Traditional Healthcare

Permaculture Design Report for TH Datam

Datam-Tihruldih , Seraikela-Kharsawan district, Ichagarh Block.
Jharkhand, India (N23° 7' 34.88", E85° 56' 45.84")
Report by Patrick O'Neill B.HSc. PDC. Site visited March 10th -14th, 2010

Introduction

Traditional Healthcare (TH) is developing a Traditional Chinese Medicine (TCM) clinic between the villages of Datam and Tihruldih, Jharkhand, India. This clinic will provide affordable, much need healthcare to many villages in the area. Permaculture design principles will guide the development of the site to supply medicinal herbs for the clinic, food for the clinic workers, interns and volunteers and ultimately act as a demonstration site for ecological food production, environmentally responsible energy production and waste removal management.

Design Brief

- To develop the land surrounding the Traditional Healthcare Clinic using permaculture design principles.
- To improve the site (soil/water) enabling intensive and extensive horticulture.
- To enable the clinic to source much of the required herbs from on-site cultivation of traditional Chinese medicinal herbs.
- To enable the clinic to work towards self-sufficiency in food and energy production and responsible waste management.
- To allow the project to showcase natural and ecological farming/gardening techniques, with possible use as a teaching site.

Site Characteristics

This region is classed as agro-climatic zone 7:(sub zone VI; humid to sub-tropical). Mean annual rainfall is around 1400mm, with major rainfall events occurring during the monsoon between June and September. Little rain falls outside this time.
Soil is depleted and low in fertility.

The site is approximately 0.4 ha, rectangular with the long-axis orientated North-south. To the south, the 'front' boundary of the property is defined by the Datam-Tihruldih Road. The western boundary is fixed and well delineated by a row of Arjun trees (*Terminalia arjuna*) and a large diversion drain.

The northern boundary, whilst slightly irregular and fixed at this time, is expected to be moved significantly northward in the future. The eastern boundary has been defined somewhat arbitrarily and it is anticipated that land east of the current boundary will be available in the future.

This design considers only the land currently available though some comment will be made about future expansion of the site.

The aspect of the site is slightly northward, the front 2/3 being basically level. There is a fall to the north of approximately 1500mm in 2 steps due to two bunds that dissect the site East-west. Northward from the 2nd bund the ground falls away further, rather irregularly with a number of large ruts crossing the site.

Beyond this, the land increasingly falls away towards the river through a number of old rice paddies that are available for the project to use. Generally across the site there is a slight fall from South-east to the North-west.

Significant features of the site

- A 3 building clinic surrounding a large tree Mahuya tree (*Madhuca longifolia*).
- A large ditch forming the western boundary with a row of Arjun trees.
- A row of Arjun trees bisecting the site East-west.

Notes

I had many conversations with Bishwanath Singh (Dada) regarding the project and the use of the site and the features it could include. Dada made one particular request, that he did not want chickens in this system because of the dust they create.

I informed him that I would like to see chickens in this design because of the many benefits they afford, particularly to this site with its poor soil structure and the low fertility. With careful placement of the chickens, and confining them to prevent free-ranging, something very rare in this part of India, I believe his concerns can be allayed.

Dada also requested that fruit grown be of a type not found in this area. This makes great sense as there is little point in growing fruit that is easily acquired at local markets. Of course much will depend upon availability of suitable graft stock.

The plant listing for this site is extensive and it is imagined that not all those listed can be effectively placed within the design. It is anticipated that sourcing of suggested species or suitable cultivars may be difficult, and an exhaustive list allows us to more readily identify alternative selections.

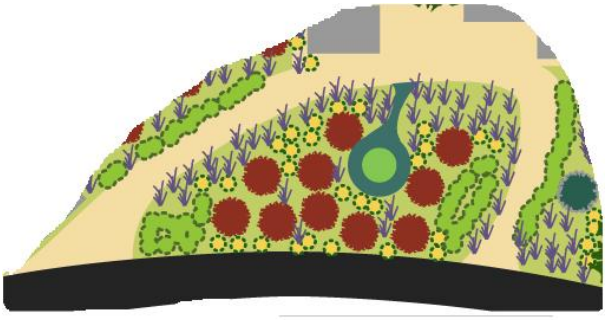
Site Details and Design Concepts

Special note

This design has been undertaken with the view that the health clinic is the primary and most important function of the site. This point is considered in all aspects of the design. In this project, the accommodation area and the kitchen are situated some distance from each other, the kitchen being in the health clinic precinct.

To that end, there have been a number of compromises in respect to the placement of elements (e.g. compost, chickens, orchard) that may not have been made in a more typical ‘residential’ or ‘farm’ design.

Front Section



Details

Approximate area = 1260m^2 (approx: 63m wide x 20m deep)
Encompasses the area bounded by the previously described eastern and western margins, Datam-Tiruldih Rd to the South (frontage) and the clinic entrance to the North (rear).

Overlaps with the western section encompassing the chai stall, water tank and driveway. This section features the planned circular driveway and the area bounded by the driveway and the road, situated immediately in front of the clinic entrance.

Design Concepts

As the entrance to the site and the clinic this area should have aesthetic as well as functional value. It needs to be relatively open to allow easy view of the clinic, enabling easy identification and a sense of welcome. This area can also serve as a spiritual heart of the property.

Driveway to be lined on both sides with stacked layers (ground-covers, shrubs, small trees) of hardy perennial plants designed to:

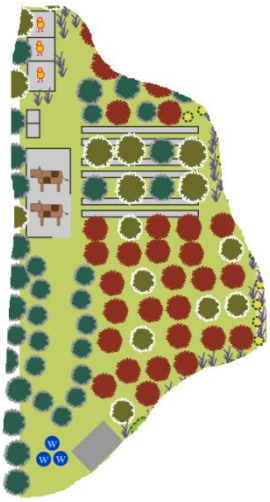
- act as a living fence to separate front and side sections
- attract predatory insect species and provide haven for small birds; and
- provide aesthetic value through the use of flowering species.

Within the area bound by the driveway and the road (approx. 300m^2) is the sealed top well with pump. Surrounding this are trees of the Sacred Grove of India (Mango, Neem,

Fig, Polas. This is dependent upon suitable grafted dwarf varieties being available to ensure trees remain of moderate size when mature).
Chai stall/restaurant to occupy South-western corner to provide sustenance for clinic patients and families and passing traffic. This will help free the clinic of crowding and also provides income for the clinic by way of rent/lease payments.

The area behind this stall is ideally suited for placement of water storage tanks.

Western Section



Details

Approximate area = 1500m^2
The southern boundary here is marked by the Chai stall, water tanks and the driveway. This section extends approximately 52 metres from the roadway to the row of Arjun trees that run across the property.

It is bordered to the sides by the clinic building to the East and the ditch/Arjun tree row that define the western edge of the property. It is approx 29 metres wide for most of its length although the useable space is a little less than this.

This section consists of two (2) very slightly sloped sections separated by a bund approximately 30 metres from the front boundary.

Design Concepts

The open aspect of this area and its proximity to the proposed water storage makes it an ideal site for an orchard system. Irrigation will be simplified and as this area is reasonably well protected from any damaging winds, productivity is enhanced.

The cow pen and associated small grazing/fodder section here enables the building of soil where it's most needed as well as desired proximity to the compost bays.

The lower section of this area is positioned close to areas of increased human activity, those being the banana circles and the pathway connecting the accommodation to the toilet/kitchen buildings of the clinic.

This allows the placement other elements that will at times require significant interaction:

- compost bays along western edge,
- chicken coup and associated runs,
- pathway from compost toilet (if selected) to compost bays,
- market garden beds.

The placement of the chicken coup here will allow easy access for a chicken tractor system to run both through the orchard and the market garden beds.

Two (2) chicken runs are to be constructed adjacent to the coup which will allow grains and grasses to be grown exclusively for chicken feed. Each run is used alternately, with one being used by chickens whilst the other is locked away for grain/grass growing.

This western zone is to be extensively border planted out with aromatic and predator-insect attracting plants to compensate for the presence of the chicken coup and cow pen. The proximity of the market garden to the chicken coup and the compost bays allows easy disposal of plant wastes.

Compost from the bays and chicken runs is easily moved to where it is needed most; the market garden beds and around orchard trees.

The market garden will be used to grow food primarily for the residents of the site. Excess produce can be diverted through the Chai stall or perhaps sold at market.

Due to the extreme solar intensity of this latitude (high light and high temperatures reducing photosynthesis) the bulk and quality of vegetables can be affected.

Leguminous shade trees (eg Gliricidia, Leucaena) will be placed along the southern border of the market garden beds to provide light shade. These trees will also provide soil nitrogen fixation, mulch and green manure where it is needed most.

Rear of Clinic

Details

Approximate area = 310m^2
Measuring approximately 26m across by 12m deep, the area is bounded by the rear of the clinic buildings to the south, the row of Arjun trees to the north and the eastern boundary of the site. To the west this area is bordered by the market garden beds. The land here slopes very slightly away from the clinic, generally in a north to north-west direction.

Design Concepts

The most intensive zone from a permaculture perspective, it consists of:

- the area immediately adjacent to the kitchen,
- the TCM herb preparation room,
- the mandala TCM herb gardens and;
- the pathway to the rear of property and accommodation buildings.

The main features here are the intensive mandala TCM herb and kitchen food garden, encompassing two (2) banana circles which are placed to allow management of grey water from the kitchen and also provide a private personal washing area.

Incorporated within and around the mandala beds will be the main path connecting the kitchen to the accommodation building, as well as paths that lead to the rear of the property.

The eastern border will consist of plantings of value to TCM including trees such as Black Mulberry, Cinnamon, Persian Silk Tree, Red Rooted Sage and White Mulberry.

The very slight slope of this area will assist in drainage of grey water away from the clinic to the banana circles and will also enable passive removal of excess water from this area.

Eastern Section

Details

The boundary here is rather nominal and following consultation with Dada, was ascertained to be parallel with the clinic at a distance of approximately six (6) metres.

There is 1 very large tree close to the road and a few smaller trees and scrub at its southern end, otherwise this strip of land is clear all the way through to the line of Arjun trees some 13m from the rear of the clinic.

Design Concepts

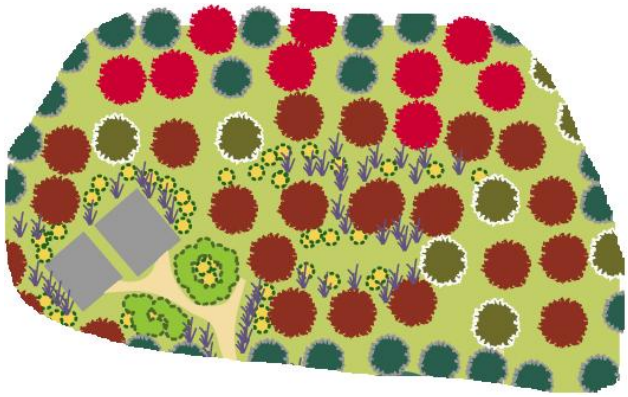
This is not a particularly useful area given that the flow of human activity is noticeably away from this side of the building, and given that the design needs to consider the proximity of this area to the main treatment rooms of the clinic, mainly in terms of patient comfort and privacy.

Plantings here should provide shade to the clinic, less so in the Southern portion to allow morning winter sunlight to reach the building.

There is an opportunity here to increase the bio-diversity of plants on site. The design will incorporate stacking of plants up to small-to-medium sized trees, consisting primarily of TCM plants, predator-insect attracting plants and some legumes. Future development of the land to the east of this area may in-time require some changes to the design of this section.

The northern end of this area experiences greater human activity and its proximity to the mandala herb beds and herb preparation room dictates that trees and shrubs with a greater value to TCM be placed here.

Rear of Property



Details

The rear section is taken to extend from the row of Arjun trees that bisect the property, northwards to the northern boundary. This boundary as mapped is rather irregular and varies in distance from 13 to approximately 29 metres. The width also varies from 35 to approximately 63 metres. The area of this section is approximately 1200m^2.

The land here sits approximately 1500mm below the level of the front of the site, and falls away more acutely towards the north. The land is particularly disrupted by large ruts that run irregularly across the site.

Design Concepts

Situated to the rear of the mandala TCM herb beds, this section includes the accommodation buildings and the pathway that leads to the clinic. In some respects this indicates that high levels of human activity will occur here, although for a number of reasons it is not ideally suited to the more intense activities to be conducted at this project.

As mentioned, the land here is badly rutted and becomes increasingly more sloped towards the rear boundary. Considerable earthworks will be required here to make the site suitable. Excavation fill from elsewhere on this project could be used to modify the topography here, and this also provides the opportunity to create some water capturing features such as small swales and ponds.

This area is useful for developing resources that require less intensive human input, such as firewood and fodder trees. A secondary orchard can be established here as well as other more useful plantings (beneficial herbs, flowering plants, grasses, utility trees).

With its proximity to the accommodation buildings, but its placement away from the clinic and busier public areas, space here can be made for a quiet meditation area.

Buildings

Some considerations for the clinic include:

Cool cupboard: the purpose of a cool cupboard is to replace or reduce the reliance on refrigeration. The cupboard allows perishable goods to be stored for longer than they would otherwise.

The cupboard is constructed such that it has access to either sub-floor air or can be ventilated from below by a network of pipes buried beneath the ground. The more stable and cooler deep soil temperatures allow the cooling of ventilation air which can be passed through to this cupboard.

A passive or active exhaust system above the cupboard creates draw which enables the cupboard to achieve temperatures significantly less than the ambient air temperature.

A system similar in principle can be used to cool the internal environment of the buildings. Air cooled by passing through buried piping can be ventilated into the buildings and vented through appropriately placed roof exhaust systems. Again these can be passive or active.

Water

Supply

Despite high total rainfall, rainfall events occur over a period of a few months in summer, leaving the region without rain for much of the year. Despite the river running dry for 8-9 months, there is usually adequate water from river soaks.
There are two options for water supply for this project:

- pump water from the river to storage tanks on site
- dig a stone or concrete walled, sealed top well on site

Pumping from the river is the most obvious and cheapest option, initially at least. The main problem is maintenance of the pump and piping system and the extra work this would create. Although the process of pumping to storage tanks may only occur 2-4 times/yr (depending on tank capacity), overall it is problematic regarding operation and maintenance.

The second, and Dada's preferred, option is that of an on-site well. Post-construction it should provide relatively trouble free access to water that should be of potable quality, although drinking water is mostly likely to be boiled and filtered.

With up to 40% of Indian groundwater contaminated in some way, testing of well water from this site is required. Dada believes that government funding may pay for the well. A hand and/or power pump (preferably solar) could be used to pump water into an above ground/raised platform storage tank.

The clinic and accommodation roofs are designed to allow capture of rainwater. This can be stored separate to the well water and may provide an alternative drinking water supply. Alternatively, during large rain events, excess rainwater can be diverted from the roofs, via a sump, to the main storage tanks. Collection of this rainwater may help offset problems associated with contaminated groundwater.

Secondary water supply is available by capturing grey water and diverting it appropriately.

The use of a septic tank system for human sanitation can also supply limited volumes of (nutrient rich) fluid.

Storage

There are several levels of water storage on this site: tanks, well and soil.

Tanks

Some small capacity (@200L) tanks can be positioned adjacent to the buildings to collect roof run-off. The primary irrigation tanks need to be placed at or near the high point of the site (behind Chai stall), ideally elevated on stands to allow for gravity irrigation of trees and garden beds.

The larger the tank the better although this will be dictated by the availability of tanks (many 2000L tanks in this part of India) but there have been no larger observed. The ability to construct a stand that will safely hold the desired water capacity will also determine the size of the header irrigation tank.

One option is to place 1 moderate size tank (ie 2000L) on an elevated platform with a number of other tanks placed on the ground nearby. This would require increased frequency of pumping water into the header tank when compared to using a larger tank, but will reduce the complexity of constructing a large tank stand. The well acts as both a source of water and as water storage.

Soil with high humus/organic matter content acts as a water 'storage' system due to its ability to hold water for longer. Whilst the soil on this site currently has very poor water holding capacity, over time this soil will be able to hold more and more moisture, thus slowly reducing the reliance on regular irrigation.

Well

To be situated in the front section of the site within the boundaries of the driveway. Together with trees of the Sacred Grove, the well represents the spiritual heart of the site. In many villages the well is a central gathering place and can perform the same function here.

The well also performs the vital function being the primary source of water for the site. A sealed top well could ensure freedom from contamination, and will allow various pumping options to be considered to enable the pumping of well water to nearby storage tanks.

The top of the well should be raised 300-600mm above the ground to help prevent contamination. This will enable ground covers and low shrubs to be planted around the well, and also facilitates diversion of spilled water to surrounding plants.

Grey water

Grey water from the kitchen to be piped directly to the banana circles, which are to be used as compost and grey water pits. This serves as an efficient use of grey water in providing nutrients and water to banana/papaya trees.

Black water / Sanitation

Toilet/Black water treatment options:

There are a number of options regarding the treatment of human waste:

- 'Black' water biological (pond) treatment,
- Septic tank systems and;
- Composting toilets.

Each obviously has advantages and disadvantages (See appendix for comparison between composting toilets and septic tanks).

Ponds

The first option of treatment of 'black' water is biologically through a series of ponds and reed and filter beds. This would be for post-septic tank discharge. In this instance it may be complicating a process that is then at risk of creating maintenance problems.

The potential risks (disease transmission, mosquito breeding sites, ground water contamination) associated with a series of ponds and reed beds would seem to preclude its use in this environment, especially given monsoonal rainfall events.

Septic tanks

This involves an in-ground tank utilising anaerobic decomposition with diversion/use of tank discharge. Septic tank effluent can be passed into long mulch trenches moving slowly away from the buildings and intensively planted out to make use of nutrients and to minimise contamination of ground water.

An alternative means of dealing with tank effluent involves discharging directly around trees as a liquid fertiliser. This ideally requires a sump/pump system, which introduces some complexity and there is also the risk of disease transmission.

Septic tank systems require higher capital and construction input and may require periodical evacuation.

The cultural toileting practices here with water cleansing and flushing may lend itself to the use of a septic system.

Compost toilet

Properly constructed and handled, a compost toilet system can be a valuable source of fertiliser, as well as an efficient and sensible use of 'waste'.

Dry or near-dry systems utilise aerobic decomposition, with further composting of manure after a period of time. Done properly, this reduces the pathogen load to a point whereby the composted material is safe to handle and to use as a fertiliser/soil conditioner.

One issue with this project is the cultural use of water to wash with after toileting. Most compost toilet systems require separation of faecal matter and fluid (or at least minimal fluid use) so a means by which to divert and collect urine and wash water would be needed. There are squatting pans that can do this.

The critical issue is that whilst urine is generally pathogen free and able to be disposed of readily, wash water could not be considered pathogen free and thus presents a handling and disposal problem.

Typically urine alone would be used on the compost and garden. Here, one option may be to divert all liquid waste to long, deep mulch trenches where biological action and slow infiltration into sub-soil will deal with this waste.

Irrigation

Ideally the irrigation tank/s will be elevated sufficient to allow gravity flow.
If an adequate water head is not achieved, then a solar powered pump could be utilised.

Orchard trees

Drip irrigation depending on availability of the necessary hardware.

- Water to be accessed from the elevated storage tank and septic system overflow if available.
- Clay pot irrigation. This involves burying unglazed clay pots around trees and filling with water as required. This is especially apt here given the abundance of unglazed clay pots in Datam. The only issue with this technique is that it can be a particularly labour intensive.

Vegetable and Herb gardens

Drip irrigation from header tank.

There is considerable landscaping in the region and immediately around this site designed to remove surface water. Extensive roadside diversion drains and bund construction indicates the intensity of monsoonal rain events.

It is anticipated that much of this rainfall moves over the land quickly with poor infiltration and certainly poor water holding capacity in the soil.

A series of small gabions placed in the diversion drain that defines the western boundary of this site, together with slotted pipe drains running slightly off contour, buried to depth of up to 0.5m can be constructed to divert some of this water onto the TH site, in the vicinity of the orchard trees and market garden.

This may help to charge sub-soil water, and although this would only happen during a high rainfall event, it facilitates infiltration that may not otherwise occur.

Banana Circles

The 2 banana circles can be supplied with grey water from the kitchen and herb preparation rooms. The banana circles can also be used to provide private human washing places provided suitable soaps are used.

This would require that each banana circle is used alternately over a 2-3 week period so as to allow adequate compost management of waste water. It is important that natural agents safe for use on gardens, including low salt and boron free products are used in the grey water systems.

The banana circle pits will need to be dug out every 6 months to access composted material. To ensure that pits are not too water logged and that adequate drainage occurs, an overflow pipe is to be placed in the rear wall of the circle directing overflow into surrounding garden beds.

Soil

Details

Sites consists of a silty clay at depth of @ 300-400mm over a deep layer of fine-to-medium gravel. Interspersed are large patches of sand consistent with the region. This soil has very low levels of humus /organic matter.

It would be highly leached and it can be safely assumed that it is deficient in most necessary minerals and trace elements.

A soil test is necessary to establish which mineral elements require replacement. The National Soil Health Mission has established soil testing laboratories in Jharkhand.

Design concepts

Amelioration of the soil is of the highest priority for this site, aiming to elevate mineral and trace element levels, humus content, water holding capacity and soil biota.

Rehabilitating poor soils in tropics/sub-tropics is a difficult and long-term undertaking. A good approach is to concentrate initially on the small, most critical areas (mandala herb beds, banana circles). Once these are established, then soil preparation for the rest of the site can commence.

To enable early planting of trees, efforts should be made on improving soil in the planting holes at the time of planting. Other areas will need longer term soil building measures such as green manures, composting and mulching.

Design Application

Soil building/regeneration here will be an ongoing process requiring intensive management through:

- importing manure/straw/plant waste for large scale composting
- extensive use of mulch trenches,
- alley cropping with legume grasses (b/w trees in orchard area),
- extensive use of legume species (trees, shrubs, grasses),
- strategically placed worm buckets,
- mulching,
- compost teas,
- green manures and;
- animal systems:
    - chickens: manure, composting and chicken tractors
    - cows: manure and grazing of legume grasses to build soil humus.

Strategies

Soil mineral/biologytest.

Composting to begin as soon as possible using manure, straw, fallen leaves, rice husks, bamboo leaves, plant waste and food waste if available. This will require multiple composting heaps to be situated around the site, concentrating initially near the site of the mandala herb beds. The piles need to be of modest size (@1metre diam.) to enable regular and efficient turning. Heaps should be covered to prevent leaching of nutrients due to monsoon rains and solarisation.

Mandala garden beds to be fashioned into shape, aged cow manure/compost to be dug into soil and planted with green manure crop (eg Cow pea or Lupin), and dug-in before flowering.

No cultivation of the soil aside from 1 or 2 passes of a thin-shanked deep ripper if one is available.

Mark out tree sites.

Mulch trenches to be dug and filled with plant waste, leaves etc.

Western diversion drain gabion pipe trenches excavated running off-contour b/w tree lines, pipes laid and backfilled**.**
Sow annual legume crop (Lab Lab, Cow pea, Clover) in alleys between trees).

Long graze with cows if can or chop/drop before flower/seed.

Follow with chook-tractor (do not allow chooks to clear ground).

Options beyond existing northern/eastern boundaries

Further to the north of the current boundary the land slopes increasingly more acutely towards the river. There exists within this section some old rice paddies which are apparently available for use now, although with significant rice production in the region, growing rice on this site is perhaps not the best activity to pursue here.

The topography here would suggest a high probability of significant surface water movement during the monsoon. Future use of this area could include the development of a food forest for browsing/foraging type fruits, a wilderness area allowed to evolve naturally (Zone 5 in permaculture) or perhaps the development of an aquaculture system dependent upon the ability of the soil to facilitate dam construction as well local knowledge of aquaculture systems.

To the east, the land could be dedicated to developing an integrated methane digestion system, incorporating the proposed swine raising with growing digester feedstock such as Miscanthus and Switch Grass.

Other potential feedstock includes corn, potatoes, yam and wheat, although growing food to 'feed' a digester would perhaps be difficult to justify in this community. It may be better to use cows (along with pigs) to provide manure for the digester given the other benefits of cows (meat, milk) for this community.

Both these species could be integrated within a silviculture system designed to create a medium to long term income producing program.

Such plant species here could include:

- Bamboo (*Bambusa spp*)
- Drumstick (*Moringa olifiera*)
- Gliricidia (*Gliricidia sepium*)
- Icecream Bean (*Inga edulis*)
- Indian Beech Tree (*Derris indica*)
- Leucaena (*Leucaena spp*)
- Neem (*Azadirachta indica*)
- Persian Silk Tree (*Albizia julibrissin*)
- Prosopis (*Prosopis cineraria*)
- Siris Tree (*Albizia lebbek*)
- Tagasaste (*Chamaecytisus palmensis*)
- White Mulberry (*Morus indica*)

Project Plan

Stage 1

Soil

Soil mineral/biology test. The National Soil Health Mission has established soil testing laboratories in Jharkhand which can assess this soil more specifically.
Source lime, dolomite, crushed rock/basalt/granite and trace element/mineral suppliers as required.

Commence soil production with large scale composting.

- collect as much straw, animal manure, plant and food waste as possible for composting (avoid excessive amounts of wood ash);
    - cover to prevent leaching,
    - keep piles moist,
    - turn regularly.

Use compost to establish mandala and banana circle beds first.

Use soil excavated from building and irrigation works to level northern section.

Mark out site including position of garden beds, pathways, trees and irrigation systems (tanks, pipes, trenches), mulch trenches.

Water

Commence water harvesting/storage and irrigation works:

- excavate and construct sealed top well,
- erect irrigation tank/s header stand,
- position clinic roof/accommodation building water tanks,
- construct rock/timber gabions in western trench.
- excavate trenches and position slotted pipe,
- excavate and position grey water pipes for banana circles,
- excavate and position irrigation piping.

Stage 2

Construct zone 1 garden (mandala/banana circles).

- shape, mound and border manadala garden beds.
- dig pits and mound banana circles.
- plant out to green manure crops.

Construct paths to accommodation area.

Lay-out market garden beds and plant green manure crops.

Continue to build soil:

- through intensive composting.
- worm buckets spread through garden beds.
- keep all areas of soil production well mulched at all times.

Remove existing trees and clear site of existing scrub as required.

When sufficient soil building has occurred, commence planting of mandala herb beds as a priority, followed by nursery, legume, windbreak and shade trees.

Construct border and herb garden beds and commence sowing of flowers, shrubs, herb and beneficial insect plants.

Commence planting of fruit trees as ground becomes suitable.

If irrigation system/water supply not ready/adequate, irrigate with unglazed clay pots.
Construct chicken coup and enclosed runs and cow enclosure.

Stage 3

Continue to build soil with intensive composting.

Continue Fruit tree plantings.

Plant out market garden beds if adequate soil with green manure crop or vegetables if able.

Sow for alley cops and long graze cattle (on short rope to protect trees) when able. Construct and begin using chicken tractor.

Conclusion

This design shows the site at its most evolved stage and at maximum production and function. In keeping with sensible design, development of the site will take place in stages, beginning with Zone 1 gardens and critical elements (soil and water), expanding as each area becomes manageable.

Exact details of how the system will be managed are unable to be ascertained at this stage. This situation will develop over time and the design and its implementation can be adjusted to accommodate this. This is particularly so with regard to the areas beyond the current boundaries that have a high probability of being available to the project at some future time.

The possible limiting factors here are the availability of capital to purchase material for the site and the labour required to undertake site works. The design lists numerous plant species, perhaps too many to place on this site, but it is anticipated that the ability to source suitable quality cultivars and tree specimens may be problematic, and so numerous options are provided.

Plant List

Front section

Sacred Grove of India trees

Mango, Neem, Polas, Fig if suitable dwarf species/grafted varieties available.

Beneficial herbs

Alyssum, Anise, Borage, Caraway, Coriander, Cosmos, Dill, Fennel, Feverfew, Lemon Balm Lupin, Marigold, Nasturtium, Queen Anne's Lace, Sunflower, Tansy, Wild Bergamot, Yarrow.

Hedge plants

Arrowroot, Comfrey, Coprosma, Desmodium, Indian Arrowroot, Lemongrass, Pidgeon Pea, Sesbania, Vetiver grass.

Driveway

Beneficial herbs

Alyssum, Anise, Borage, Caraway, Coriander, Cosmos, Dill, Fennel, Feverfew, Lemon Balm Lupin, Marigold, Nasturtium, Queen Anne's Lace, Sunflower, Tansy, Wild Bergamot, Yarrow

Hedge plants

Arrowroot, Comfrey, Coprosma, Desmodium, Indian Arrowroot, Lemongrass, Pidgeon Pea, Sesbania, Vetiver grass.

Western Orchard

The selection of fruit trees has been generally prioritised according to the relative nutritional values of the various fruits. Whilst all fruits display good nutritional properties, some are higher in certain values and others have a greater spread of nutritional constituents. Other factors may in time influence the trees selected such as taste preference, culture, success in growing, ease of harvest etc.

Fruit trees

Avocado, Carambola, Custard Apple, Fig, Guava, Papaya, Jujube, Mango, Orange, Pomegranate, Tamarillo.

Utility Trees

Arjun tree, Crested Wattle (Spiked Acacia), Drumstick, Gliricidia, Icecream Bean, Indian Beech Tree, Leucaena, Mahua (Mahwa), Neem, Persian Silk Tree, Polas, Prosopis, Siris, Tagasaste, White Mulberry

Rear Orchard

Fruit trees

Bael, Indian jujube, Tamarind, White Sapote, White Mulberry

Utility trees

Arjun tree, Crested Wattle (Spiked Acacia), Drumstick, Gliricidia, Icecream Bean, Indian Beech Tree, Leucaena, Mahua (Mahwa), Neem, Persian Silk Tree, Polas, Prosopis, Siris, Tagasaste, White Mulberry

Nut trees

Cashew, Macadamia

Eastern Side

Black mulberry, Cinnamon, Persian Silk Tree, Red Rooted Sage, White Mulberry

Fruit Trees

Avocado (*Persea americana*)

x 5m	E	Partially self-fertile	Main orchard x 5

Bael (*Aegle marmelos*) Bilwa

10 m x	D	Pollination unknown	Rear orchard

Banana (*Musa spp*)

2m x		No pollination required	Banana circle

Carambola (*Averhhoa carambola*) Star fruit

6-8 10m x 6	E	Requires cross-pollinator	Main orchard x 3

Custard Apple (*Annona squamosa*) Sharifa

3-5m x	D/E	Self-fertile	Main orchard x 3

Fig (*Ficus spp, carica*)

5 x 2m	D	Pollinated by small wasp	Main orchard x 3

Guava (*Psidium spp*)

5+m x 2	E	Some cross-pollination	Main orchard x 4

Indian jujube (*Ziziphus mauritiana*) Ber

15m x	E	Requires cross-pollinator	Rear orchard

Jujube (*Ziziphus jujube*)

9 x 2m	D	Better cross-pollinated	Main orchard x 3

Mango (*Mangifera indica*)

30+ x 10m	E	Self-fertile	Main orchard x 3

Orange (*Citrus* sinense)

5-10m x	E	Self-fertile	Front orchard 3

Papaya (*Carica papaya*)

10 x 2	E	Self-fertile x pollination	Banana circle

Pomegranate (*Punica granatum*)

5-8m x	D	Self-fertile	Main orchard x 3

Tamarillo (*Cyphomandra betacea*)

4 x 2m	E	Self-fertile	Main orchard x 3

Tamarind (*Tamarindus indica*) Tentul, Imli

6-10m x	E	Self-fertile better with x p.	Rear orchard

White Sapote (*Casimiroa edulis*)

10+ x 5m	E	Everbearers are self-fertile	Rear orchard
		Seasonal bearers need x-pollinator (Ortego/Vernon)	

White Mulberry (*Morus indica*)

10m x	E	Self-fertile	Near chook pen

Nut Trees

Cashew (*Anacardium occidentale*)

10m x	E	Self-fertile better with x-pollinator

Macadamia (*M. integrifolia, tetraphylla*)

15+m x	E	Self-fertile better with x-pollinator

Utility Trees

Arjun trees (*Terminalia arjuna*)
25m E

Crested Wattle, Spiked Acacia (*Albizia lophanthia*)
10m x E/D Leguminous

Drumstick (*Moringa olifiera*)
10 x 4m D Leguminous

Gliricidia (*G. sepium*)
10m x D(e) Leguminous

Icecream Bean (*Inga edulis*)
15+m x 5 E Leguminous

Indian Beech Tree (*Derris indica*)
8m x D Leguminous

Leucaena (*L. leucocephala, latisiliqua, glauca*)
5m x 3 E +/- D Leguminous

Mahua. Mahwa (*Madhuca longifolia*)
20 x 10m E

Neem (*Azadirachta indica*)
15+ m x E

Persian Silk Tree (*Albizia julibrissin*)
5-10m x D Leguminous

Polas Trees (*Butea monosperma*)
D Leguminous

Prosopis (*Prosopis cineraria*)
5-10 m x E Leguminous

Siris Tree (*Albizia lebbek*)
30m x Leguminous

Tagasaste (*Chamaecytisus palmensis*)
4 x 3 E Leguminous

White Mulberry (Morus indica)
10m x E

TCM Trees/Plants

Black mulberry (*Morus nigra*)
10 x 20m D

Cinnamon (*Cinnamomum verum*)
10m x E
Persian Silk Tree (*Albizia julibrissin*) Pink Siris, Mimosa
5-10m x D Leguminous
Red Rooted sage (*Salvia Miltiorrhiza Radix*) Dan Shen
White Mulberry (*Morus indica*)
10m x E

Other Plants

Amaranth Grain (*Amaranthus spp*)
Amaranth Leaf (*A. cruentus, blitum, dubius, tricolor*)
Arrowroot *(Maranta arundinacea*) Obedience plant
50-100 cm x Perennial rhizome/Annual flower
Banna grass Fast growing Windbreak
Comfrey (*Symphytum x uplandicum*) Bocking 14 of Russian Comfrey
Coprosma (*C. grandifolia*)
Shrub to small tree. Has nitrogen fixing bacteria in leaves. Fodder potential
Desmodium (*D. dichotomum*)
.6m x Legume, perennial
Indian Arrowroot (*Hitchenia caulina*)
50-100 cm x Perennial rhizome/Annual flower
Lemongrass (Cymbopogan citrate)
East-Indian Lemon Grass(C. flexuosus), Cochin, Malabar grass.
to 2m x perennial.
Pulses (Chickpea, lentils, mung)
Sesbania (*S. spp)*
S. grandiflora - Hummingbird tree/Scarlet Wisteria. Gaach-munga
3-5m x Fodder tree
Vetiver grass (*Vetiveria zizanioides*)
Monto is non-seeding variety
1.5 m x Companion to Banana plants.

Other Legumes

Glycine (*Neonotonoia wightii*)
Legume. Trailing, climbing perennial
Peuro (*Puearia phaseloides*)
Vigourous perennial and climbing legume
Siratro (*Macroptilium atropurpureum*)
Legume. Trailing, climbing perennial. Drought resistant

Pasture legumes

Cowpea (*Vigna unguiculata*)
Shade tolerant. Alleycrop in orchard
Clover (*Trifolium spp*)
Greenleaf Desmodium (*D. intortum*)
Vigourous trailing perennial
Lablab (*L. purpureus*) Wal
Can be long-grazed.
Peanut (*Arachis hypogaea*)
Annual
Pidgeon Pea (*Cajanus Cajan*) Toor Dal
Short-lived perennial/annual. Can develop into small tree (2-4m x)

Growing Notes

Fruit Trees

Avocado (*Persea americana*)
Avoid waterlogged soil, must protect from wind. Partially self-pollinating
Need A and B type

Bael (*Aegle marmelos*) Bilwa
Spiritual and medicinal tree

Banana (*Musa spp*)

Protect from wind. Need high fertility. Mulch well and keep weeds away.
Keep moisture and fertilised at all times. Select spear point sucker, not one with biggest leaves. It will have wide base and tapering stem, narrow leaves. If transplanting dig out corm with roots. Remove bell as fruit fills to improve banana quality.

Carambola (*Averhhoa carambola*) Star fruit

Main crop late winter but can bear all year. Like the grapefruit, carambola contains oxalic acid, care with people with kidney failure.

Custard Apple (*Annona squamosa*) Sharifa

Insect or hand pollinated. Prefers hot, low altitude, needs well drained soil, full sun.
Fruits on current year growth, prune vigorously.

Fig (*Ficus spp, carica*)

Protect from wind. Adriatic var. needs no pollinator. Fruit fresh or preserved (dried or jam). Too much pruning compromises Breba crop, which forms on tips of previous years growth (1 year old wood). 2nd, or main crop, forms at base of current year growth. This growth will produce the Breba crop the following autumn (12-15 months away).

Guava (*Psidium spp*) Jaam

Fruit fresh or preserved. Medicinal.

Indian jujube (*Zizipus mauritiana*) Ber

Requires cross-pollinator

Jujube (*Ziziphus spp*)

Mango (*Mangifera indica*)

Check dwarf varieties fruiting, not ornamental. Try Kensington pride or related cultivar.

Orange (*Citrus* sinense)

Fruit on new wood. Can prune hard. No pollinator required.

Papaya (*Carica papaya*)

Avoid wet-feet. Plant can alter sex of flower. Best to have cross-pollinators.

Pomegranate (*Punica granatum*)

Grows in wide range of soil. Drought tolerant

Tamarillo (*Cyphomandra betacea*)
Shallow-rooted. Protect from wind. Self-fertile

Tamarind (*Tamarindus indica*)
Slow growing, large tree. Protect from wind. Self-fertile. Fruits on new growth so hard prune.

White Sapote (*Casimiroa edulis*)
Bears on older wood, don't over-prune.
Fruit may take 8-10 months to mature. Everbearers self-pollinate.
Seasonal bearers need cross-pollinator (Ortego/Vernon). Has very invasive root system
Has messy fruit fall. Withhold water from mature trees in winter to encourage flowering.
Tends to sappy growth, tip prune to encourage laterals

Nut Trees

Cashew (*Anacardium occidentale*) Kaju

Macadamia (*M. integrifolia, tetraphylla*)
Slow growing, protect from wind. Wide spacing required, but slow growth means can interplant in meantime.

Utility Trees

Arjun trees (*Terminalia arjuna*)
Useful as timber and firewood, medicinal properties in both Ayurvedic and Yunani systems. Drought tolerant.

Crested Wattle, Spiked Acacia (*Albizia lophanthia*)

Fast growing, short lived, some fodder potential. Drought tolerant

Drumstick (*Moringa olifiera*)
1 of few legume trees with with edible fruit. Prune annually to promote fruit.
Coppices well. Good fodder. Insect pollinated. Drought tolerant.
Seeds- crushed use to clean water. Bark- medicinal. Sap-rheumatism
Leafs- HT

Gliricidia (*G. sepium*)

Leguminous. Fodder, insect repellent, medicinal, firewood. Drought tolerant
OK for ruminants. Wash from leaves used to prevent parasites on animals

Icecream Bean (*Inga edulis*)

Edible bean, fodder. Needs regular water.

Indian Beech Tree (*Derris indica*)

Use leaf as green manure, fodder tree, insect repellent. Drought tolerant

Leucaena (*L. leucocephala, latisiliqua, glauca)*

Leaves, pods, flowers, seeds edible. Great fodder. Mimosine toxicity if too much (>30% of diet). OK for ruminants. Alley-crop tree, Very fast grower. Tolerates prolonged dry.

Mahua (*Madhuca longifolia*) Mahwa

Long-lived holy tribal tree. Seeds supply oil- skin care, soap, fuel. Sseed-cake makes good fertilizer, flowers fermented to alcohol.

Neem (*Azadirachta indica*)

Very tolerant tropical/arid conditions. Timber, furniture, excellent firewood, coppices well, insect repellent, toothbrushes.

Persian Silk Tree (*Albizia julibrissin*) Pink Siris, Mimosa

Leguminous. Medicinal (TCM). Attracts bees, ornamental. Fodder (seeds)

Polas Trees (*Butea monosperma*) Begal Kino

Sacred grove of India tree. Drought tolerant, multiple uses, medicinal.

Prosopis *(Prosopis cineraria*)

Leguminous. Fodder. Ok for ruminants. Firewood, medicinal.
Very drought tolerant.

Siris Tree (*Albizia lebbek*)

Fast growing. Tolerates wide range of environments.
Grows in marginal soils, good fodder, firewood, furniture, erosion control.

Tagasaste (*Chamaecytisus palmensis*)

Fast growing, short lived, coppices well, excellent fodder, not toxic to animals, good firewood.

White Mulberry (*Morus indica*)
Berries and fodder tree. Wind pollinated.

TCM Trees/Plants

Black mulberry (*Morus nigra*)
Need dwarf variety

Cinnamon (*Cinnamomum verum*)
Requires coppicing

Persian Silk Tree (*Albizia julibrissin*) Pink Siris, Mimosa
Attracts bees, ornamental

Red Rooted sage (*Salvia Miltiorrhiza Radix*) Dan Shen

White Mulberry (*Morus indica*)
Berries and fodder tree. Wind pollinated.

Other Plants

Amaranth Grain (*Amaranthus spp*)
Grain species highly tolerant of arid conditions. Considered the food of the future. Very high protein, lysine and iron and is gluten free.

Amaranth Leaf (*A. cruentus, blitum, dubius, tricolor*)
Leaf is high in Vitamins A, C and B group. Moderately high in oxalic acid which inhibits calcium/zinc absorption. Moderate consumption by people with kidney disorders, gout, rheumatoid arthritis.

Arrowroot *(Maranta arundinacea*) Obedience plant
Perennial rhizome/Annual flower.

Banna grass

Fast growing. Provides mulch. Windbreak. Stabilises soil.

Comfrey (*Symphytum x uplandicum*) Bocking 14 of Russian Comfrey

Coprosma (*C. grandifolia*)
Shrub to small tree. Has nitrogen fixing bacteria in leaves. Fodder potential.

Desmodium (*D. dichotomum*)
Legume, perennial.

Indian Arrowroot (*Hitchenia caulina*)
Perennial rhizome/Annual flower.

Lemongrass (*Cymbopogan citrate*)

East-Indian Lemon Grass (*C. flexuosus*), Cochin, Malabar grass
Perennial, medicinal. Around back of FT to catch soil/hold mulch.

Sesbania (*S. spp.)*
S. grandiflora - Hummingbird tree/Scarlet Wisteria. Gaach-munga
Legume. Fodder tree.

Sweet Potato (*Ipomoea batatas*)
Perennial vine. High in Vitamins A, C and B6.

Vetiver grass (*Vetiveria zizanioides*)
Monto is non-seeding variety. Companion to Banana plants.

Other Legumes

Glycine (*Neonotonoia wightii*)
Trailing, climbing perennial. Phosphate cycler. Grazed in winter, rested in summer. For grazing pen.

Peuro (*Puearia phaseloides*)
Vigourous perennial and climbing legume. Needs light grazing. Cut and carry forage. Shade tolerant.

Siratro (*Macroptilium atropurpureum*)

Trailing, climbing perennial. Drought resistant. Needs light grazing. Cut and carry forage.

Pasture Legumes

Cowpea (*Vigna unguiculata*)

Annual summer-growing legume. Needs innoculant, grows well in poor soils. Shade tolerant. Alleycrop in orchard.Excellent for long-grazing.
Entire plant is edible. High in Ca++, Folic acid and Vit. A

Clover (*Trifolium spp*)

Excellent forage

Greenleaf Desmodium (*D. intortum*)

Vigourous trailing perennial - need to start with test area for orchard area only, after trees established. Needs grazing - cow and/or/chicken tractor maybe chop and drop.

Lablab (*Lablab purpureus*) Wal

Legume (needs innoculant). Is an annual summer-growing legume. Grown for beans(dhal), forage or both. Can forage regrowth after harvest. Bean high in vitamins A, B and C. Can be long-grazed/Chop and drop.

Peanut (*Arachis hypogaea*)

Annual

Pidgeon Pea(*Cajanus Cajan*) Toor Dal

Requires innoculant.Short-lived perennial/annual. Can develop into small tree (2-4m x). Drought resistant. Crop diminishes over time. Tolerates heavy pruning.

Appendix

Deep Ripping Notes

Rip when soil moist (after 1st good rain). This is a discrete vertical cut in soil. Soil is not inverted/turned over as in traditional 'ploughing'. Ideally a long think shank with foot ('sheeps foot') on the end.

1 pass on or near contour 10-15cms deep. Sow annual legume crop
long graze if can or chop/drop before flower/seed
2nd pass to 20-25cm. Sow to perennial grass or cover crop…followed by trees with hole dug out over around rip so tree planted on rip line
begin long-grazing and/ chook-tractor. Do not allow chooks to clear ground. Only graze chooks/cows when grass long and move on frequently. With chooks maybe 1 pass per season. Do not graze cows on wet ground.

Double-vault composting latrine

Advantages	Disadvantages
• Low construction costs. • Excreta (when safely composted) is a useful soil conditioner. • Urine provides a rich source of nitrogen and phosphorous. • Water not required for use. • May be able to educate locals as to excreta as a valuable fertilizer.	• Poorly constructed or maintained latrines can attract flies and cause bad odours. • Early removal of faeces can lead to exposure to pathogens. • Requires periodic maintenance and management including removal of composted faeces from vault.

Septic tank latrine

Advantages	Disadvantages
• Odourless due to water seal between the stored excreta and the inside of the latrine. • Low maintenance required when operating correctly.	• Higher capital costs associated with ensuring adequate supply of water for flushing. • Susceptible to blocked underground pipes which are difficult to repair. • Costly emptying of septic tanks required periodically – specialised equipment and service personnel needed. • Leachate and leakage from tanks can cause ground water pollution and is a potential human health hazard. • Large volumes of water required for flushing. • No benefits from use of urine or decomposed faeces as fertilizer.

Reference; *Sustainable sanitation in South East Asia and the Pacific*. WaterAid Australia, March 2008

Species List

Beneficial Insect Herbs

Alyssum, Anise, Borage, Caraway, Coriander, Cosmos, Dill, Fennel, Feverfew, Lemon Balm Lupin, Marigold, Nasturtium, Queen Anne's Lace, Sunflower, Tansy, Wild Bergamot, Yarrow

Border and Hedgerow

Arrowroot (*Maranta arundinacea*)
Comfrey (*Symphytum x uplandicum*)
Coprosma (*C. grandifolia*)
Desmodium (*D. dichotomum*)
Indian Arrowroot (*Hitchenia caulina*)
Lemongrass (*Cymbopogan citrate*)
Pidgeon Pea (*Cajanus cajan*)
Sesbania (*S. spp)*
Vetiver grass (*Vetiveria zizanioides*)

Miscellaneous plants

Banna grass
Sweet potato

Pasture Legumes

Cowpea (*Vigna unguiculata*)
Clover (*Trifolium spp*)
Greenleaf Desmodium (*D. intortum*)
Lablab (*L. purpureus*)
Peanut (*Arachis hypogaea*)
Pidgeon Pea (*Cajanus cajan*)

Fruit Trees

Avocado (*Persea americana*)
Banana (*Musa spp*)
Bel fruit (*Aegle marmelos*)
Carambola (*Averhhoa carambola*)

Custard Apple (*Annona squamosa*)
Fig (*Ficus spp, carica*)
Guava (*Psidium spp*)
Indian jujube (*Ziziphus mauritiana*)
Jujube (*Ziziphus spp*)
Mango (*Mangifera indica*)
Orange (*Citrus sinensis*)
Papaya (*Carica papaya*)
Pomegranate(*Punica granatum*)
Tamarillo (*Cyphomandra betacea*)
Tamarind (*Tamarindus indica*)
White Mulberry (*Morus indica*)
White Sapote (*Casimiroa edulis*)

Nuts

Cashew (*Anacardium occidentale*)
Macadamia spp (*M. integrifolia, tetraphylla*)
Peanut (*Arachis hypogaea*)

Utility Trees

Arjun (*Terminalia arjuna*)
Crested Wattle, Spiked Acacia (*Albizia lophanthia*)
Drumstick (*Moringa olifiera*)
Gliricidia (*G. sepium)*
Icecream Bean (*Inga edulis*)
Indian Beech (*Derris indica*)
Leucaena (*L. leucocephala, latisiliqua, glauca*)
Polas Trees (*Butea monosperma*)
Prosopis *(Prosopis cineraria*)
Siris Tree (*Albizia lebbek*)
Tagasaste (*Chamaecytisus palmensis*)
White Mulberry (*Morus indica*)

Medicinal

Arjun trees (*Terminalia arjuna*)

Drumstick (*Moringa olifiera*)

Gliricidia (*G. sepium*)

Neem (*Azadirachta indica*)

Prosopis (*Prosopis cineraria*)

Firewood

Arjun trees (*Terminalia arjuna*)

Gliricidia (*G. sepium)*

Indian Beech (*Derris indica*)

Neem (*Azadirachta indica*)

Prosopis (*Prosopis cineraria*)

Siris Tree (*Albizia lebbek*)

Tagasaste (*Chamaecytisus palmensis*)

Benefits of Moringa Olifera