen & Dining Space:** The kitchen and dining space will house locally trained chefs and welcome anyone who needs resources to get meals cooked or just eat at an open dining space at any time throughout the year. Members of the community can learn how to grow, harvest and use indigenously grown food and manage kitchen waste.

4. **Office / Library / Internet Cafe / Seed Bank:** The existing structure on ground will be retrofitted to have a small office cum reception for anyone who seeks any information on the strategies being adopted at Alphonso. The space will have a small library along with a few computers where people can access the internet and a storage for seeds collected over time.

5. **Processing Unit / Tool shed / Storage:** This structure will be the processing, storage and distribution unit for all the produce/ products created on the farm. The structure will be designed to ease access for, loading and off loading produce and house all necessary tools required for the maintenance of the community zone.

6. **Temporary Living Quarters / Workshop:** Few staff will use this space as a living quarters for security purposes and to manage the community zone. A part of the structure will be available for people to use the space as their own temporary work station.

Staff/Farmer's Quarters

LEGEND

- Building / shed
- Unlined infiltration pond
- Swale (1m wide)
- Mud pathway
- Gazebo / roofed platform
- Keyhole bed
- Rock channel / gully
- Boundary planting
- Compost

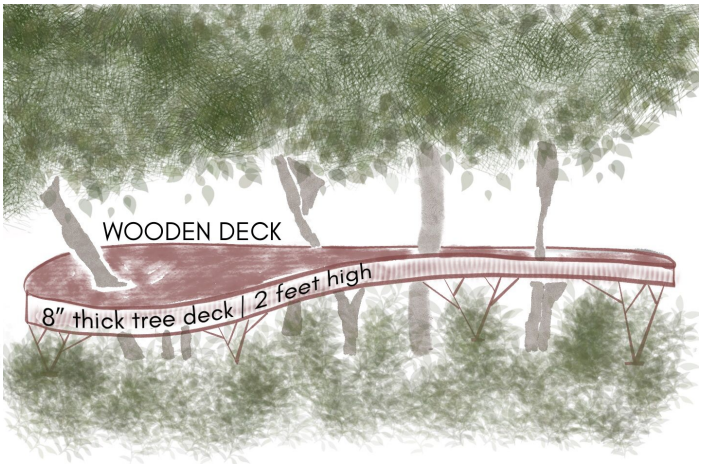
0 10 20 50m

Scale

STAFF / FARMERS' QUARTERS AND ANIMAL SYSTEMS

Existing Camp Site

The existing campsite to have **machans** (pictured above) and **tree decks** (pictured below). These will be wound around the existing tamarind trees. Essentially, we'd like to keep the human movement on the ground minimal and have connected it with decks all around. One can sit, walk, relax on these decks and machans. They're non intrusive and offer protection for both humans and animals.The idea is also to be able to use these platforms during the rains and not particularly disturb the wetland below.



Energy Systems

ANANAS

The Story of Energy

Humans have used energy to improve quality of life, process food, and to power livelihoods since we learned how to build a fire. At a small scale this was sustainable, and we enjoyed the plentiful resources provided by the sun and the wind, and the forests and water ways nearby where we lived. The problems started when we learned how to extract and burn fossilised energy, releasing carbon into the atmosphere that had been locked up for millions of years, causing the global climate crisis now gripping the world.

Renewable energy generation has developed in response to this crisis; solar PV for example is now the cheapest source of energy in India. It is now possible to power livelihoods and food processing, as well as keep our buildings cool and lit, using just sustainable energy sources.

Decentralised energy is a renewable source of energy available at the point of consumption. We no longer need to build large, centralised power stations, distributing energy over hundreds of kilometres. The energy systems of the twenty-first century will consist of collections of **local** energy systems, **integrated** into a wider energy grid. Communities will become **producer-consumers** of energy.

This transition to decentralised-renewable energy **improves community level resilience**; energy generated locally does not depend on an unreliable electricity grid, or complex global energy supply chains. Energy availability is put into the hands of the communities; building a new livelihood or healthcare centre is not dependent on access to a grid connection.

Note - *The figures in this section are based on a range of broad assumptions and are likely to alter significantly as the project progresses. This chapter is therefore more about highlighting the importance of considering energy in regenerative design, and to provide an example of what areas of enquiry will be pursued in the next phase of the project.*

Energy Systems

Key terminology

- **Energy** is measured in **kWh** (kiloWatt Hours). Around 1kWh is consumed by a large fridge each day.
- For annual energy demands, **MWh** (megaWatt Hours), or 1000 kWh, is more practical.
- **Power** is measured in **kW** (kilo Watts)– power is the rate of consumption of energy, so the average power demand of a fridge over a whole day is 1kWh/24 hours = 0.041kW (or 41W).
- **Solar irradiance** is the amount of energy from the sun hitting the earth's surface.
- **Photovoltaics** use semiconductors to absorb light photos from the sun to generate an electrical current.
- **Dispatchable loads** – these are energy demands that can be switched on or off without negative effects – e.g. pumping water into a tank. These loads help maximise sustainable energy use – e.g. switch a pump on when the sun is strongest.

Energy management

There are three key parts to energy management:

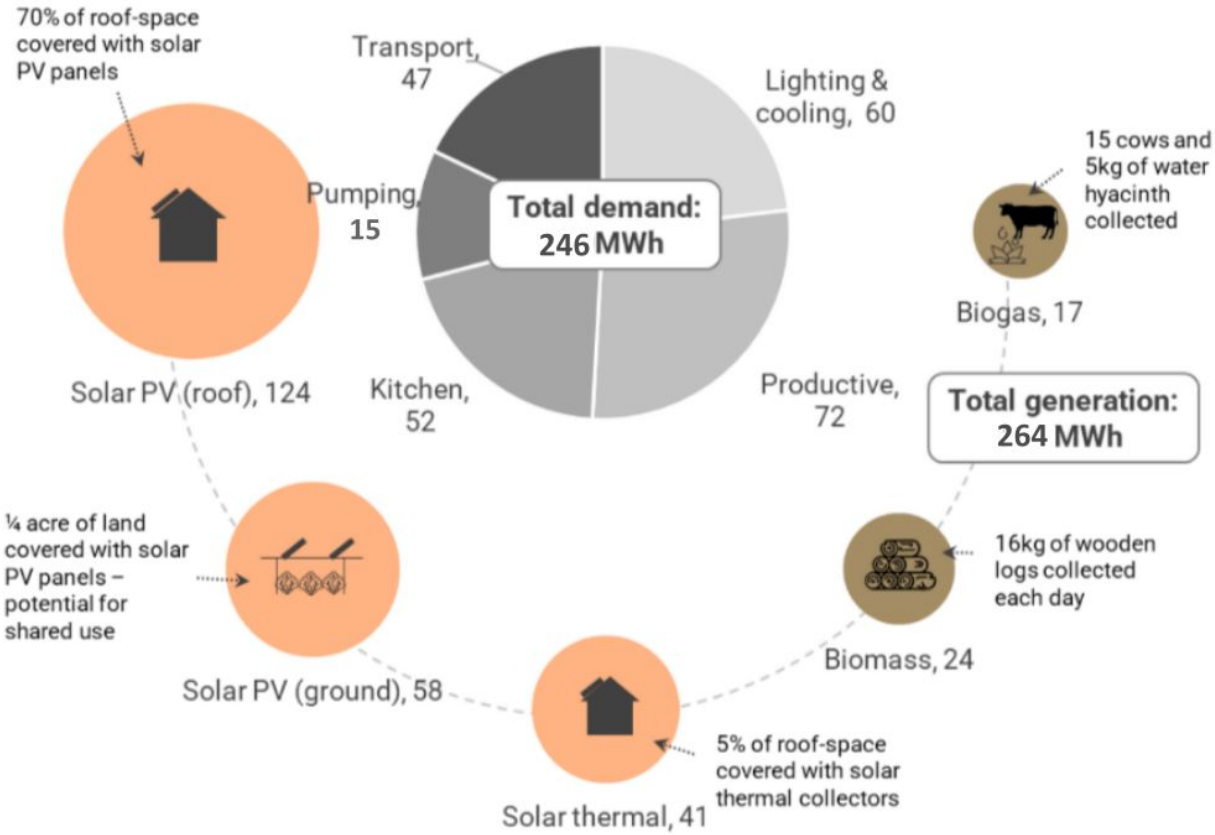
1) **Minimise demand through energy efficiency**, including efficient building design and selection of energy efficient appliances.
2) **Optimise the energy system design** by modelling energy demands and sources in detail.
3) **Monitor and manage** ongoing usage and generation to maximise sustainability and minimise costs.

A Local Energy System for ABTL

In this section we briefly introduce the energy sources available at the site, and an initial, indicative estimate of energy demands. Through the proposed developments of the site, energy use will increase. The aim is therefore to show how this increase can be provided for sustainably.

Energy demands and sources at Alphonso by the Lake – indicative analysis

Total energy sources potential: **264 MWh >** Total energy demand: **246 MWh**

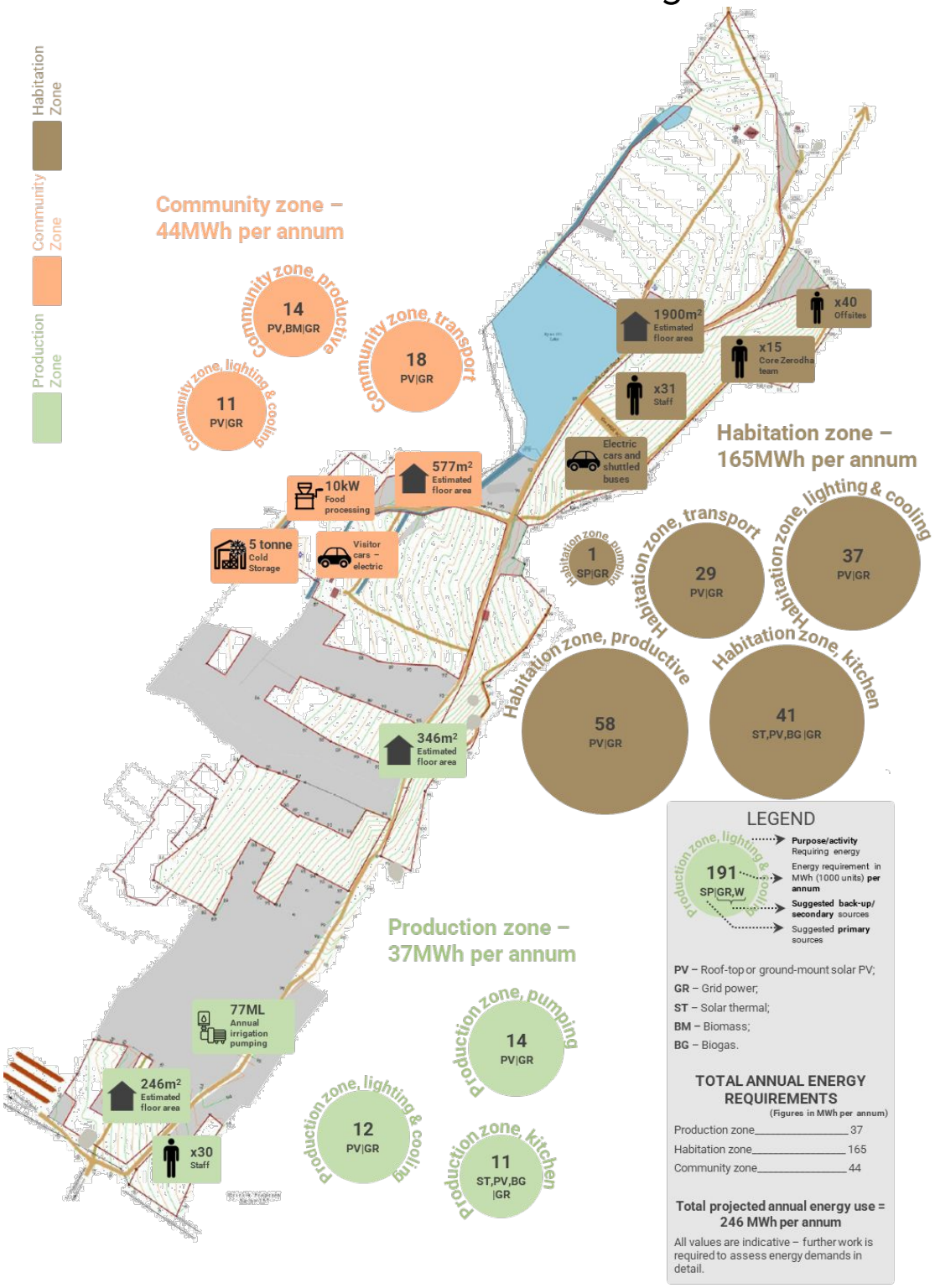


The ***sources*** assessed include solar, biogas and biomass – the primary resource available. Small wind and micro-hydro are potential sources to be investigated further.

The ***demands*** assessed include lighting and cooling, productive uses (offices, food processing, cold storage), kitchen demands (cooking, food storage), transport, and water pumping. Further analysis is required to quantify pumping demand, and so only household water usage has been included so far.

The ***storage and management*** techniques discussed include battery storage and the use of the grid as a backup source.

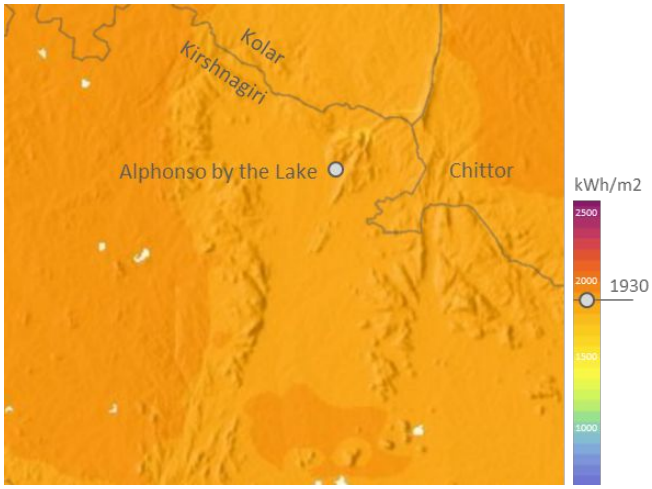
Energy Demand - Indicative Analysis



Energy Sources

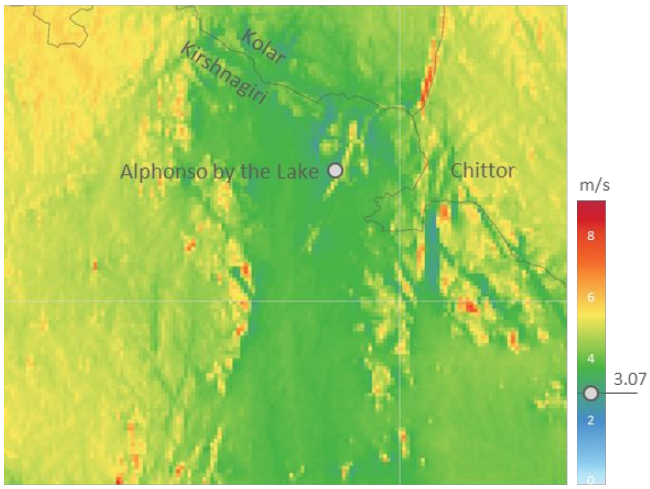
Solar energy is an abundant resource in South India. Alphonso by the Lake is situated in the Melagiri Hill range, part of the Eastern Ghats Forest system, where cloud cover is more frequent than neighbouring regions. As such solar irradiance is slightly reduced, but still reaches an annual average of 1930 kWh/m^2. Solar energy at the site is therefore a key resource that is both renewable and plentiful. Solar PV can be installed on roof-tops, or on the ground, potentially sharing space with shade loving plants.

Regional Solar Irradiance



Wind speeds are highly influenced by topography and ground conditions – the shelter of the hills reduce wind speeds down to an average of 3m/s around Alphonso on the Lake at 50 m height from ground-level. So, within the shelter of the valley and forests, wind-speeds are unlikely to be high enough for reasonable yields from wind-turbines. However local site conditions can be investigated further.

Regional wind-speeds



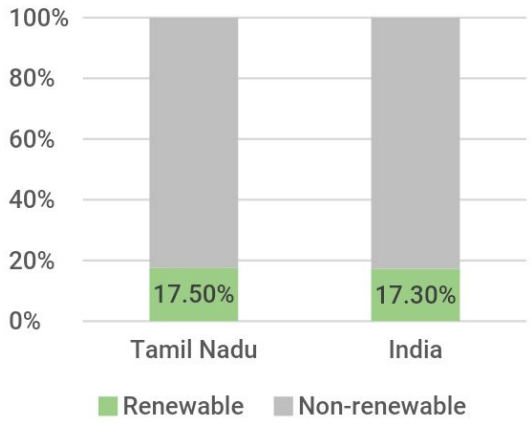
Biomass can be collected from the living fences and Zone 4 or from across the site as fallen or dead wood. The best uses for biomass are for thermal energy demands – for example for the pottery kiln.

Biogas is produced in a bioreactor as animal manure and other feedstock decomposes to produce methane. When collected this can be used for cooking. With 15 cattle and 100 chickens, the biogas potential is reasonable.

Energy Sources

A **grid connection** is recommended to provide backup power. However, whilst India and Tamil Nadu are rapidly building solar and wind generation, the energy mix is still dominated by fossil fuels such as coal. As such, energy consumption from the grid should be minimised.

The grid's renewable generation mix



Community Engagement

Livelihoods

Livelihoods

Solidarity Economy

The idea here is to see if we can achieve social profitability along with financials for the village. The lake can come into play, setting standards for these benefits. Fodder parks, community centers, barter clubs, libraries, skill exchange and trading could be pivotal.

Community Economy

This is to see if we can, through reforestation, generate economy that benefits the community monetarily by incentivising them to maintain the forests as well. Through collection of grasses, preservation of native seeds, creating forest nurseries and selling it to regular nurseries in the cities

Community Private

This will be Alphonso's land and Zerodha preferred idea of farmers being employed to grow the necessary food for the land and its people. The surplus can be shared or sold through shared economy.

This will have

1. Management of different zones
2. Facilitating Animal systems
3. Food production
4. Community integration
5. Recreation

Implementation Sequence

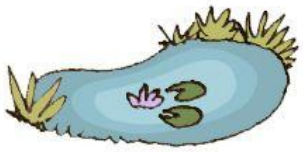
Implementation Sequence

During Phase 1, until the end of June, due to Covid restrictions only soft work will be done by the 4-member team on ground. This involves: nursery completion, plant propagation, boundary planting & sowing (Vetiver, locally available cuttings, biomass seeds).

From July or August onwards the following work can be conducted with small groups of vaccinated teams:

1. Nursery area

a. Complete nursery construction



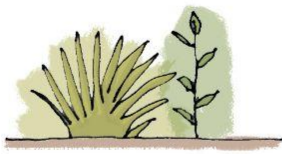
b. Earthworks - Boomerangs, Ponds, Basins, Channel, Boundary basins and pathway

c. Planning and Guiding set up of Tanks and Piping

d. Continue Propagation in the Nursery (3000 saplings target)

e. Mango Syntropic (demo Forest Garden) planting & clay pot irrigation

f. Boundary Direct Sowing and Planting

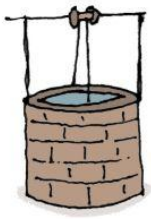


g. Sowing Cover Cropping and Grasses for Mulch

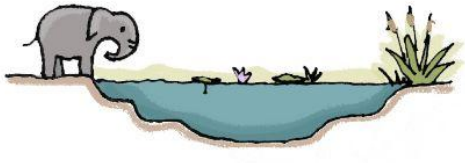
h. House rainwater harvesting system

Implementation Sequence

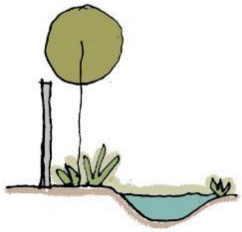
2. Northern Area (fenced), incl. Habitation Zone



a. Open well digging and restoration



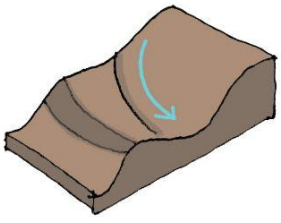
b. Make Kalyani / Elephant tank



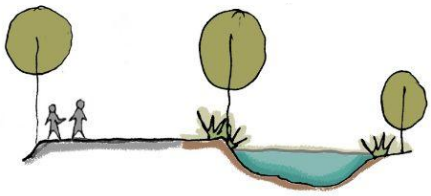
c. Boundary basins

d. Direct Sowing & Planting - Firebreaks, Non-Browsable, Biomass

3. Other



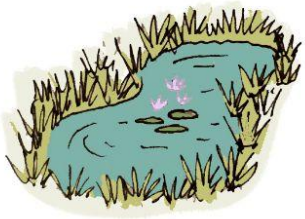
a. Diversion swales on Roads



b. Roadside Basins and Direct Sowing & Planting

Implementation Sequence

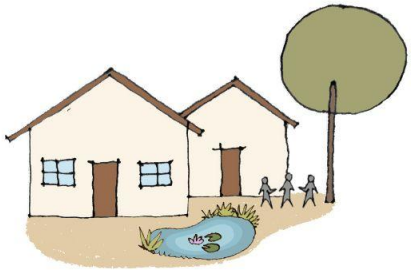
4. Northern Area



a. Earthworks - Eucalyptus basin, Wetlands, Ponds

b. Mango Area (Zone 4) - Boomerangs, Planting

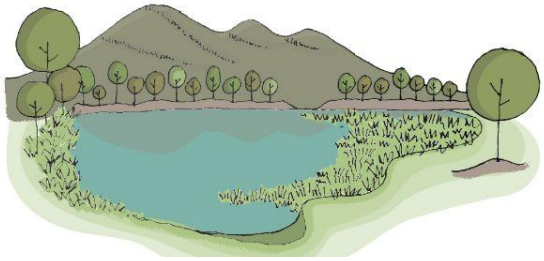
d. Continue Boundary Planting (Trees)



c. Habitation Zone Earthworks & Planting

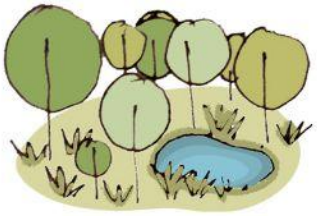
5. Pottery Yard and Seed Bank

6. Lake work



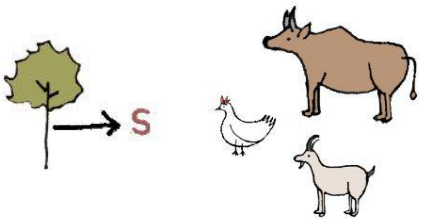
Implementation Sequence

6. **Wild Zones East Earthworks**



7. **Community zone construction and planting**

8. **Continue expanding production down South & Start Animal Integration Programme**



Appendices

Appendix (I) - Seed Saving

Why save seeds?

- So that the seed required is available at the right time
- To save the cost of buying and transporting seeds
- To ensure that the seeds used are adapted to local climate and soil conditions
- To trust that the species or variety is the one you need
- To increase income from local and renewable resources
- To improve and promote local, traditional varieties and to conserve biodiversity
- A seed bank becomes an important node in any community, farmers can exchange seeds and access varieties that are otherwise hard to find.
- Seed banks provide resilience and autonomy.

Seed Selection:

- Choose healthy, disease-free plants to save seed from
- Most seeds are ready for collection before the rains (May) and through to September.
- Select plants according to the qualities and characteristics you need – what is the function you're looking for? Timber? Biomass? Fodder? Food? Medicine?
- Seed selection and production should be need-based.
- Collect mature pod just prior to its falling and remove the best seeds without damaging them.

Seed Preparation and Storage:

- Clean them properly to remove all plant material and foreign matter.
- Dry them well in light shade. Allow them to cool before storing.
- Store them in airtight containers in a cool, dry, dark place.
- Protect them from air, moisture, heat, light and animals and insects

Appendix (II) - Boundary Plant List

Common Name English	*Botanical Name*	Type	Habit	Use	Method of Propagation
Vetiver	*Chrysopogon zizanioides*	Grass	Perennial	Drought tolerant, deep fibrous root system, tolerant to waterlogging Fire break, erosion control/soil stabilisation, mulch, hedging	Direct plant slips
Hop Bush	*Dodonaea viscosa*	Small shrub	Perennial	Erosion control, Fire break, Pollinator attractor, living fence, hedging, erosion control/soil stabilisation, Colonizer on disturbed ground. The flowers are bee forage. Roots are soil binding and effective in soil conservation	Direct sow seeds
Agave	*Agave sp.*	Shrub	Evergreen	Highly effective at capturing moisture, drought tolerant, fire resistant Fire break, living fence, fibre	Direct plant pups
Karonda	*Carissa carandas*	Small shrub	Evergreen	Edible Fruit	From seed in nursery
African Milk Bush	*Euphorbia umbellata*	Big shrub	Evergreen	Non-browsable living fence, fire break Fire resistant, drought tolerant	Direct plant cuttings
Madras Thorn	*Pithecellobium dulce*	Tree	Deciduous	Birds, Drought tolerant, Thorny fencing, Edible fruit	From seed in nursery
Peacock flower	*Ceasalpinia pulcherrima*	Big Shrub	Evergreen	Living fence, Nitrogen fixer, Ornamental, Drought tolerant	Direct sow seeds
Henna	*Lawsonia inermis*	Shrub	Evergreen	Dye, Living fence, Medicinal, Fodder, Ornamental, Erosion control	From seed in nursery
Gamhar / Gmelina	*Gmelina Arborea*	Small Tree	Deciduous	Drought Resistant, Food Source, Edible Fruit, Timber	From seed in nursery
Indian Coral Tree	*Erythrina variegata*	Small Tree	Deciduous	Fodder	From seed in nursery
Perennial pigeon pea	*Cajanus cajan*	Shrub	Evergreen	Edible, Mulch, Chop & Drop, Windbreak, Nitrogen fixer, Pollinator attractor	Direct sow seeds
Gliricidia	*Gliricidia sepium*	Small Tree	Evergreen	Mulch, green manure, poles, pollinator attractor, windbreak, fodder, Nitrogen fixer, Bee forage	From seed in nursery
Indian Tulip Tree	*Thespesia populnea*	Tree	Evergreen	Mulch, green manure, pollinator attractor, windbreak	Sapling
Bitterwood	*Simarouba glauca*	Tree	Evergreen		Sapling
Pink Cedar	*Acrocarpus fraxinifolius*	Tree	Deciduous		From seed in nursery
Chinese chaste tree	*Vitex negundo*	Tree	Deciduous	Medicinal, Apiary, Drought tolerant	From Cuttings in Nursery
Simpleleaf chastetree	*Vitex Trifolia*	Tree	Deciduous	Medicinal, Apiary	Sapling
Siamese Cassia	*Senna siamea*	Big Shrub	Evergreen		From seed in nursery
Buttercup bush	*Senna multiglandulosa*	Big Shrub	Evergreen	Adaptable to both dry and moist locations Excellent as a loose screen or tall border planting Edible flowers Dye from root stems and leaves Medicine	From seed in nursery

Common Name English	*Botanical Name*	Type	Habit	Use	Method of Propagation
Agathi/Sesbania	*Sesbania grandiflora*	Tree	Deciduous	Mulch, pollinator attractor, windbreak, living fence, quick shade, support for vines, edible (leaves, pods, flowers), fodder, Nitrogen fixer, Bee forage, Drought tolerant, Tolerant to waterlogging	From seed in nursery
Mexican sunflower/ Tree Marigold	*Tithonia diversifolia*	Big Shrub	Evergreen	Quick hedge, Chop and Drop/Green manure, Nutrient accumulator, Beauty, Privacy screen, Drought tolerant, Insect habitat	Direct plant cuttings
C4 grasses (sugarcane, elephant, Guniea, Coix,Sorghum)		Grass	-	Fast growing, Carbon Fixation, Fodder	Direct sow seeds
Shrubby legumes: Sunhemp, Berseem (Trifolium alexandrinum), Hedge lucerne (Desmanthus virgatus),Daincha (Sesbania bispinosa)		Shrub	-	Pioneer Annuals, Dried silage, Fodder	Direct sow seeds
Neem	*Azadirachta indica*	Tree	Deciduous		Sapling
Jamun	*Syzygium cumini*	Big Tree	Evergreen	Medicinal, Edible fruits (also relished by bats and birds) Fodder, Strong heavy timber, Good fuelwood, host plant for tasar silkworm, Good source of nectar for bees Windbreak	Sapling
Banyan	*Ficus benghalensis*	Big Tree	Evergreen		Sapling
Bullet Wood	*Mimusops elengi*	Big Tree	Evergreen	Drought tolerant	Sapling
Indian Almond	*Terminalia catappa*	Big Tree	Deciduous		Sapling
Sultan Champa	*Calophyllum inophyllum*	Big Tree	Evergreen		Sapling
Copper Pod Tree	*Peltophorum pterocarpum*	Big Tree	Evergreen	Nitrogen fixing	Sapling
Mahogany	*Swietenia mahogani*	Big Tree	Deciduous	Mulch, Timber	Sapling
Java olive tree	*Sterculia foetida*	Tree	Deciduous	Edible seed, rootstock, leaves Edible non-drying oil from seeds Medicinal Fibre Gum for book binding Timber for indoor furniture	Sapling
Guava	*Psidium guajava*	Medium Tree	Deciduous		Sapling
Buttonwood	*Conocarpus erectus*	Tree	Evergreen		Sapling
Singapore Cherry	*Muntingia calabura*	Medium Tree	Evergreen	Edible fruit, tea from leaves Medicinal Pioneer species - quick establishment, colonizes disturbed sites Fibre and paper from bark	Sapling
Asiatic Tarenna	*Tarenna asiatica var rigida*	Small Tree	Evergreen	Termite resistant branches for fencing / used as a crowbar Ripened fruits edible Medicinal	From seed in nursery

Common Name English	*Botanical Name*	Type	Habit	Use	Method of Propagation
Ceylon Boxwood	*Psydrax dioccus*	Medium Tree	Evergreen	Pollinator Attractor, Shade and Shelter, Bird forage, Hedge plant	From seed in nursery
East Indian Rosewood	*Dalbergia lanceolaria var lanceolaria*	Big Tree	Evergreen	Timber, Nitrogen fixer, Medicinal, Avenue	From seed in nursery
Malabar Neem	*Melia dubia*	Big Tree	Deciduous	Quick shade, living fence, poles/timber, green manure, fodder, Nitrogen fixer, erosion control	From seed in nursery
Black Siris	*Albizia odoratissima*	Big Tree	Deciduous	Timber, Firewood, Shelterbelt, Drought Resistant	From seed in nursery
Kadamba	*Neolamarckia cadamba*	Big Tree	Evergreen		From cuttings/seeds in nursery
China Berry	*Melia Azedarach*	Big Tree	Evergreen	Apiary, Food Source, Timber, Medicinal	From seed in nursery
Drumstick	*Moringa oleifera*	Small Tree	Evergreen	Quick shade, Edible (leaves, pods, flowers), support for vines, living fence, pollinator attractor, fodder, Nutrient cycling, Bee forage, Drought tolerant, Nutrient miner	From seed in nursery
Siris Tree	*Albizzia lebbeck*	Big Tree	Deciduous	Timber, Firewood, Shelterbelt, Drought Resistant	From seed in nursery
Notched Leaf Soapnut / Reetha	*Sapindus trifoliatus*	Medium Tree	Deciduous	Shelterbelt, Soap Alternative	From seed in nursery
Pongam, Pongamia, Indian Beech Tree	*Pongamia pinnata (P. Glabra)*	Big Tree	Deciduous		From seed in nursery
Mulberry	*Morus varieties*	Small Tree	Evergreen		From Cuttings in Nursery
Arjun Tree	*Terminalia arjuna*	Big Tree	Evergreen	Food for silkworms	Sapling
Tamarind	*Tamarindus indicus*	Big Tree	Evergreen		From seed in nursery
Mango	*Mangifera indica*	Big Tree	Evergreen		Sapling
Teak	*Tectona grandis*	Big Tree	Deciduous		Sapling
Cluster Fig	*Ficus racemosa*	Big Tree	Evergreen		Cutting / Sapling
Mysore Fig	*Ficus mysorensis*	Big Tree	Evergreen		Cutting / Sapling
Red Bead	*Adenanathera Pavonina*	Big Tree	Deciduous		From seed in nursery
Ankola	*Alangium Salvifoium*	Big Tree	Deciduous	Medicinal, Pollinator attractor (nectar), Twigs for brushing teeth, Fuelwood, Fodder, Living fence, Berries eaten by birds	From seed in nursery
Casuarina	*Casuarina equestifolia*	Medium Tree	Evergreen	Soil building,, Poles and Timber, Salt and drought tolerant, windbreak/ shelterbelt, nitrogen fixer, Timber, Mulch, Tannins	From seed in nursery

Appendix (III) - Forest Garden Plant List

Type	Common Name English	*Botanical Name*	Ecological Function & Human Use
Emergent Trees (15-40m)	Teak	*Tectona grandis*	Pioneer species, but with a long life span. Insect attractor (flowers), Leaves are used as food for larvae of moths, Timber, Natural oils for prevention of termites
	Rosewood	*Dalbergia sissoo*	Hardy pioneer, mulch, nitrogen fixing
	Mahogany	*Swietenia mahagoni*	Hardy pioneer, mulch, timber
	Indian Blackwood/Anjan	*Harwickia binnata*	Keystone species, hardy pioneer, mulch, deep rooting
	East Indian Rosewood	*Dalbergia latifolia*	Nitrogen fixing pioneer species, Timber, Medicinal, Avenue
	Mahua	*Madhuca longifolia*	Edible flowers, fruit and leaves, Edible oil from seed, can be used for making soap, candles Medicinal, Seed cake as fertilizer, Erosion control and wasteland reclamation, Wood is strong, hard, heavy and durable and gives a fine finish, Wood can also be used as fuel
High trees (15-30M)	Indian date palm	*Phoenix sylvestris*	Edible Fruit, Sap is a source of sugar, Leaves for making bags and mats, Stems in making local houses
	Indian Jujube, Ber	*Ziziphus jujuba*	Edible fruit, Medicinal, Hedge Plant, Wood is dense, hard, compact, tough, Wood makes excellent fuel and a good charcoal
	Wood Apple / Bela	*Limonia acidissima*	Edible fruit and young leaves, Medicinal, Pollinator attractor (Nectar source), Seeds dispersed by mammals, Food forest, Medicinal
	Jamun	*Syzygium cumini*	Fruits are eaten by various native birds and small mammals, such as jackals, civets, and fruit bat, Pollinator attractor, The ripe fruits are also used to prepare squashes, juices, jam, jelly, pickles,wine. Timber used for bullock cart wheels and other agricultural equipment.
	Casuarina	*Casuarina equestifolia*	Salt and drought tolerant, erosion control, windbreak/ shelterbelt, nitrogen fixer, Timber, Mulch, Tannins used for tanning
	Mango	*Mangifera Indica*	Provide fruit, organic matter for soil amendment, shade, soil conservation,Carbon sequestration, Habitat for wildlife, Edible fruit, leaves and bark used to make dye, timber, all parts medicinal.
	Rose apple	*Syzygium jambos*	Birds, Beauty, Dense growth, Windbreak/hedge
	Jackfruit	*Artocarpus heterophyllus*	Mulch, Pollinator attractor, Fruit eaten by bats, Edible fruit as an aphrodisiac or for diabetes and used as mock meat. Fruit paste is applied to the skin for poisonous bites. Also, the wood of the jackfruit tree is used to make furniture or musical instruments.
	Tamarind	*Tamarindus indica*	Nitrogen Fixer of soil, efficient in trapping dust and removing pollutants from the air, Edible fruit, planted along roads
	Neem	*Azadirachta indica*	Dust and Pollution Trapper, pollinator attractor, Pest control, mulch, almost all parts highly medicinal
	Arjun Tree	*Terminalia arjuna*	Pollinator attractor, keystone species (improves soil condition, attract beneficial wildlife), The leaves are fed on by the Antheraea paphia moth which produces the tussar silk, a wild silk of commercial importance, Ayurvedic medicine with emphasis medicine for cardiovascular ailments. Also used for timber.
	Indian Beech	*Pongamia pinnata*	Controlling soil erosion and binding sand dunes because of its dense network of lateral roots., Nitrogen FIxer, Recovering a variety of wastelands such as saline soil reclamation, Reforestation of marginal lands., Adds nutrition to the soil from decomposition of fallen flowers, Mulch, flowers make great manure, seeds give oil used for burning lamps and producing Biodiesel
	Banyan	*Ficus benghalensis*	Attracts pollinators, Fruits eaten by birds, bats, encourage the growth of other tree species because their figs attract a diverse range of seed dispersers. Fiber used for making paper and coarse ropes. Wood is used for furniture, Twigs and prop roots are used as tooth stick. Figs are edible, can be eaten fresh or dried. Medicinal uses of the leaves and seeds are used to treat more than 20 disorders
	Coconut	*Cocos nucifera*	Support, Pollinator Attractor, Erosion Control, Food, Fibre, Timber, Husk, Cocopeat
	Kadamba	*Neolamarckia cadamba*	Soil enriching, Insect attractor, Medicinal (Skin Disease, Cancer, Diabetes)

Type	Common Name English	*Botanical Name*	Ecological Function & Human Use
Medium trees (7-15M)	Drumstick	*Moringa oleifera*	Pollinator attractor, Birds, Deep rooted nutrient miner, Mulch, Green manure, Edible fruit, leaves, root. Can make a growth promoting liquid compost with the leaves
	Hummingbird tree	*Sesbania grandiflora*	Legume, Mulch, Green Manure, Windbreak, Nurse Plant, Pollinator Attractor, Support, Pioneer, Edible flowers, young pods, leaves
	Mulberry	*Morus alba*	Birds, Mulch, Pollinator attractor, Edible fruit
	Golden Rain	*Cassia fistula*	Pioneer species, bird and insect attractor, Aesthetic value
	Amla	*Emblica officinalis /Phyllanthus emblica*	Soil conservation - rehabilitation of degraded lands, good for intercropping, fire resistant, windbreak. Deep rooted nutrient miner, Edible fruit, medicinal
	Bael/ Wood Apple	*Aegle marmelos*	Acts as a 'Sink' for poisonous gases, absorbs and makes them inert. This plant is a part of a special species group called the 'Climate Purifiers' which emit more oxygen in sunlight than most plants. Attracts birds and pollinators, Edible fruit, Leaves, bark, roots and fruit pulp are all used against snakebite
	Common Fig	*Ficus carica*	Pioneer species, Bird and Insect attractor, Edible Fruit
	Rusty Acacia	*Acacia ferruginea*	Nitrogen fixer, Attracts pollinators, Aesthetic / Ornamental value
	Red Kutch	*Acacia chundra/ Senegalia chundra*	Nitrogen fixer, Thorny, fencing, Chop & Drop, Attracts birds and insects, Timber
	Custard apple	*Annona squamosa*	Pest Management, Pollinator Attractor, Birds
	Starfruit	*Averrhoa carambola*	Edible fruit, ornamental, food & shelter for birds and other vertebrates, dense shade, Fresh fruit juice removes stains from clothing
	Pomelo	*Citrus maxima*	Wildlife shelter, Edible fruit, Essential oil, Medicinal
	Soursop	*Annona muricata*	Edible fruit, Pollinator attractor & nectary, Medicinal, Seeds of the fruit possess insecticidal properties
	Cashew	*Anacardium occidentale*	Edible fruit & Nut, Medicinal, Oil for wood treatment
	Notched Leaf Soapnut	*Sapindus emarginatus*	Soap nuts are used in the remediation of contaminated soil, Fruits possess several medicinal properties and are widely used for example in the treatment of asthma, colic and dysentery, and during childbirth, Soapnut powder is a very good antibacterial and antifungal agent. It is mostly used in the cosmetic and contraceptive creams. It is also used as detergent, bio-surfactant and remedial for organic soil pollution in the modern science.
	Krishna Siris	*Albizia amara*	Nitrogen Fixer, Attracts pollinators, Leaves, roots, bark and gum are medicinal. Used for timber.
Low trees (2-7m)	Chikoo	*Manilkara zapota/Achras zapota*	Attracts birds and fruit bats, Drought tolerant, Edible and Nutritious fruit, cultivated for the extraction of "Chuckle" which forms the base for making chewing gum
	Guava	*Psidium guajava*	Pest Management, Birds and Wildlife attractor, Mulch, Common host for fruit flies, Edible Fruit,Guava seed oil, which may be used for culinary or cosmetics products,
	Pomegranate	*Punica granatum*	Erosion control, Hardy, Mulch.,Drought Tolerant, Edible Fruit, Juice of flower is used to treat nose bleeds. The fruit pulp and the seed are stomachic. Dried, pulverized flower buds are employed as a remedy for bronchitis.
	Lemon	*Citrus Limon*	Pollinator Attractor, Host plant, Edible Fruit, used as ingredient for many dishes and medicinal purposes
	Curry Leaf	*Murraya koenigii*	Pollinator attractor, Pest Management, Host plant, Known as the 'sweet neem of India', leaves are edible and used widely dishes prepared across South India, Paste of leaves used to treat cuts, bruises and burns.
	Banana	*Musa acuminata*	Soil improvement, biomass, soup plant, Edible Fruit, Medicinal Properties of the stem, Banana Leaves Can Be Used as Natural Leaf Platters, stem fibres as natural craft materials, Banana flowers are edible, Rhizomes have medicinal uses and traditionally used in Ayurveda.
	Papaya	*Carica papaya*	Attracts pollinators, Young leaves used as mulch, Edible Fruit, Seeds used as a spice, Male flowers cooked and used as a green vegetable, All parts of the plant have medicinal purposes, leaves can be used to make soaps

Type	Common Name English	*Botanical Name*	Ecological Function & Human Use
Low trees (2-7m)	Singapore Cherry	*Muntingia calabura*	Nectar plant, The seeds are dispersed by birds and fruit bats, it thrives in poor soil, able to tolerate acidic and alkaline conditions and drought, but doesn't grow in saline conditions. "Edible Fruit, timber, fuel, soft wood used for rural construction, while the bark is fibrous and used for making ropes.
	Lime	*Citrus limon*	Host plant, Attracts pollinators, Edible Fruit
	Bidi leaf tree	*Bauhinia racemosa*	Nitrogen fixer, The leaves are used in the production of beedi, a thin Indian cigarette. Medicinal
	Tree Spinach, Chaya	*Cnidoscolus aconitifolius*	Pollinator attractor, Support, Edible eaves & shoots
	Asiatic Tarenna	*Chomelia asiatica*	Attracts pollinators, The plant is harvested from the wild for local use as a food, medicine and source of dyes and essential oils
	Bee Sting Bush	*Azima tetracantha*	Pioneer species and can be used for reforestation. Thorns keep intruders at bay. Ornamental shrub.
	Ceylon leadwort	*Plumbago zeylanica*	Pioneer species, Attracts pollinators, Used in Ayurvedic Medicine
	Bidi leaf tree	*Bauhinia racemosa*	Nitrogen fixer, Pollinator attractor, Bird attractor
	Reticulated Leaf-flower or Potato Bush	*Phyllanthus reticulatus*	Attracts pollinators (flowers all year round), Chop and drop (responds well to coppicing)
Biomass Trees	Gliricidia	*Gliricidia sepium*	Fodder, Nitrogen fixer, Pollinator attractor, Mulch, Poles, Chop & Drop
	Red Kutch	*Acacia chundra/ Senegalia chundra*	Timber, Nitrogen fixer, Thorny/fencing, Chop & Drop
	Mexican sunflower/	*Tithonia diversifolia*	Nutrient accumulator, Mulch, Fodder for chickens, Erosion control, Chop & Drop, Ornamental
	Perennial Pigeon Pea/ Togare	*Cajanus cajan*	Edible, Mulch, Nitrogen fixer, Pollinator attractor, Chop & Drop, Edible
	Rusty Acacia	*Acacia ferruginea*	Nitrogen fixer, Attracts pollinators, Aesthetic / Ornamental value
Biomass Plants	Sorghum	*Sorghum bicolor*	
	Coix	*Coix lacryma-jobi*	
	Guinea Grass	*Panicum maximum*	
	Elephant/Napier Grass	*Pennisetum purpureum*	
	Hedge Lucerne	*Desmanthus virgatus*	
	Dhaincha	*Sesbania bispinosa*	
	Berseem	*Trifolium alexandrinum*	
	Sunhemp	*Crotalaria juncea*	
	Stylo	*Stylo hamata*	
	Vetiver	*Chrysopogon zizanioides*	

Type	Common Name English	*Botanical Name*	Ecological Function & Human Use	Edible Part/s
Edible perennials	Sweet potato	*Ipomea batatas*	Also Groundcover, Soil improvement	Shoots, leaves, tubers
	Nasturtium	*Tropaeolum sp.*	Ground cover, Companion plants for biological pest control, repelling some pests, acting as a trap crop for others and attracting predatory insects.	Leaves, flowers
	Pumpkin	*Cucurbita moschata*	Ground cover, Erosion Control	Shoots, fruit, flower
	Rosella/ Gongura	*Hibiscus sabdariffa*	Host plant, windbreak, support	Leaves, sepals ('fruit'), flowers
	Katuk/ Chakramuni / Multivitamin	*Sauropus androgenous*	Hedge plant	Leaves, shoots
	Pigeon pea	*Cajanus cajan*	Edible, Mulch, Nitrogen fixer, Pollinator attractor, Chop & Drop, Windbreak	Fresh peas and pods, dried peas
	Yams	*Dioscorea sp.*	Soup plant, soil improvement	Tubers
	Tapioca/ Cassava	*Manihot esculenta*		Leaves, tuber
	Taro	*Colocasia esculenta*	Soup plant, tolerant of water logging	Leaves, shoots
	Ginger	*Zingiber officinale*	Pollinator Attractor, Pest Management, Soup Plant	
	Ceylon Spinach	*Basella rubra*	Living hedge, windbreak	Leaves, shoots
	Ivy Gourd	*Coccinia grandis*	Pollinator and bird attractor	Fruit, shoots, leaves
	Winged Bean	*Phosphocarpus tetragonolobus*	Pollinator attractor	Pods, shoots, leaves, tuber
	Chayote	*Sechium edule*	Groundcover	Fruit, shoots
	Passionfruit	*Passiflora sp.*	Pollinator Attractor, Soil improvement	Fruit
	Sword Beans	*Canavalia gladiate*	Pollinator attractor	Pods
	Scarlet Runner Beans	*Phaseolus coccineus*	Pollinator attractor	Pods
	Pineapple	*Ananas comosus*	Erosion Control	Fruit
	Butterfly pea	*Clitoria ternatea*	Nitrogen fixer	Flowers, Leaves
	Brahmi	*Bacopa monnieri*	Living Mulch, Erosion Control	Leaves
	Ceylon Spinach	*Talinum sp.*	Living mulch, pollinator attractor	Leaves, flowers

Appendix (IV) - Elephant corridor species

Documented below are the various species that elephants feed on in the Sathyamangalam forests and surrounding areas.

ELEPHANTS	Common Name	Type	Latin Name	Edible Part
1	Acacia	Medium-Big deciduous trees	Acacia spp.	Leaves, bark and branches
2	Indian Aspen	Medium evergreen tree	Acronychia pedunculata	Leaves
3	Wood apple	Medium deciduous tree	Aegle marmelos	Fruit
4	Albizia	Large deciduous trees	Albizia spp.	Leaves, bark and branches
5	Mauritian grass	Grass	Apluda mutica	Grass
6	Spiny Bamboo	Tall thorny bamboo	Bambusa arundinaceae	Leaves and shoots
7	Burmese silk orchid	Medium deciduous tree	Bauhinia racemosa	Fruit and leaves
8	Red cotton tree	Large deciduous trees	Bombax ceiba	Fruit and leaves
9	Wild guava	Medium deciduous tree	Careya arborea	Fruit
10	Coconut	Medium deciduous tree	Cocos nucifera	Leaves
11	Lemongrass	Grass	Cymbopogon spp.	Grass
12	Chinese lantern	Small deciduous tree	Dicrostrachys cinerea	Leaves, bark and branches
13	Finger grass	Grass	Digitaria spp.	Grass
14	Scrambling bamboo	Climbing evergreen bamboo	Dinochloa scandens	Leaves and shoots
15	Bakini	Small tree	Diospyros montana	Leaves
16	Horse gram	Shrub	Dolichos biflorus	Shrub
17	Goose grass	Grass	Eleusine indica	Grass
18	Lovegrass	Grass	Eragrotis spp.	Grass
19	Bendai	Small deciduous tree	Erilaena quinquelocularis	Leaves
20	Banyan tree	Large evergreen tree	Ficus benghalensis	Leaves
21	Phalsa	Medium tree	Grewia tiliifolia and other spp.	Leaves, bark and branches
22	Niger	Herb	Guizotia abyssinica	Herb
23	Indian black wood	Medium deciduous tree	Hardwickia binata	Bark and leaves
24	Indian screw tree	Small deciduous tree	Helictres isora	Leaves and twigs
25	cogon grass	Grass	Imperata cylindrica	Grass
26	Roxburgh's kydia	Medium deciduous tree	Kydia calycina	Leaves, bark and branches
27	Elephant apple	Large deciduous trees	Limonia acidissima	Fruit
28	Kamala tree	Medium tree	Mallotus philippensis	Bark
29	Mango	Large evergreen tree	Mangifera Indica	Fruit
30	Mimosa	Shrub	Mimosa rubicaulis	Shrub
31	Banana	Small tree	Musa paradisiaca	Tree
32	Paddy	Grass	Oryza sativa	Grass
33	Screwpine	Medium palm like deciduous tr	Pandanus	Foliage
34	Little millet	Tall grass	panicum miliare	Grass
35	Dwarf date palm	Shrubby palm	Pheonix humilis	Leaves
36	Sugar cane	Tall grass	Saccharum officinarum	Plant
37	Snake plant	Small thin shrub	Sansieviera	Foliage
38	Sandalwood	Small evergreen tree	Santalum album	Leaves
39	Ceylon oak	Large deciduous trees	Schleichera oleosa	Leaves
40	Sesame	Grass	Sesamum indicum	Grass
41	Sorghum	Tall grass	Sorghum vulgare	Grass
42	Tamarind	Large evergreen tree	Tamarindus indica	Fruit
43	Teak	Medium deciduous tree	Tectona grandis	Twigs, bark and branches
44	Themeda	Tall grass	Themeda cymbaria spp.	Grass
45	Charcoal tree	Small spreading tree	Trema orientalis	Bark
46	maize	Tall grass	Zea mays	Grass
47	Gote	Evergreen shrub	Ziziphus xylopyrus	Shrub

Appendix (V) - Sloth bear corridor species

Documented below are the various species that Sloth bears feed on in the Nilgiri forests and surrounding areas.

SLOTH BEAR	Common Name	Type	Latin Name	Edible Part
1	Albizia species	Large deciduous tree	Albizia odoratissma	Fruit
2	Axlewood	Medium tree	Anogeissus latifolia	Fruit
3	Jackfruit	Large evergreen tree	Artocarpus heterophyllus	Fruit
4	Spinous kino tree	Medium tree	Bridelia retusa	Fruit
5	Golden shower tree	Medium deciduous tree	Cassia fistula	Fruit
6	Cordia	Medium tree	Cordia domestica	Fruit
7	East indian ebony	Medium tree	Diospyros melanoxylan	Fruit
8	Bakini	Small tree	Diospyros montana	Leaves
9	Ficus	Large evergreen tree	Ficus spp.	Fruit
10	Grewia	Straggling shrub	Grewia hersuta	Fruit
11	Phalsa	Medium tree	Grewia tiliifolia	Fruit
12	Helicopter tree	Medium deciduous tree	Gyrocarpus americanus	Fruits
13	Spear grass	Grass	Heteropogon contortus	Grass
14	Lantana	Thorny shrub	Lantana camara	Fruit
15	Nilgiri privette	Small evergreen tree	Ligustrum perrottetii	Fruits
16	Mango	Large evergreen tree	Mangifera Indica	Fruit
17	Marking nut tree	Medium deciduous tree	Semecarpus anacardium	Fruit
18	Setaria	Grass	Setaria intemedia	Fruit
19	Sporobolus	Grass	Sporobolus sp.	Grass
20	Jamun	Large evergreen tree	Syzygium cumini	Fruit
21	Orange climber	Climber	Toddalia asiatica	Fruit
22	Peesundai	Small evergreen tree	Viburnum punctatum	Fruit
23	Indian jujbe	Small evergreen tree	Ziziphus mauritiana	Fruit
24	Jackal jujube	Climber	Ziziphus oenoplia	Fruit
25	Zunna berry	Climber	Ziziphus rugosa	Fruit

Appendix (VI) - Wetland/Aquatic Plant Species

Common Name	*Botanical name*	Type
Sweet Flag	*Acorus calamus*	Emergent and beach
Taro	Alocasia sp.	Emergent
Dwarf copper leaf	*Alternanthera sessilis*	Beach
Dwarf reed grass	*Arundinella pumila*	Emergent and beach
Feathered mosquito fern	*Azolla pinnata*	Free Floating
Indian Pennywort	*Bacopa monnieri*	Emergent and beach
Blyza	*Blyxa aubertii*	Submerged
Fish grass	*Cabomba caroliniana*	Submerged
Vankeli	*Canna Indica*	Beach
Coons tail	*Ceratophyllum demersum*	Submerged
Foxtail sedge	*Cyperus alopecuroides*	Emergent and beach
Umbrella sedge	*Cyperus corymbosus*	Emergent and beach
Clustered sedge	*Cyperus glomeratus*	Emergent and beach
Shingle flastedge	*Cyperus imbricatus*	Emergent and beach
Umbrella Palm Tree	*Cyperus involucratus*	Emergent and beach
Drooping sedge	*Cyperus nutans*	Emergent and beach
Paper reed	*Cyperus papyrus*	Emergent
Dwarf papyrus	*Cyperus prolifer*	Emergent
Water Hyacinth	*Eichhornia crassipes*	Free Floating
Spike Rushes	*Eleocharis acicularis*	Submerged
Aquatic Horse Tail	*Equisetum fluviatile*	Emergent
Branched Horsetail	*Equisetum ramosissimum*	Submerged
Pipeworts	*Eriocaulon sp.*	Emergent and beach
Roundleaf Bindweed	*Evolvulus nummularius*	Beach
Stalked Persian Violet	*Exacum pedunculatum*	Emergent and beach
Great Manna Grass	*Glyceria maxima*	Emergent and beach
Tara Ginger	*Hedychium coccinea*	Emergent and beach
Heliconia	*Heliconium wagneriana*	Beach
Water thyme	*Hydrilla verticillata*	Submerged
Water grass	*Hygroryza aristata*	Free Floating
Water spinach	*Ipomea aquatica*	Free Floating
Blue and Yellow Flags	*Iris spp.*	Emergent and beach
Soft rush or common rush	*Juncus effusus*	Emergent and beach
Giant rush	*Juncus ingens*	Emergent and beach
Lagenandra	*Lagenandra toxicaria*	Emergent
Lagenandra	*Lagenandra toxicaria*	Beach
Common Duckweed	*Lemna Minor*	Submerged

Common Name	*Botanical name*	Type
Duck weed	*lemna perpusilla*	Free Floating
Dwarf ambulia	*Limnophila sessiliflora*	Submerged
Marsh weed	*Lymnophilia Indica*	Submerged
Water Clover	*Marsilea quadrifolia*	Emergent
Murdannia	*Murdannia sp.*	Emergent
Parrot's Feather	*Myriophyllum aquaticum*	Emergent
Spiked water milfoil	*Myriophyllum verticillatum*	Submerged
Lotus	*Nelumbo Nucifera*	Free Floating
Brandy Bottle	*Nuphar lutea*	Submerged
Water Lily	*Nymphaea odorata*	Free floating
duck lettuce	*Ottelia alismoides*	Submerged
Napier Grass or Elephant Grass	*Pennisetum purpureum*	Beach
Common Reed	*Phragmites sp.*	Emergent and beach
Water cabbage	*Pistia stratiotes*	Free Floating
Long root	*Polygonium amphibium*	Free floating
Floating leaf pond weed	*Potamogeton natans*	Free floating
Clasping leaf pond weed	*Potamogeton perfoliatus*	Submerged
Great Bulrush	*Schoenoplectus validus*	Emergent
Bullrush	*Scirpus spp.*	Emergent and beach
River hemp	*Sesbania javanica*	Emergent
Common duckmeat	*Spirodela polyrhiza*	Free Floating
Powdery Alligator Flag	*Thalia dealbata*	Emergent
Bullrush	*Typha angustifolia*	Beach

All these aquatic plants have the characteristic ability of transporting air (oxygen) from the atmosphere to the roots from where a part diffuses into the liquid substrate.
They have relatively deep roots and rhizomes that create a large volume of active rhizosphere per unit surface area. They supply oxygen to the microorganisms in the substrate, and help stabilize the organic matter applied. The plants create oxidized micro-zones in an otherwise reduced substrate with anoxic and anaerobic zones in which microorganisms perform, stabilizing organic matter and promoting nitrification-denitrification also. Plants provide a substrate for microorganisms, which are the most important processors of wastewater contaminants. They also provide microorganisms with a source of carbon.

Stands of vegetation also reduce current velocity, allowing solids to settle out of the water column.