Handbook for Regenerative Agriculture

Regenerating sand to loam

USAID
FROM THE AMERICAN PEOPLE

NSRC

Written and compiled by

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Maragalakanda mountain range, Moneragala District

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This book is a culmination of several years of field based learning that is still continuing. Writing it has been a challenge since it is experiential knowledge that was gleaned in part from my interactions with farmers in the past years and recently with those associated with the USAID/CORE Programme in regenerative agriculture. Some of this learning has also been from the work done by others.

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Through the publication of this Manual I share first hand experience and understanding with others who engage in farming.

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Introduction

The Connecting Regional Economies (CORE) is a project established by the U.S. Agency for International Development (USAID), as part of the Integrated Strategic Programme for the Economic Development of Sri Lanka. The USAID CORE project implemented programs to amalgamate economies of the East, North Central and Uva provinces with the main economic stream of the country. One important activity was the enhancement of productivity and quality through providing new agricultural knowledge and the introduction of new methods. USAID/CORE supports regenerative agriculture, as it is an eco friendly method for improving productivity through new technology, increasing income and creating new market opportunities.

What is regenerative agriculture, you may wonder. Regenerative agriculture enables the regeneration of soil through the restoration of vegetation in a farm landscape using a high diversity of both annual and tree crops. It seeks to convert a home garden into a forest garden. The farmer gains not only in terms of income but also other benefits like nutrient recycling, hydrological stability and natural pest predator control.

The farmer regenerates his health and that of his family by eliminating the use of chemical fertilizers and biocides in agriculture. Regenerative agriculture only uses biological fertilizers and pesticides that do not contaminate soil and water.

Regenerative agriculture improves the fertility of the soil whilst reducing the cost of production. It creates an abundance of a wide variety of food and other agricultural products that contributes to vibrant communities and equitable economies. It also helps the soil to retain moisture and thereby leads to a decrease in water required for irrigation.

Regenerative agriculture is an integrated systems approach. It includes organic farming[1] and agroforestry[2] that will reduce atmospheric carbon dioxide (CO_2) through sequestration and storage as soil carbon, biomass and lignified tissue in trees. By changing how we farm it is possible to mitigate the impacts of global warming instead of contributing to them. Farmers can adopt new practices relatively quickly and inexpensively using low- cost technologies.

The key to greater and more stable carbon sequestration lies in the handling of soil organic matter (SOM). Because SOM is primarily carbon, increases in these levels will be directly correlated with carbon sequestration. While prevailing farming practices using synthetic inputs typically deplete SOM, regenerative farming practices, including the integration of crop and animal production, build it.

[1] *Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. International Federation of Organic Agriculture Movements, IFOAM, 2006*

[2] *Agroforestry is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land-use systems. USDA, National Agroforestry Centre*

Before forests were converted to field agriculture, SOM generally composed 6-10% of the soil volume, well over the 1-3% levels typical of today's agricultural field systems. Hence, the inclusion of tree crops in agriculture will serve to lock atmospheric CO_2 and return carbon to the soil in the form of biomass. Tree dominated agriculture therefore has a greater capacity for carbon sequestration than the above ground biomass measurements that are often only used in conventional estimations.

Regenerative agriculture relies on inputs from the land itself and is easy to engage in. It has many other benefits that include:

- Maximum utilization of land since the landscape design of a farm garden uses a diversity of both tree and annual crops.
- Reduced dependence on any one crop and little risk.
- Increased food security and diets that are diverse, nutritious and chemical free.
- Improved water management minimizing the impact of drought or flood.
- Increased organic matter in the soil through mulching reduces soil erosion, decreases evaporation of moisture from the soil and increases moisture retention.
- Increased water infiltration and thereby recharge of ground water.
- Reduced cost of production since all inputs are sourced from the farmer's garden or in close proximity to it.
- New markets open for organic food.

However some aspects to consider are that:

- There is greater involvement of family labour.
- The initial quantum of work is high but it is only a one-time investment in terms of time and energy.

Anyone can engage in regenerative agriculture, regardless of the extent of the farm garden.

Background

Over 35 farmers who were involved with the USAID CORE Project in the cultivation of lime (Moneragala district) and Papaya (Ampara district) engaged in regenerative agriculture based on a watershed perspective. This handbook is based on their actual experiences and bears real life testimony to the efficacy of the technologies described. Hence the Manual may adopt a somewhat narrative record of the work done in the Project where great detail is paid to the technologies adopted. The objective is for farmers to use this as a Primer.

CHAPTER 1
Identifying our needs

The very first step is to identify what our needs are.

Economic:
Our primary need is usually to generate an increase in our income. We can do this by increasing the yield of our present crops, reducing the cost of production or even diversifying crops. Or we can do all of these. Associated with these are to identify which crops perform better than others.

Social:
It is important to assess what we spend on food. Are we getting our monies worth? Is the food that we buy good for our health? Can we feed our family with better quality food? Can we grow our own food and be food secure? How can we do this?

Gal Oya in flood, Oluvil

Ecological:
On examining our garden, it is pertinent to address the issues we face: decreasing soil fertility, reducing crop yields, increased incidence of attacks from pest and diseases, increased growth of weeds, increased variability of rainfall, increased frequencies of extreme events like drought and floods and the need for irrigation.

These issues are predicted to become increasingly more serious with the onset of climate change. Also predicted is the decrease in soil moisture combined with an increase in ambient temperature, specifically nighttime temperature. It is known that increased temperatures can affect the yield of paddy and other crops.

Hence after we identify and prioritise our needs, we will have a good idea as to what we have to do. To do that, we need to assess our resources, in terms of our water, soil, vegetation as well as in terms of manpower, livestock and machinery.

CHAPTER 2
Asessing our resources

Crops

The very first assessment must deal with the crops one has on the land. The assessment must involve an economic analysis since at the end of the day the most important aspect of farming is to generate more income. The need to keep the family fed is usually secondary, eventhough in real terms the farmer's food security is sovereign.

The need is therefore to examine the crops being cultivated presently, the income generated thereof *vis a vis* the costs incurred and how the addition of other crops can increase income. The farmer must consider the addition of a greater diversity of crops keeping in mind his resources, mainly water. He must also consider his ability to manage the crops specifically if they are labour intensive. The system promoted is tree dominant. Hence the farmer has now the ability to improve the design of his farm landscape by including perennial crops that will bear in the long and short terms.

Pineapple interplanted with traditional rice, Kularatne's garden

Further given that climate change impacts like increased rainfall variability are already a reality, there is the need to reduce our dependence on seasonal rainfall and thereby seasonal cropping. In economic terms it means that there will be a reduced risk since the farmer will generate yield and income from a diverse array of crops that have differing times of harvest and are spread throughout the year. Aside from the economic basis, the inclusion of tree crops in the landscape design will also mean the addition of soil organic matter via leaf litter, increased shade and increased pollinator frequency. The addition of tree crops will provide habitat for pests and predators thereby reducing the risk factor. *Chapter 3* will deal with landscape designs that demonstrate highly diverse cropping systems. However, the thumb rule is always, feed the soil and not the plant.

Soil

It is critical to assess the soils in your garden since for plants to be healthy, the soil they grow in must be fertile. One measure of soil health is the amount of organic matter or carbon that it contains. Soil that is rich in organic matter and biodiversity

creates a healthy and more stable environment for plants. In times of stress, organically managed soil has the greater ability to provide for crops. Soil organic matter performs many crucial functions like acting as a reservoir for plant nutrients, binding soil particles together, maintaining soil temperature, providing a food source for microbes, binding heavy metals and pesticides, increasing water holding capacity and enhancing aeration.

Another important facet is that soil should be well drained. Most plants do not like to grow in clay dominant soils since it impedes aeration. However, some proportion of clay is important since it facilitates cation exchange and thereby nutrient uptake.

It is also important for soils to have a high proportion of sand to facilitate drainage. However too much sand would be a cause for concern since it means that your land suffers from soil erosion. To identify whether a field is affected by soil erosion you should look in the gullies on the land. A compact soil crust after heavy rain is an indicator of probable soil erosion, as is brown-coloured drainage or turbid water. Though soil erosion is not a big problem in the Dry Zone, rain during the monsoon period is intense and therefore erosive.

Ranwanna Oya, Kularatne's land

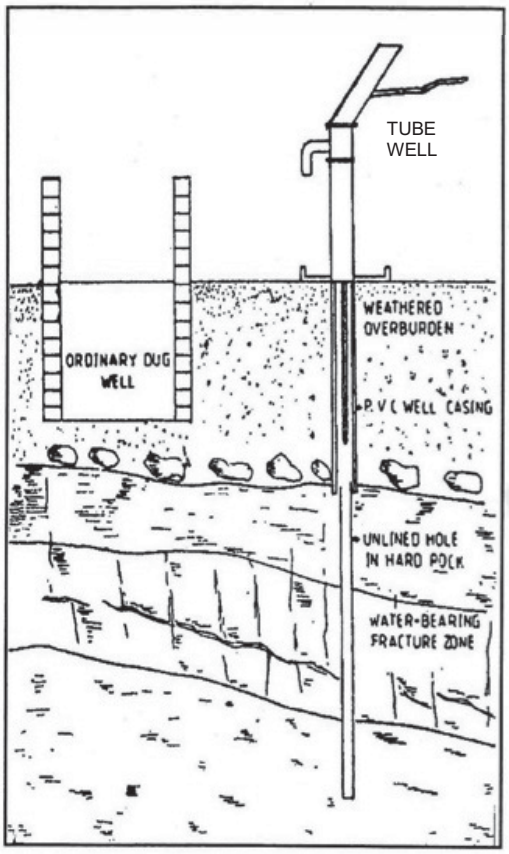
The most serious constraint in the Dry Zone is the vulnerability to drought. The impact of low water availability results in a deficit of soil moisture compounded by poor moisture retention if the soils are deficient in organic matter. It could also result in the accumulation of salts, leading to saline or sodic soils. All of these factors could affect nutrient retention and impact crop productivity.

Water

The availability of water determines the distribution of vegetation over space and time. Agriculture is not possible without adequate water at the right time. The water source could be located on your land such as a well or even a stream/river/canal flowing through/by the land. It may even be an agricultural well located near your land or a tank in the vicinity. However, for most of us, the best time for cultivation is during the rainy season, before which, land preparation is undertaken for both paddy and other field crops.

Water scarcity is a common phenomenon during the dry season. This is especially critical if we are dependent on ground water. Groundwater in much of the Dry Zone is found in the shallow aquifer of the upper weathered zone and in the deeper fracture zone of the basement rocks.

Shallow Dug Wells in weathered overburden and deep bore wells in fracture zone - *after Dissanayake, 1989*



The upper weathered zone generally ranges from 2 – 10 m in thickness, while the fracture zone is located at depths of more than 30 – 40 m (Panabokke, 2003). While the weathered, shallow aquifer is recharged only by rainfall, the water in the deep fracture zone is that which has collected over millennia and is now being tapped through tube wells.

During the dry season, the pressure of ground water in the shallow aquifer is low and hence its ability to penetrate the walls of a well are made easy only if the well is made of a porous material like bricks. Traditional people knew this well and constructed their wells using specially made bricks called *lin gadol*. However, the walls of most modern wells are completely lined with cement both from inside as well as on the outside. Even though there are a few openings in the well walls, these do not facilitate the weak passage of water and hence most of these wells tend to go dry during the dry season. Farmers are then placed in a difficult situation where they have a well but the well has no water!

If the well or other water source lacks tree cover around it, the possibility of water during the dry season becomes even more scarce since there is no shade and evaporation is high. Our ancient people realized this and to this day one could see majestic Arjun (Kumbuk) trees near water sources. Hence, in these dire situations, the possibility of cultivation becomes remote and only possible with the availability of irrigation facilities.

Further, the presence of a tree around a well makes for greater infiltration of water into the ground water table. Tree roots open up the soil enabling the recharge of the shallow aquifer.

A good organic farmer knows this and seeks to improve water retention and infiltration on his land by promoting water conservation, water harvesting and improved storage. Improved soil moisture retention will save costs on irrigation.

The ability of a soil to absorb and store water depends on its composition and the organic matter it holds. Soil organic matter acts like a sponge and hence soils rich in organic matter will preserve moisture for longer. The application of organic manures, compost, mulch or green manure can be used to increase organic matter in soils and is described in *Chapter 5*. Shallow digging of topsoil or reduced tilling helps reduce the drying up of soil layers beneath. A layer of mulch can reduce evaporation of soil water by shading it from direct sunlight thereby preventing it from getting too warm.

Pond in Pushpa's land, Liyangolla

Effective water management is necessary and hence it is vital to identify the drainage pattern on one's land. Water will flow in a gradient dependent direction on the land. Hence digging shallow drains along the slope contours will ensure unhindered flow and make it possible for storage in a pond/ponds located strategically. Good drainage is essential during the intense rains of the monsoons since otherwise water logging or erosion could manifest as serious problems.

Tree cover, vegetation and weeds

Another very effective way of decreasing soil moisture deficit is to grow trees to increase shade and reduce evaporation from soils. Trees shed leaf litter that contributes to humus formation thereby facilitating moisture retention. Tree roots penetrate deep into the soil creating pathways for increased infiltration. Hence, competition to crop plants is at a minimum. In addition, trees are important sources of food, fuelwood, timber and medicine etc.

Malabar Pied Hornbills in Kularatne's garden

Vegetation is also essential in terms of providing habitat for biodiversity, especially if your land is adjacent to a forest. The vegetation acts as a buffer and can protect your crop whilst serving as a corridor for biodiversity. Vegetation will provide habitat for both pests and predators and help keep nature's balance. Vegetation planted around your well will serve to bioremediate the water. It will also increase infiltration during rainfall and increase the potential for recharge to the well. Riparian vegetation planted alongside a stream will prevent soil erosion, stabilize the stream bank, act as a buffer to prevent polluted water from entering and provide habitat for aquatic biodiversity like fish, frogs, etc.

Of significance are the weed populations in your garden. Please do not burn weeds since they can be useful as green manures and mulch although one must be careful not to use weeds when with seed as these propagate very quickly. Weeds are important along the bunds of paddy fields since they provide habitat for predators and are useful in biological pest control.

Crimson Rose butterfly

Biodiversity

Of critical importance is the faunal biodiversity in one's garden; especially soil biodiversity. Almost all of nature's essential functions are carried out by biodiversity; pollination by bees, butterflies, moths and bats; forest plant propagation by birds, monkeys, civet cats, squirrels and other animals whose dung serves as a repository for seed; insect pest control by frogs, lizards, geckos and spiders. Further, macro invertebrates like earthworms, termites, ants, beetles, and millipedes, etc play a definite and prominent role in regulating soil fertility while soil micro fauna like bacteria, actinomycetes and fungi, etc aid in humus formation.

Mychorrhizae www.finegardening.com

The fungi that are probably the most abundant in agricultural soils are Arbuscular Mychorrhizal (AM) fungi. They account for 5-50% of the biomass of soil microbes (Olsson *et. al.,* 1999). Mychorhizal fungi only live in union with plants. Both the fungus and the plant benefit from their relationship. The plant provides sugars to the fungus while the fungus provides a variety of services to the plant. (http://www.agroecology.org/glossary/)

Finger Millet or kurakkan

Mychorrhizal fungi play a major role in a plant's exchange system. They grow as a vast web of tiny filaments in plant roots and in the surrounding soil thereby exploring a much larger area than the plant roots could alone. When the mycorrhizae encounter

limited resources like water, phosphorus or micronutrients, they can pass them on to their associated plant. Mycorrhizae can increase phosphorus uptake and facilitate access to other soil nutrients such as ammonium, potassium, calcium, iron, copper, manganese, zinc and nickel (Jordan, *et. al,* 2000). Drought resistance and heat tolerance are benefits attributed to mycorrhizae (Henson, 2003). Soils are able to store more carbon when mycorrhizae are active (Dalpe *et. al*., 2003) and thereby help to mitigate climate change. In short, the presence of mycorrhizae in soils offers an exciting prospect for organic and low input farmers.

Many crops support mycorrhizae. Legumes like long beans, mung bean, winged bean and horse gram, cereals like finger millet as well as vegetables like cucumber, melon, watermelon, squash, pumpkin, ladies fingers and brinjal are some plants that are prone to mycorrhizal associations. Even tree crops like citrus, coffee, tea, rubber and coconut harbor mychorrizal associations. However, plants of the cabbage family, beet, mustard and amaranthus do not respond to mychorrizal associations. Hence the wise farmer must seriously look into promoting mychorrhizal associations in his soils if long-term soil fertility is sought.

Water hyacinth, a green manure

Light

Another important aspect is the management of light in your garden. Too much light can harm certain crops while too little light can impede the growth of others. Most vegetables and annual crops require sunlight. This is an important feature to remember when designing your garden where tree crops also form part of the design. The area in the garden that will be best suited for vegetable cultivation must be kept as open space with a modicum of shade. Crops like coffee, pepper, ginger, turmeric and taro prefer reduced light conditions and are best cultivated under shade or tree cover.

Water hyacinth enriched bed

Wind

It is vital that the direction of wind be identified before planting since otherwise plants could be damaged by wind impact. Climbers like snake, ridge or bitter gourd that grow on trellises must be planted along the direction of the wind since otherwise the trellises could get de-stabilised. This is especially critical during the time of the North East monsoon when heavy rain and strong winds prevail. Strong gusts of wind can also erode soil especially if there is no mulch or leaf litter on the surface.

Waste

The question that should be answered first is: what are you doing with your waste? Waste can take many forms and is either degradable or non degradable. The first step is to sort out degradable waste from non degradable waste.

Degradable waste is really not waste since on an organic farm, all loppings, weeds, plant parts and refuse can be composted. *Chapters 5 and 7* describe effective ways to deal with organic waste both from the garden and from the kitchen. They will also deal with farmyard waste and resources like water hyacinth, a highly invasive plant that has colonized our waterways, canals and tanks. However since it contains nitrogen, phosphorous, potassium and other trace elements, water hyacinth is a highly suitable green manure for direct application to the field or in making compost (Gunnarsson *et. al.,* 2006).

Slightly burnt or singed paddy husk can be used to make compost that when fortified with cow's urine works extremely well in the cultivation of yams (purple yam), rhizomes (ginger, turmeric) and tubers (sweet potato). Waste, if digested in a biogas tank can generate energy that can be used for cooking and lighting. Biogas is a cheap and efficient way of managing waste.

Waste or greywater can be a pollutant if effective management is not taken.

Non-degradable waste includes all items that cannot be composted. Some items can be recycled like paper, polythene, glass and metal. These are stored for delivery to a storage facility like those established by the Pradeshiya Sabha in your area that implements waste recycling programmes initiated by the Central Environmental Authority.

Manpower

The cropping pattern is absolutely dependent on the farmer's available resources of which manpower is essential. Making compost, liquid fertilizer and biopesticides though inexpensive require consistent manufacture and maintenance. Land preparation, planting, weeding, mulching, watering and harvesting take up energy; so you need to assess your manpower resources and then commit to what you have planned for your garden. Perhaps your family can help you.

Farm Plan

After you have taken stock of your needs and the available resources, you need to draw up a plan of what needs to be done next. This is the Farm Plan.

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CHAPTER 3
Drawing a Farm Plan

A Farm Plan is the key reference document that describes the characteristics and capacity of a farm. It also identifies the resources and opportunities for it to be successful in economic, social and ecological terms. The Farm Plan is a living, working document that lays the foundation for decision-making for optimal efficiency and profitability. A farmer's vision and goals provide the supportive framework to develop a farm plan.

In order to do this one must identify the dominant existing features in the farm landscape and the attributes that should be conserved and enhanced. To do this effectively, the farm landscape and landuse areas need to be visualized where zones for farming activities, human use and conservation are designated. Thereafter appropriate goals for each farm zone need to be developed. However, before you start planning, you need to know what you have to work with. Hence the more baseline information you have about your farm, the easier it will be to make good decisions. A Farm Plan must include:

- An inventory and assessment of the farm's natural resources. They include the physical features (location, topography and streams), climatic features (rainfall, temperature, humidity, sunlight and wind); ecological features (vegetation, wildlife) and anthropogenic impact on the landscape. The more you know about your land the greater your ability to make the best use of it.

- A description of the built infrastructure includes houses, wells, toilets, barns, sheds, greenhouses, fences, irrigation ponds, ditches, roads and access lanes, processing and storage facilities and on-farm marketing facilities. Farm equipment that has been permanently installed like pumps, irrigation systems, power plants and processing machinery can be included.

- A description of the activities being carried out and land use in each of the zones designated in the farmer garden and adjoining areas.

Mapping

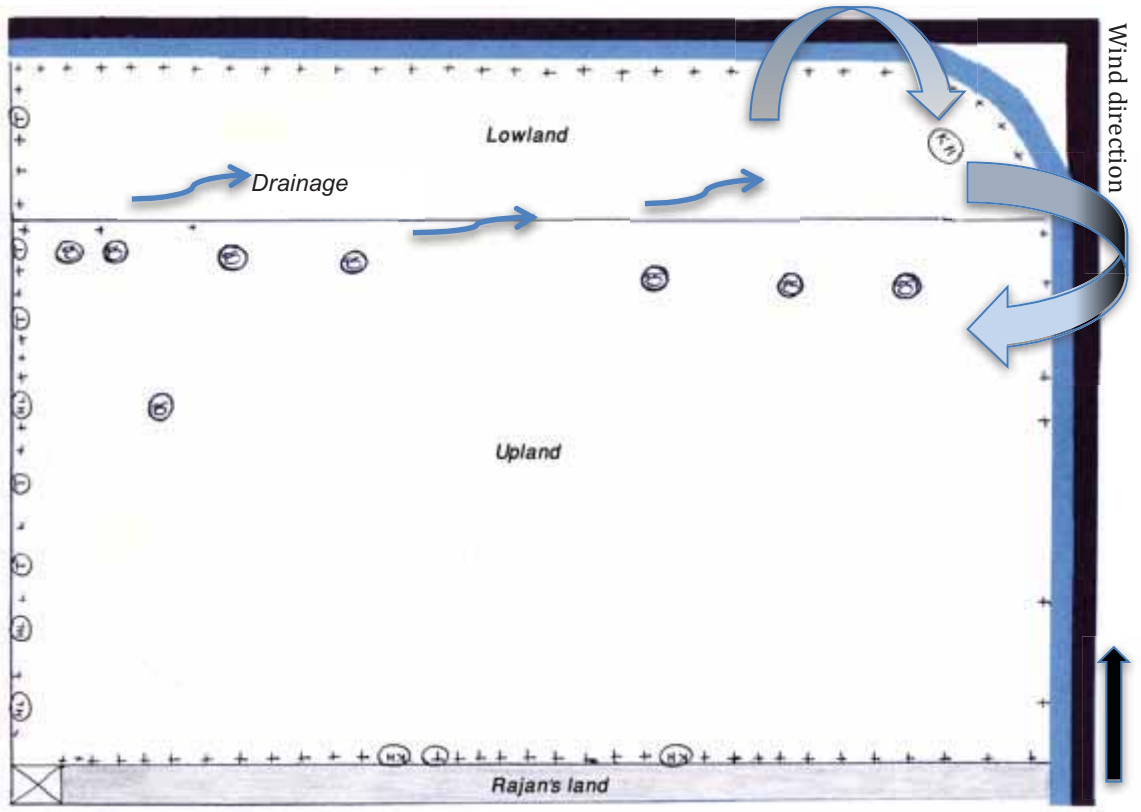
The best way to visualize your land is to actually draw a map. Hand-drawn maps are a creative approach to mapping. Maps aid in information collection, planning and communication and bring a useful perspective to discussions in your farm planning process. While they need to be in scale, the level of accuracy is not so important. What is important is to get your bearings correct and know as to which direction is 'north'; this is easily done if you anchor your present location with a known site and then figure out which way is 'north'.

Mapping could be undertaken to visualize the present status of your farm garden and subsequently, the changes as they occur in each stage of production.

Drawing a Base map

The base map shows the land as it is. It must include both natural (rocks, rivers, streams, canals, etc) and manmade (roads, buildings, wells, toilets, etc) features. The physical features - topography, drainage, land use and vegetation in the farm garden need to be shown. The Base Map drawn for Mylwaganam's garden in Kannagipuram, Ampara District is a good example that even displays wind direction.

Map 1 - Base Map of Mylwaganam's garden



Key

Symbol	Common Name for tree	Qty.
KH	Neem	3
T	Teak	6
HL	Trincomalee Wood (Halmilla)	3
(P)	Papaya	8
+	Gliricidia	83
	Other features	
	Canal	
	Road	
X	Gate	

Fence between Mylwaganam's and Rajan's land

Description of Mylwaganam's land

Background	Mylwaganam is married and has three children.
Topography	Flat and undulating, upland and lower, wetland (paddy field)
Extent	Upland: 1 acre and Lowland (paddy field): 1 acre

Location	Part of the Kannagipuram, irrigation settlement. Road borders the land on one side and Farmer Rajan's land is on other side.
Water	Rain mostly from 2nd Inter Monsoon and North East Monsoon. Groundwater from well on adjacent land and pond in paddy field. Irrigation water from Gal Oya Scheme. Canal adjacent to garden.
Drainage	Rainwater drains through to the canal that borders the land.
Vegetation	No annual crops on the land. There are Papaya, Neem, Teak and Halmilla trees on the farm. Gliricidia trees fringe the canal.
Wind direction	From seaside during monsoon and from hinterland during drought.
Sunlight	Well lit and almost no shade.
Erosion	Soil erosion occurs between up and lowland areas and Rajan's land.
Land use	Previously Mylwaganam cultivated vegetables using agrochemicals While he has stopped, neighbor Rajan continues to use agrochemicals.
Labour	The family assists Mylwaganam. He does not use outside labour.

Mylwaganam's farm garden showing lowland and upland areas

Designing your land

The landscape design you adopt needs to:

1. Be developed in participation with your family. You must first talk to your family and find out their needs.
2. Identify the diverse components of your land be they natural, man made, spatial, temporal, social or even religio/cultural.
    - Natural components include a stream, canal or river flowing by your land, its riparian zone, a natural forest patch located in the vicinity, rocks and anthills etc. The amount of vegetation on your land will reflect the amount of light or shade available. It will also be a decisive factor on the choice of crops you cultivate whether they are annual or perennial.

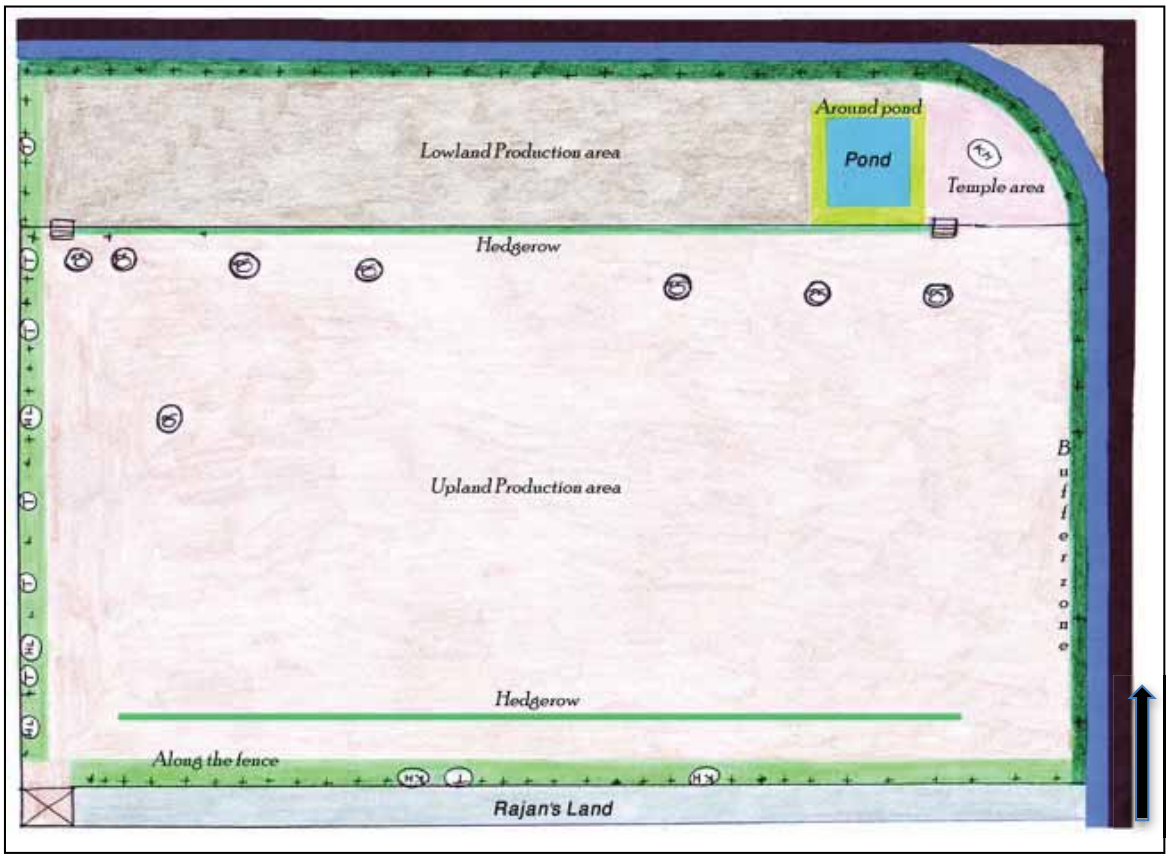
- Man made components include your house, toilet, well, pump house etc. It could also include land use like your neighbor's farming practices specifically if he uses agrochemicals.
- Temporal components would include the changes that occur in your farm seasonally (during the monsoon rains your land could face inundation and require proper drainage) or when the trees planted grow and give shade.
- The spatial component examines farmland area.
- The social aspect of your landscape design must take into consideration the needs of your family; the crops that you cultivate must provide food, fuel wood, timber and medicine, etc after which the excess can be sold.

3. Take into consideration that yours will be an organic farm where biodiversity performs ecosystem services such as nutrient recycling, pollination, pest control and bioremediation, etc. Bees, butterflies, spiders, lizards, birds and microorganisms that carry out these essential functions require habitat.
4. Observe the vegetation in the closest natural systems (forests, wetlands) around you and identify the plant species that provide habitat for the useful organisms as described above. You can recreate habitat if you include those species. Some of the plant species may also be useful in terms of providing timber, medicines, firewood, etc. This information will provide insight into which of the native species could be used in the landscape design and where they should be planted.
5. Observe the processes or functional aspects of each component identified:
   - For instance, where does rainwater flow to and in which direction? If the neighbouring farm uses agrochemicals then where does the leachate wash off to? Is there erosion taking place?
   - What is the distance between the toilet and your well; if yours is a pit latrine could the distance be adequate to prevent contamination of water?
   - Which area in your farm faces waterlogging problems during the monsoon rains? Can anything be done? Can you construct a pond?
6. Identify the plant species that you will use for your landscape design where:
   - Some of these species will be those native species that you had identified from the natural forest in your area.
   - The greater number will be crop species that grow best in your area and include both perennial and annual crops.
   - Considering what your income levels are at present, your selection of crops must be based on how productive those crops are.
   - Whichever the crop that is selected, its performance is dependent on the climatic features and elevation of your farm garden.
7. Take into consideration the resources your farm has to offer: specifically in terms of water, soil, light, green manure, animal manure and manpower.
8. Take into consideration that seasonal changes will result in changes in your farm environment; for instance, increased ambient temperatures will reduce soil moisture levels and your crops will require irrigation.
9. Look at your present energy source and cost for: land preparation (manpower, machinery), irrigation (pumps, fuel, electricity etc) and lighting (fuel, electricity) and how much more or less you would have to spend.

10. Site the cattle/poultry shed in a suitable spot on your land if you want to rear cattle, goats or poultry.
11. Site the processing centre in a suitable spot on your land if you intend drying lime, lemon grass or other.

Thereafter, demarcate your land into zones or sections that require different design treatments. The manner in which Mylwaganam divided his farm landscape into zones that required different treatments is seen below.

Map 2 – Zonation in Mylwaganam's garden

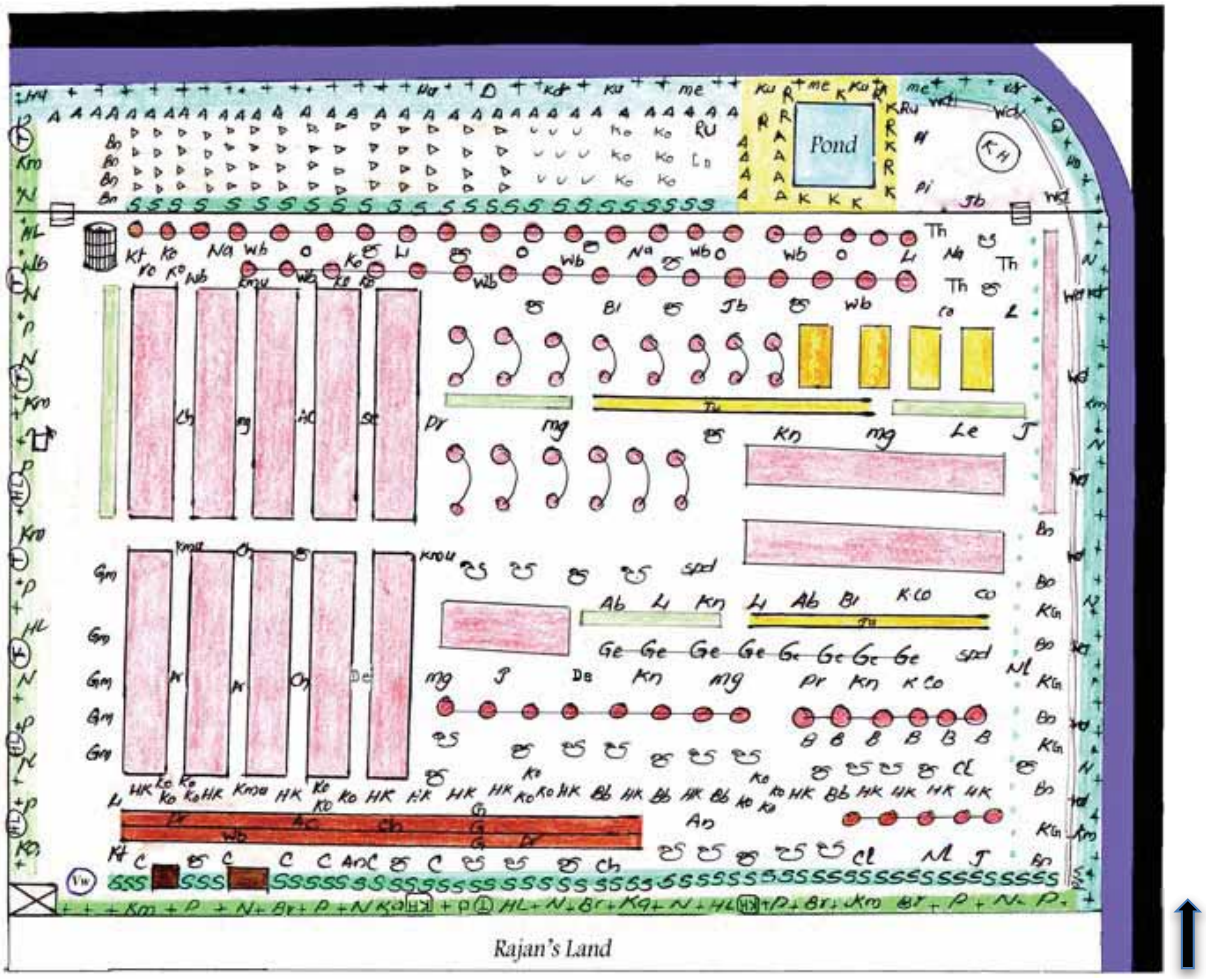


Key

Symbol	Zone	Utility value of plant species to be used
	Buffer	Native tree and shrub species for habitat, timber, medicine, shade, bioremediation and carbon sequestration
	Fence	Native and indigenous tree and shrub species for green manure, habitat re-creation, timber and carbon sequestration
	Hedgerow	Plant species that will prevent soil erosion and provide green manure
	Around pond	Tree and shrub species to create shade, habitat and filter water
	Lowland production	Crop species that will provide food: vegetables, pulses, fruit trees
	Upland production	Crop species that will provide food including vegetables, green leaves, yams, pulses, oils, fruits, spices, beverages and medicine
	Temple	Species that are ornamental and used for cultural purposes

The design adopted by Mylwaganam can be seen in **Map 3**

Map 3 – Landscape Design of Mylwaganam's garden



Key

Around Pond

Symbol	Common Name	Qty.
A	Arecanut (Puwak)	8
R	Pandanus (Rampe)	6
Ku	Arjun (Kumbuk)	2
Me	Mahwa (Mee)	1
K	Cinnamon	7
	Aponogeton (Kekatiya)	
	Lasia (Kohila)	
	Water lily and/or Lotus	

Temple area

Ru	Devil tree (Ruk attana)	1
Jb	Malay apple (Jambu)	1
Pi	Jasmine	2
KH	Neem	1

Along the fence

N	Vitex (Nika)	10
HL	Trincomalee wood (Halmilla)	7
Ka	Ebony	3
T	Teak	5
Br	Satinwood	4
Wb	Lettuce tree (Wathabanga)	1
P	Indian pavetta	11
Km	Calamander (Kalumadiriya)	5
D	Java plum (Dang)	2

Buffer Zone

Symbol	Common Name	Qty.
Ku	Arjun (Kumbuk)	1
Me	Mahwa (Mee)	2
Hu	Albizzia (Huriya mara)	3
Km	Calamander (Kalumadiriya)	2
A	Arecanut (Puwak)	33
N	Vitex (Nika)	4
P	Indian pavetta	1

Hedgerows

S	Lemon grass	66
+	Gliricidia	83

Production Area Lowland

V	Pineapple	56
Bn	Banana	4
U	Ulundu	
Ko	Kollu	
Co	Cowpea	

Production Area Upland

FRUIT

Mg	Mango	4
O	Orange	4
Li	Lime	5
Le	Lemon	2

Production Area Upland

Symbol	Common Name	Qty.
Na	Mandarin Orange	3
	Papaya	34
Pr	Guava	5
An	Sugar apple	2
Wd	Passion fruit	15
Ge	Grapes	8
Jb	Malay apple	1
Bi	Billin	1
KG	Cashew	4
Kn	Star fruit	3
NL	Nelli	2
Ab	Amberella	2
Spd	Sapodilla	1
De	Pomegranate	2
Bn	Banana	6
J	Jak	4
Ac	Acerola	1

SPICE

Tu	Turmeric	3 beds
CL	Curry Leaf	2 beds

BEVERAGE

C	Coffee	6

LEAVES

Kmu	*Sesbania* (Kathuru Murunga)	4
B	Betle	6

MEDICINE & BIO PESTICIDE

Symbol	Common Name	Qty.
Ko	Aloe	20
G	Ginger	4 beds
Hk	*Andographis paniculata*	15
Bb	*Sida spinosa*	4
	Marigold	

ORNAMENT

Kt	*Tecoma stans*	2

Vegetables

	Long beans
	Brinjal
	Green chillies
	Ladies Fingers
	Capsicum chillies
	Radish
	Bushita beans
	Red Onions
	Sweet Potato
	Melon
	Pumpkin
	Jack Bean
	Snake Gourd
	Ridge Gourd
	Bitter Gourd
	Purple yam (Raja ala)

Vegetables

Symbol	Common Name
	Winged Bean
	Maize
Th	Gingelly

Green Leafy Vegetables

	Centella (Gotukola)
	Altenanthera (Mukunuwenna)
	Amaranthus (Thampala)
	Spinach
	Seed bed
	Single side Trellis
	Double side Trellis
V	Vermiwash
	Basket Compost
Compost	Pile Compost
U	Liquid Fertiliser
	Steps

Designing the landscape of Mylwaganam's garden

Having demarcated the different zones in Mylwaganam's farm garden we need to identify the species of plants that will be established in each zone.

The **buffer zone** could incorporate species that are seen in the nearby forest like Kumbuk, Mee, Huriya Mara and Kalumadiriya all of which are large trees. In addition smaller trees and shrubs like Arecanut, Nika and Pavetta could also be planted. Aside of their use to man, each of these species provides habitat and food for biodiversity - for pests and predators. They act as biodiversity generators.

The species designed for the area **along the fence** include both native and exotic species of large and small trees that provide timber (Halmilla, Satinwood (Burutha), Teak and Kalumadiriya), green manure, (Nika, Pavetta) medicine (Nika), food (Wathabhanga) and habitat for biodiversity (Halmilla, Burutha, Kalumadiriya and Dang).

Wetland in lowland area; arrow shows intended pond

The **area around the pond** needs trees and shrubs that grow near water. They must also provide shade in order to reduce evaporation; their root structure must strengthen the bank and filter the water that comes into the pond. Arecanut is highly suitable and is also useful to man. Rampe shares similar characteristics. Kumbuk and Mee are seen in riparian situations. Cinnamon that likes moist conditions is a new crop to the area that can generate a good income. Aquatic plants like *Lasia* (kohila), *Aponogeton* (kekatiya), water lilies and lotus can be planted in the pond that will serve to provide food, filter pollutants and enhance the aesthetic appeal of the pond.

Pond, lowland area, Mylwaganam's garden

Lotus

Mylwaganam had planted *Gliricidia* around his farm and Lemon grass was incorporated as a hedgerow to stop erosion. *Gliricidia* is a small tree that belongs

to the *Leguminosae* family that fixes nitrogen in soils. It also provides green manure essential in the manufacture of compost and liquid fertilizer. Lemon grass binds soil, is a biological pesticide and the roots are used as a herb along with its leaves that enjoys current market demand.

Temple area around Neem tree

The area at the extreme end of the farm has a large Neem tree that is worshipped by the family. This area is referred to as the Temple area and ornamental plants like the Jasmine creeper and Rukattana trees are part of the design.

The largest allocation of land is for annual and perennial crops. The **production area** as it is referred to is divided into two: upland and lowland areas.

The **lowland** area was previously a wetland used for paddy cultivation. Now that the excess water has been channeled through drains that feed the pond, the area can be used for the cultivation of field crops. Hence, the area is earmarked to plant pineapple in part of the central region and banana along the sides. The land will also be used to cultivate annual crops like ulundu, kollu and cowpea.

Pineapple intercropped with ulundu and banana - Mylwaganam's lowland area

The **upland** area is designed for maximum utilization of space where both perennial and annual crops will be cultivated. The vegetable beds will be interplanted with several small fruit trees (Papaya, Lime, Orange, Mandarin, Pomegranate, Guava, Acerola and Katuru-murunga, etc).

Large trees like cashew, Mango, Nelli, Sapodilla, Jambu, Curry Leaf and Jak will be planted along borders. Shade loving small trees like Coffee and tubers like Taro will be planted in the shade of the Neem and Teak trees planted previously by Mylwaganam. Crops like Grapes will be mounted on a single sided trellis while Betle will occupy a double-sided trellis; both located in the centre of the land. Passion fruit will be mounted on a single sided trellis that skirts the extreme border of the upland area. Turmeric and Ginger will be planted in narrow, raised

beds. Plants used as biopesticides – *Sida spinosa, Andrographis paniculata,* Marigold and *Aloe* will be planted near and in between the vegetable beds. Ornamental trees like *Tecoma stans* will be planted at the entrance of the garden. Aside from the trees mentioned, several others will be used in the landscape design. Please see Key to **Map 3** for more details.

Snake Gourd - double sided trellis

The vegetable beds will be the dominant feature of the garden. These raised beds are specially constructed (see *Chapter 4*) and because of their size can hold several crops at the same time, both on top of the bed and on the sides. For instance one can plant Brinjal in the centre and surround it with Ladies Fingers. Gotukola can be planted along the sides. So at any given time, the farmer has three crops in one vegetable bed without overcrowding. Climbers like Snake and Ridge Gourd will be mounted on double sided trellises while Bitter gourd will use a single sided trellis.

A plan for managing Mylwaganam's garden was drawn up subsequently.

Mylwaganam's upland area showing raised and circular beds, one-sided trellis Mukunuwenna and Sweet Potato

Designing farm gardens located in hilly regions of Moneragala District

While the landscape of Mylwaganam's farmland in Kannagipuram is flat and undulating, the Project also worked in areas that encompassed the foothills of the Maragalakanda mountain range in the Moneragala District. In order to satisfy a reader who lives in such an area the landscape design of a farm garden in a sloping land can be seen in **Annexure 1**

Drawing the Management Plan

The landscape design you draw will stipulate explicit design goals:
a) You need to be clear about how you are going to achieve your design goals
b) You will need to look at when you need to enact the activities
c) You will also need to assess the resources you need and in what quantity
d) A clear understanding of the steps involved in executing the landscape design will ensure efficient and smooth management of the farm garden.

MANAGEMENT PLAN FOR MYLWAGANAM'S FARM GARDEN IN KANNAGIPURAM

	Timeline in months	1	1	1	1	1-12	1-12	1-12	1-12	1-12	1-12	1-12	9-12	1-12	1-12	1-12
	ctivity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Resources and quantity required	Clear Land	Construct Fence	Identify drainage, dig drains and ponds	Construct vegetable beds	Construct basket compost	Construct seed bed	Prepare pile compost	Cultivate annual crops	Prepare Liquid Fertiliser	Prepare Bio Pesticide	Mulch	Plant Trees and other perennial crops	Monitor	Maintain farm garden	Maintain Log Book
1	Labour	2 days	1 day	5 days	7 days	2 hours	1 hour	3 hours	Continuous	2 hours	2 hours	Continuous	During rainy season	Continuous	Continuous	Continuous
2	Cadjan		200 fronds			See Chapter 5		See Chapter 5	See Chapter 4	See Chapter 5	See Chapter 6		See Chapter 4			
3	Barbed Wire		2 rolls*													
4	Timber Posts/ Gliricidia stakes		100													
5	Green Manure				1/2 Load**							✓				
6	Water Hyacinth				1/2 Load							✓				
7	Maize refuse				1/2 Load							✓				
8	Garden refuse				1/2 Load							✓				
9	Kitchen refuse				1/2 Load							✓				
10	Paddy Straw				1/2 Load							✓				
11	Cattle Manure				1/2 Load											
12	Coconut husks				for bed borders											
13	Sand						1/2 bag***									
14	Leaf mould						1/2 bag									
15	Vegetable seeds						See Chapter 4									
16	Trees, plants													See Chapter 4		
17	Log book															1

*Roll - 25 metres | **Load - Hand Tractor | ***Bag - Gunny/Old Fertiliser

CHAPTER 4
Implementing our Plan

Land clearing

Regenerative agriculture depends on the health of the biodiversity in your soils. Aggressive tilling of farmland soils can be detrimental to soil health and hence minimum disturbance is recommended. We advise you to clear only the surface weeds and incorporate them into the soil. Do this with care since weeds that are flowering or bearing seed must not be ploughed back as they will only serve to increase weed populations.

Instead of clean weeding with a pointed hoe (sorandiya), it may be better to hand weed, mulch the soil surface or grow a cover crop. Mylwaganam grows green leafy vegetables like Mukunuwenna and Sweet Potato between vegetable beds that perform the dual function of providing a crop and shading the soil.

Kularatne and wife weeding around pond

Fence establishment

Most farms are susceptible to damage from stray cattle, chickens and dogs because they are unprotected and easy to enter. The very first step is to secure a fence either out of cement or timber posts, and barbed wire or preferably a 'live' fence comprised of Gliricidia, *Jatropha curcas* or other plant stakes that will grow and provide green manure. In Kannagipuram and Oluvil, farmers affix cadjan (either Coconut or Palmyrah leaves) onto stakes that prevent animals entering through the gaps between stakes. Farmers train climbers like Bitter Gourd, Snake Gourd or Passion Fruit on these fences that then serve a multitude of purposes.

Bullocks ploughing Kularatne's field

Land preparation

The landscape design involves the cultivation of both annual and perennial crops.

In order to cultivate annual crops it is necessary to prepare the land. This involves the establishment of raised vegetable beds that are constructed and filled with organic matter in order to hold maximum moisture and contribute to soil fertility. Organic inputs can include any kitchen or garden waste,

water hyacinth, refuse from the maize crop or paddy husk. Aside from being a repository for organic matter, another reason for constructing 'raised beds' is because many farm gardens in the Moneragala and Ampara Districts get flooded during the monsoon rains. Hence an elevated vegetable bed as opposed to a lowered/depressed bed will protect crops from getting inundated.

Digging demarcated vegetable bed

To construct a vegetable bed you need to first demarcate an area that is roughly 2 m in length and 1.5 m in breadth. Remove soil to a depth of about .5 m and fill the trough created with organic matter as described above. If it is possible, alternate the organic matter with cow dung or other manure. Farmers are urged to make use of garden waste that is usually burnt. This carbon rich trough is then covered with soil that was removed and the result is a raised bed that is over .5m in height. Coconut husks can be used to line the border of the bed that in turn enables the cultivation of leafy vegetables in between. Organic matter

matter Filling bed with organic

Maize refuse for filling vegetable bed

like paddy straw, leaf litter or other can be used to mulch the bed. The result is a sophisticated vegetable bed that has the capacity to house a diverse array of vegetable crops. Given that both the Moneragala and Ampara Districts are prone to long drought periods, these carbon rich vegetable beds will increase the retention of soil moisture and reduce the vulnerability of agriculture to drought.

Beds can also take a circular shape suitable for planting single crops like Long, Ridge or Bitter gourd for example. This type of bed is amenable to trellis construction since the stakes can be inserted between them. The circumference of these beds will be site specific to the land available. Beds of this type can be placed along the direction of the wind in order that they follow the path of least resistance. Strong gusts will then tend to blow 'through' rather than 'against' the trellises causing minimal damage to the crop plants.

While construction of these beds is time and labour consumptive, they are a 'one time only' effort where the positive benefits are many and include:

Circular vegetable beds

- Increased ability to grow several crops in one bed
- Increased soil fertility over a long period of time since the organic matter inside will decompose slowly.
- Increased habitat for soil biodiversity and thereby increased fertility.
- Increased sequestration of soil carbon.
- Increased soil moisture since organic matter absorbs moisture like a sponge.
- All organic waste in the garden and kitchen is used including waste in the nearby reservoirs (water hyacinth). Hence waste management becomes easy and profitable because it is a low cost solution for sustainable soil management.

Carbon rich vegetable bed with Red Onion, Chillies and Mukunuwenna growing within

Water management

Equally if not more important, is the management of water on the farm since no cultivation is possible without water and too much of water is detrimental to plant health.

As pointed out in the Management Plan for Mylwaganam's garden, one of the first activities was to determine the drainage pattern of rainwater flowing through his land. These natural flowpaths follow the gradient or slope of the land and water either remains in a depression or falls into a canal, stream or other water body at a lower level.

Drain alongside paddy field

The route and direction in which water flows define the skeleton of the drainage system that needs to be put in place. The next step is to dig shallow drains along these paths. The width of a mammoty is what is usually used as a rule of thumb. The depth of the drains get deeper and wider as they reach a depression or exit point since the volume of water is greatest at this point. There could also be several junction points that accommodate the confluence of water from two or more drains. The depression/s could either remain as wetland patch/es or dug to create a pond ecosystem. A pond is usually preferable since it provides an alternative source of water, recharges the ground water table and creates habitat for frogs, dragonflies and other aquatic creatures that assist in natural pest control. This is especially important in the Moneragala and Ampara Districts that suffer dry periods annually.

Digging ponds, Kularatne's land

The proper management of water will mitigate the creation of stagnant conditions in the field thereby enabling an increased availability of arable land area for farming. Kularatne's farmland in Liyangolla and Mailwaganam's in Kannagipuram are classic examples where the drainage of excess rainwater enabled the cultivation of Pineapple and other field crops in otherwise bog and stagnant conditions. Kularatne created an extensive network of drains along the gradient of his farmland and constructed 3 holding ponds along the junction points. He then planted riparian vegetation around each pond. The ponds stored water and trapped silt that would otherwise have washed into the Ranwanna Oya.

He also planted several indigenous species like Kumbuk, Kitul (fish tail palm) and Arecanut (Puwak) alongside the river.

Planting downstream along the Ranwanna Oya

Pond in Kularatne's garden

If the source of water on the land is a well, there is then the need to plant vegetation in the micro catchment of the well. The planting could take the shape of one or more concentric rings around the well depending on the amount of space available. The vegetation to be planted should include large trees - Kumbuk, Mee, Halmilla, Palu (*Manilkara hexandra*), small trees - Nika, Wathabhanga, Huriya, Ingini (*Strychnos nux vomica*), Murunga, Surya (*Thespepsea populnea*) and shrubs like *Pandanus* (Wetakeiiya or Rampe) that have lateral rooting systems. The planting must follow a 'dense' fashion in order that a root mat is created underground. The mat will act like a filter sucking up contaminants and in time the water will be fit for drinking. This process of water purification carried out by plants is referred to as bioremediation and has been successful in cleaning contaminated water in many wells in Sri Lanka.

Bioremediation plot in Kalpitiya

Soil conservation

Lemon grass, Kularatne's garden

The management of excess water on the farmland is accompanied by the management of soil in land that is prone to erosion. The identification of such areas on your farm necessitates immediate action. You can either dig drains along the contours of your land, place silt traps or even plant hedgerows using plants like Lemon grass or Vettiver. Both plants are also excellent biocontrol agents since their roots contain aromatic oils. Their close-growing culms help to obstruct surface water runoff thus reducing flow velocity and increasing infiltration. Of current commercial interest are the leaves of Lemon grass that make it a fast growing, lucrative crop.

Small, fast growing trees like Gliricidia, Pavetta and Nika can also be used in combination with the grasses described above. In addition to mitigating soil erosion they provide green manure and are important ingredients in the manufacture of liquid fertilisers.

Pavetta and Lemon grass in Dhanapala's garden

Pile compost, Shanta Malar's group

Composting – *Basket and Pile Compost*

While compost making has been described in great detail in *Chapter 5*, it is important to understand that compost is a soil amendment. It not only adds nutrition to the soil but also increases soil biodiversity and improves soil structure or tilth. It increases the texture of the soil and enables it to retain greater moisture.

The other important aspect in regenerative agriculture is that it fosters the use of resources from the farmer's garden itself reducing the import and payment for materials from outside. This

reduces the cost for the farmer and also enhances sustainability and self-reliance. One of the best ways to ensure that you have adequate green manures for making vegetable beds, compost or liquid fertilizer is to incorporate the cultivation of green manures in your landscape design. The agronomy of Gliricidia, Pavetta and Nika are encouraged in Mailwaganam's landscape design.

Making seedbed in Guruhela

The need to make compost before you plant your seeds/seedlings/plants is in order that it can be added to the vegetable bed or planting hole at the time of planting. Compost is also applied in to the soil and not on to the surface. Most people make the mistake of adding compost as mulch.

Propagating vegetable and tree seed

One of the greatest stumbling blocks in cultivation is the low performance of the vegetable seed nursery. There are many reasons for this but most often it is due to erroneous germination procedures and inadequate care.

The ideal soil medium for germinating seeds should be coarse grained and loosely packed in order that a seedling can push through without difficulty. It should also be free of weeds, harmful insects and disease causing contaminants such as fungi and other pathogens. Do not use cattle manure in the mixture since microorganism populations are high therein.

Shading the seedbed, Guruhela

One can make a seed starting mix using:

- 1 part coarse river sand
- 1 part leaf mould (obtained under a pile of decaying leaves)

Mix these two ingredients well and pile as a small bed in an area that is not waterlogged, exposed to wind or harsh sunlight. It must also be a place that is free of stray cattle or dogs since warm beds are good places for them to lie down on! You can use old bricks, stones or wooden poles to secure the bed. Moisten the soil prior to planting.

Once the bed is ready, make furrows to about a centimeter in depth and place seeds as recommended on the packet. Cover the seeds and gently tamp the soil along the furrow to make good contact between the seed and soil. Use a fine nozzle spray to water the seedbed initially.

Seedlings, Mylwaganam's seedbed

You could give the seed bed a temporary cover made from sticks and a cadjan roof to shelter it from splash erosion caused by rain or sunlight especially when the seedlings are small. This cover should be removed when the seedlings are big since then they need sunlight to grow. Transferring seedlings is ideally done early morning or late afternoon when ambient temperature conditions are moderate in order to minimize the shock.

Once the seeds have sprouted, water the bed using a fine bore, watering can. Water from a hose can result in splash erosion of the seedbed and cause damage to the seedlings.

The seedlings may not always sprout in an orderly fashion. In the case of 'crowded' seedlings, you can scoop them from the nursery bed and place them in another container filled with good potting soil until they grow large enough to be transplanted.

Seedlings planted in vegetable bed, Mylwaganam's garden

One way to avoid disease attacks on the seedlings is to dip the vegetable seed in 10% solution of cow's urine, 24 hours prior to planting.

This procedure can also be used to germinate seeds of forest plants. However, the seed coat of many forest plants is hard and requires treatment before germination. The seed could be left overnight in cow's urine solution, hot water or immersed in fresh cow dung before planting. The seed coat may even be 'scarified' where small cuts are carefully made on the seed coat without damaging the seed. Once the seed has sprouted, seedlings can be transferred to another container and nurtured till they grow large enough to be planted in the ground.

Your best choice is to obtain open pollinated (OP) seeds since they have been bred for desirable traits for hundreds of years. Insects, birds, wind, or other natural mechanisms carry out open pollination. Plants that are bred from OP seed grow well without high inputs. These varieties have better flavour, are hardier and adapt to local conditions easily.

There are few commercial suppliers of (OP) vegetable seed in Sri Lanka and fewer suppliers of 'organic' seed. Your best choice is to purchase the 'freshest' seed. To do this look at the date of manufacture that is labeled on the packet of seed. The Department of Agriculture sells a few varieties of OP seed. Whichever the seed they sell is certified and usually viable. Many non-government organisations have initiated the propagation of seeds some of which are of traditional crop varieties. Contact details for seed suppliers are found in **Annexure 2.**

Madathavalu - traditional rice in Kularatne's garden

'Traditional' seed is open pollinated and has been passed down for generations. Many varieties of traditional seed can still be found like the rice varieties - *Kalu Heenati, Patcha Perumal, Suwandel, Madathavalu,* etc, yams and low country vegetables.

Mylwaganam's garden after 3 months

Laying Out the Garden in Advance

The landscape design of your entire farmland must incorporate the plan of your vegetable garden. This will give you the opportunity to think through important factors such as space requirements and nutrient needs before you put seeds or plants into the soil. **Map 3** depicts the plan for vegetable cultivation in Mylwaganam's garden.

Planting annual crops

Planning your garden means deciding on the vegetables you would like to grow, how many plants you will need, where and when to put them in the ground. This allows you to use available space and resources to their best advantage. Other techniques such as succession planting and intercropping allow you to harvest two or more crops from the same space in one growing season; crop rotation minimizes the possibility of pests and diseases and slows the depletion of soil nutrients.

Selecting crops to plant

To decide on what crops to grow, begin with a list of the vegetables that you and your family like to eat. You will also want to include vegetables that have market demand. Your selections need to be crops that will grow well in your area taking into consideration the conditions that prevail in the dry and wet seasons since attacks from pest and diseases are greater then. For example, too much rain could bring on fungal diseases whilst a very dry period may enable infestations of Mealy bugs. In the Moneragala and Ampara Districts, Tomatoes are best sown during the rainy season. Red Onions perform well during the dry months and do not like rain. By drawing up a cropping calender you can effectively plan the cultivation of crops.

Preparing for red onion cultivation

How much of crop to plant

Given the high diversity of vegetable crops planned, it is necessary to ascertain what you can expect to harvest from each crop. Although the yield will depend in part on your growing conditions, certain vegetables and specific varieties are known to be strong producers.

Space between beds in Mylwaganam's garden

If you have a small plot for your vegetable garden, you may have to winnow your list to accommodate only a few crops that will fit comfortably.

A number of techniques will help you to get the most out of a small plot, but overcrowding a bed is not one of them. Cramped plants will yield less than those given ample room to grow, and are more susceptible to disease and infestation by insects.

Purple yam in Kularatne's garden

How to plant

Adopting techniques like crop rotation, succession, intercropping and companion planting can maximize productivity. If space is an issue, use containers for planting.

Rotating Crops

Crop rotation means planting each crop in a different location in the garden each time you plant. This technique applies only to annual vegetables.

When laying out your garden, keep in mind whether plants are heavy or light feeders or are soil builders; arrange the crops according to their nutrient demands. For example, in one bed, first plant Beans, that are light feeders and release nitrogen into the soil; after harvesting follow with Maize that is a heavy feeder and uses a lot of nitrogen. Conversely, follow a heavy feeder like Purple Yam (*Dioscorea alata*) with a legume like Winged Bean that releases nitrogen or a cover crop like Horsegram (kollu) that will be turned back into the soil after harvesting to nourish it.

Varying where you plant your crops each season also minimizes the problems caused by diseases that attack particular plants. These diseases settle into the bed where the plant is growing and remain in the soil to do their damage later on. Rotation of crops also discourages insect pests, even though they are more mobile than most diseases.

Chillies planted in succession with Ladies Fingers and Brinjal

Succession planting

Instead of planting all the seeds of a vegetable at once and being faced with a glut of crop, plant some of the seed, then wait 2 to 3 weeks and plant again. Different sections of the bed can then be harvested over a longer period of time. This technique maximizes your garden space and extends the harvest of certain crops. It works best with vegetables such as Maize, Radish, Bushita, Long Beans, Spinach and Red Onions.

Brinjal with Long beans

To use limited garden space most efficiently, practice **mixed crop succession**. With this technique, you will follow one season's harvest with a different crop in the same space.

Radish intercropped with Long Beans

Intercropping

Intercropping, or combining two plants in the same space, allows you to fit more vegetables into your allotted space. It can also provide shade from tall plants that will protect shorter plants from wilting in the afternoon sun. Vining vegetables like Pumpkins do well along the edges of a bed where they can creep without encroaching on other plants. Combine early crops that mature fast with slow growing ones. For example, plant Radish among Chillie plants. By the time the slow-growing Chillie plants need more room, the Radish will be ready for harvest. As an added bonus, when you pull out the Radish, you till the soil for nearby plants.

Intercropping Brinjal, Mukunuwenna and Hog plum (Ambarella)

Arrange perennial vegetables like Brinjal centrally in the vegetable beds so that they are not disturbed when the time comes for tilling the soil for annual plantings.

Long beans with Pumpkin on the side

Companion planting

Companion plants when grown together are mutually beneficial where flavour improves and they attract beneficial insects. For example Maize grows well with Beans and Pumpkin. As they grow, Beans release nitrogen into the soil for Maize and Pumpkin. The three crops use a minimum of space: vining Bean plants are supported by tall maizestalks, while pumpkin spreads out along the ground. Brinjals do well with Bushita, Long Beans and Spinach. Tomatoes grow well with Garlic. Marigold if planted between vegetable beds reduces nematode attacks. Garlic if interplanted keeps aphids away. Planting herbs like Mint or Coriander that give out an aroma will also help in pest control.

Garlic plants

Marigold with Brinjal

Planting flowers in the garden willl attract pollinators like bees and butterflies that could increase yield.

The Baron, butterfly

On the other hand do not plant Onions with Beans because they are not good companions.

Zinnias interplanted between vegetables, Kularatne's garden

Vegetable Gardening in Containers

Containerized planting is useful in urban areas or where space is an issue. It gives the opportunity to plant more crops. Small farmers in Liyangolla use the mature, mid rib of coconut leaves to build plant containers. However plants in containers require more attention than plants in the ground. The soil dries out quickly and needs water regularly. In order to retain soil moisture, potting soil must be rich in compost and mulched adequately.

Planting in old fertilizer bags in Chandrawathie's garden in Liyangolla

The volume or depth of soil needed for the roots of a plant determines the size of the container. Deep-rooted vegetables like Brinjal need a deep container while Cabbage will require less depth. You can plant a single plant type or a mixture of vegetables in one container where Gotukola or Mukunuwenna can be planted in between spaces. Bitter Gourd if planted in a container can be tied to a tree and look ornamental as well.

Brinjal and Bitter Gourd

Onion plants in containers made of coconut leaf mid rib, Liyangolla

Planting tree and other perennial crops

When planting tree crops one is often faced with the problem of locating the species selected.

Halmilla or Trincomalee wood, a native species

Most native species can be propagated in the nursery established in your farm garden where seeds are collected from the closest natural forest patch during the seed setting season. If you are unable to source all the species selected you can purchase these plants from the Forest Department nursery or other nurseries. Details are given in **Annexure 3**.

Mango with Gotukola underneath

Papaya variety selected for sweet fruit

Some of the utility species selected can also be propagated in your nursery like Papaya, Beli or Lime. You may want to purchase high value, grafted varieties like Karthakolomba or Villard Mango, Orange and Mandarin from outside nurseries though the cost and availability of these species could be a limiting factor. This is why you should set up the nursery in your farm garden as early on in the year as possible in order that plants will be ready in time for the rainy season in October. We have already described how you propagate seed earlier on in this Chapter. You can also use this nursery to experiment with different methods of propagation (cuttings, seed, grafting, etc.).

Vinodhini's plant nursery in Guruhela

The next step is to identify where each tree will be planted in your farm garden. While the design you have drawn will give you a rough idea of the location, you need to consider the tree's requirement when it is mature; in terms of the space, the shade its canopy will cast and the impact on crops in its immediate vicinity. It is also important to understand 'why' you are planting the species in order to obtain the greatest benefits. Therefore some knowledge of the species is essential.

Planting Coffee in the shade of Coconut

Sesbania or Katurumurunga planted between vegetable beds

Ginger, Taro and Turmeric planted as understorey crops since they need shade

How best to plant a tree

Coconut in Mylwaganam's garden

It is good to add some compost into the hole when planting a tree. Mulching the surface of the planting hole with organic material like straw or leaves, etc will cover the surface area and prevent weed formation. It will also add nutrition to the soil on decomposition. Mulching facilitates moisture retention by absorbing water.

Pomegranate in Yogasudha's garden

When planting tree crops one must ensure that they are watered regularly. When many trees are planted at one time watering becomes cumbersome. Hence the best plan is to plant trees during the rainy season. This way trees get watered continuously for a 2-3 month period enabling firm root establishment.

Nelli, Haniffa's garden

Fertiliser bag as protection

If you plant trees along the boundary of your farmland that is unprotected or where the live hedge has still to develop, covering the tree with an old fertilizer bag that is open on both sides, will protect the tree from stray cattle. It will also protect the tree from strong sunlight or wind.

Monitoring

A good farmer must always be vigilant and be on the look out for attacks from pests and diseases. He must take remedial action. In times of stress like drought or too much rain, there is the greater potential for such attacks.

Indian roller

In those times it is pertinent to take preventive action like the addition of neemseed kernel into the soil.

In addition to the proliferation of pests, there will also be an increase in populations and frequency of 'friendly' biodiversity like birds, spiders, grasshoppers, frogs, butterflies, moths, dragonflies, lizards, skinks, snakes, etc or soil biodiversity like pill bugs, earthworms or millipedes. Frequent sightings of these insects and animals means that your garden is becoming conducive to biodiversity.

Green Vine Snake

Oriental scarlet, dragonfly

Common Skink

Blue Mormon, butterfly

These are positive indicators that the farm landscape is maturing.

Maintenance

As effort is taken in land preparation, planting trees and the cultivation of annual and perennial crops, equal effort must be taken to maintain the land if you are going to benefit from your labours.

For annual crops, you need to:

- Water plants daily, preferably in the evening since then there is reduced evaporation. If you have mulched the vegetable bed, the mulch will absorb water that will percolate slowly into the soil through the cool of the night.
- Continue to mulch your vegetable beds by replacing organic matter. In the drought you can engage in 'sheet mulching' where organic matter is applied like a 'blanket' over the surface of the entire production area.

Mulching radish with dried banana leaves, Dhanapala's garden

Sheet mulching, Vinodhini's garden

- Weed the vegetable beds and take out dead or diseased plants
- Apply compost by digging lightly around the plant and after insertion, replace soil. You can do this at least once in 10 days
- Apply liquid fertilizer once a week. If you spray in the morning, water the plants in the evening or *vice versa*. One should not 'wash off' the foliar fertilizer immediately after it has been sprayed.
- Apply a growth hormone like Panchagavya as recommended in *Chapter 5.* Time of application is similar to that of liquid fertilsers.
- If a pest or disease afflicts your crops, use any one of the biological pesticides or fungicides described in *Chapter 6.*
- Rotate your crops and follow the advice given earlier on in this Chapter.

In the case of tree crops you need to engage in rigorous maintenance mostly when plants are small. However it is important to mulch the soil above the roots in the drought.

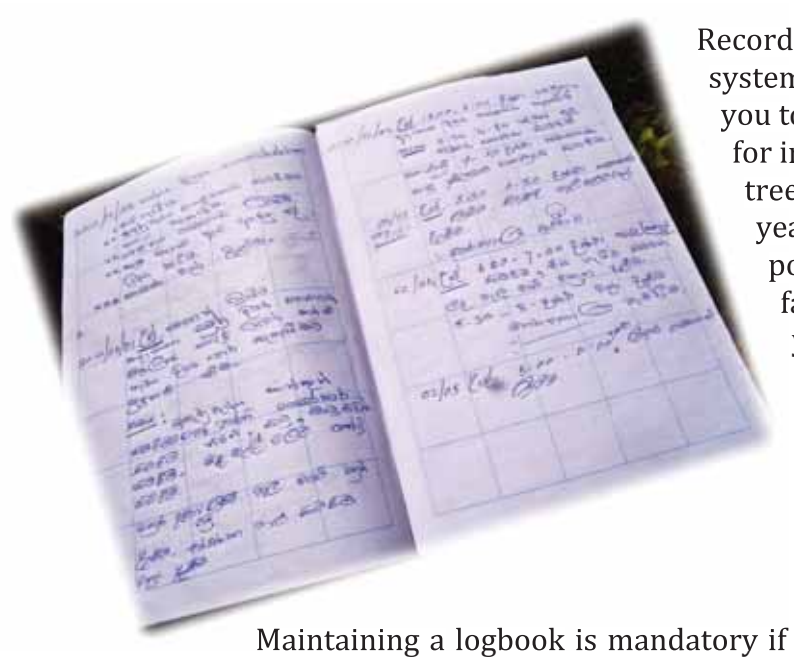
It is also important to manicure trees before the rainy season if a substansial crop is sought. Crops like Mango, Cashew, Lime, Orange and Mandarin respond well to manicuring and perform even better if followed by applications of mineral enriched, compost.

Manicuring Lime trees in Kularatne's garden

Maintaining a Log Book

The best way to remember what you have done on the land, what you have to do and why, is to maintain a record. You can do this simply by writing down what you do in your farm garden on a daily basis; much like keeping a diary. A simple example is given below.

It is also useful to record how much you spend and on what. Equally important is a record of how much yield you harvest for each crop, how much is sold and at what price. This information will reveal how productive your farm garden is and which crops perform better than others.



Recording information systematically will also enable you to determine a pattern; for instance, if your Papaya trees were affected in July this year by Mealy bugs, there is a possibility that you could face the same threat next year at the same time. This will enable you to be well prepared in the face of an attack.

Maintaining a logbook is mandatory if you intend certifying your farm garden. Please see *Chapter 7* for details on certification.

Keeping records of your activities

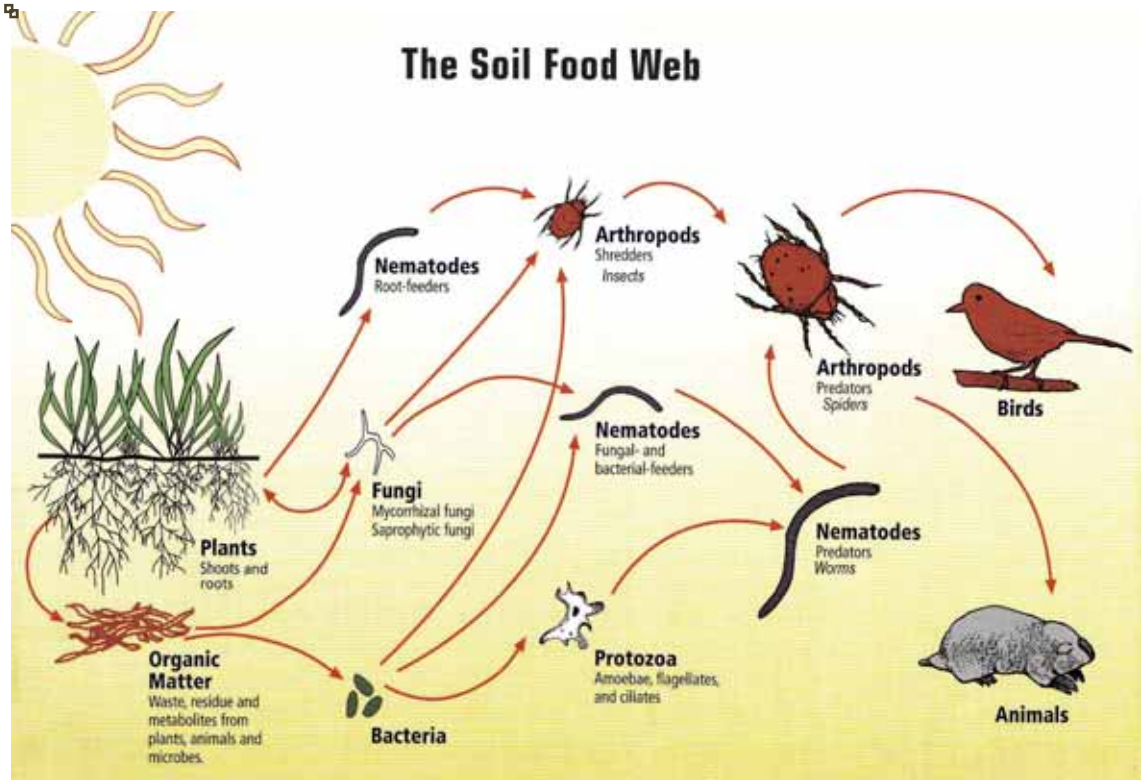
Date	Activities	Labour	Crops	Inputs	Materials From Outside	Value	Cost	Income	Pest /Diseases recorded	Biodiversity Recorded

CHAPTER 5
Increasing Productivity

The Soil, a Living Organism

Healthy soil is the foundation of the food system. It produces healthy crops that in turn nourish people. Maintaining a healthy soil demands care and effort from farmers.

The soil is a diverse and complex system that can be viewed as a living organism, because it is habitat for plants, animals and microorganisms, all of which are interconnected.



Credit: Roy A. Norton, State University of New York, Syracuse, U.S.A.

Soil consists of mineral particles, organic matter and pores. Mineral particles originate from subsoil and rock that break down due to physical and chemical weathering processes to form sand, silt and clay. Mineral particles contain nutrients that are slowly released in the process of weathering that plant roots and some microorganisms actively dissolve and use for their growth. Soils that have equal amounts of clay, silt and sand are referred to as loam and are ideal for agriculture.

Soil also contains organic matter that is of tremendous importance to soil fertility. Organic matter that is mainly present in the top layer of the soil is subject to continuous transformation by soil organisms to form humus that can remain in the soil for years. Humus remains stable in the soil and contributes to improving soil structure in which mineral particles and soil organic matter form stable aggregates. Organic matter works as a kind of glue, sticking together soil particles.

Soil organisms facilitate this process and are key elements in the quality and fertility of soils. The greater the variety of soil organisms and the higher their number, the greater is the natural fertility of the soil.

For the organic farmer, feeding the crop means feeding the soil. Only a fertile soil can yield healthy crops and it is the most important resource of every farm.

To improve and maintain soil fertility, farmers need to:

- Grow diverse crops and rotate annual crops.
- Integrate fallow periods with green manures in the crop rotation.
- Leave crop residues on the field, instead of burning them, as they constitute biomass.
- Grow green manures or cover crops to contribute to biomass.
- Reduce tillage since this will speed up the decomposition of organic material and stimulate soil organisms.
- Adopt an appropriate tillage method that permits good soil structure without causing erosion and compaction.
- Aim at having the soil covered with plants throughout or wherever possible.

Organic materials collected, Razak's garden, Central Camp

- Protect soil from strong sunlight and heavy rain by means of a cover through mulching with plant materials or agro-wastes that are hardy like water hyacinth, maize refuse or paddy straw. This will increase the organic matter content and remain in the soil for a long time.
- Integrate fodder cultivation in the farm where possible (grass, fodder hedges).
- Let your or the neighbour's cattle graze on harvested fields in order to profit from their droppings.
- Apply organic manures as they contain organic material that increases soil organic matter. This provides food for soil organisms stimulating their activity.
- Apply compost since organic matter in the compost is already stabilized and will remain in the soil for a longer time than fresh plant material.
- Adopt good nutrient management where the application of fertilizers:
    a) Are in accordance with crop demands at respective growth stages.
    b) Protect soil organisms and enhance their activity.

In keeping with these suggestions, the following recipes help to increase farm productivity.

Pile Compost

By piling organic materials and providing the pile with adequate water and oxygen, soil fauna will digest and convert it into compost in 4-6 weeks that is dark brown, crumbly and full of nutrition.

The dimensions of a compost pile can be a rectangle of 1.5 m x 1 m or more or less depending on the space you have. What is of significance is the height of the pile. The higher the pile the more efficiently does the process of digestion occur since microorganisms and other soil fauna need air to breathe and a higher pile fosters the circulation of air. Keep in mind that the pile will reduce to about 1/3rd of its original height on completion.

The pile also needs adequate water daily and this is a major reason for poor digestion in dry areas like Moneragala and Ampara.

Suitable location

- Semi shade
- Flat ground
- Place convenient for turning pile
- Not waterlogged
- Preferably close to a cattle shed
- Easy to transport from

Singed rice husk

Materials required

- Dry organic matter - grass, straw, maize waste, rice husk (singed)
- Fresh organic matter - green leaves, water hyacinth, banana pith. Leaves from *leguminous* species of plants are preferred since their nitrogen content is high
- Kitchen waste
- Animal waste - cow dung/goat dung/ chicken dung/cow's urine
- Old compost
- Minerals –Rock phosphate, Dolomite, Wood Ash, Granite dust (For this size of heap, half coconut shells - 2:1:1:1)
- Water
- 8 – 10 straight sticks of 2 or 3 m in length and 8 cm diameter
- Coconut cadjan (woven, if possible) to cover the sides of the pile if stocks of paddy straw are unavailable

Pre mixing Rock phosphate, Dolomite and Granite dust

Utensils required

- Mammoties
- Shovels
- Knives
- Buckets/Watering Cans/hose

Method for preparation

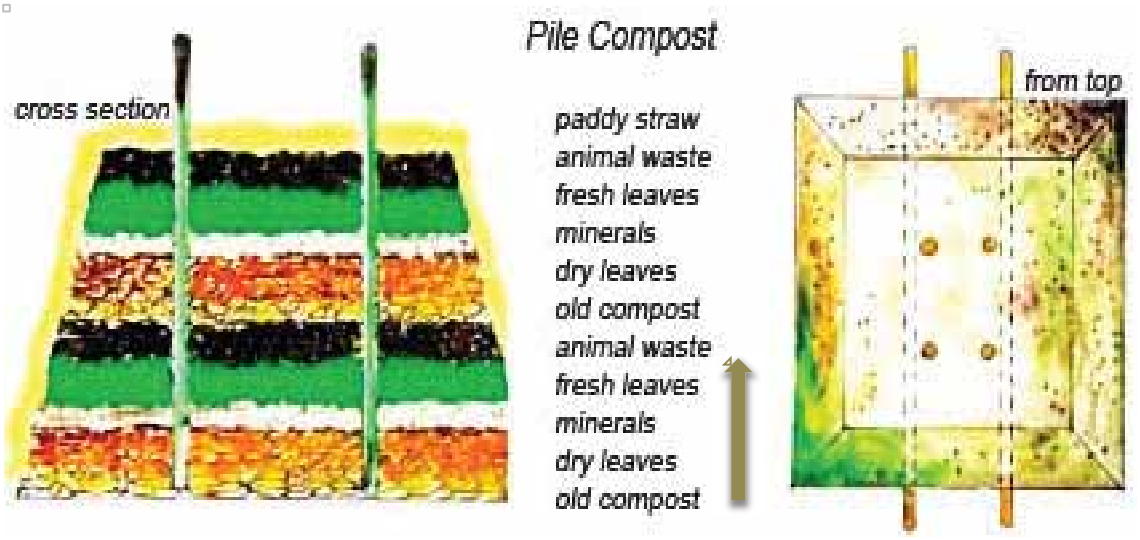
1. Clear the selected location and create a flat base/platform.
2. Demarcate the dimensions of the rectangular pile: 1.5 m length x 1 m width.
3. Loosen the topsoil of the selected location.
4. Place a layer of twigs or sticks on the floor to promote the circulation of air.
5. Fix the balance sticks in the 4 corners of the rectangle.
6. Place layer of old compost 3 – 5 cm on the ground as a starter/accelerator.
7. Place a layer of dry leaves 10 cm height.
8. Add minerals and kitchen waste (if available).
9. Place a layer of green leaves 10 cm.
10. Place a layer of animal waste of 5 cm.
11. Add water.

Making compost in Shanta Malar's Garden, Central Camp

12. Continue this piling process for 4 – 5 times or as high as you can go with the materials in hand. Add a layer of old compost in the middle and again towards the top of the pile. This will accelerate decomposition of the pile. Sufficient water should be added after every layer of animal waste where water should seep from underneath the pile.
13. Cover the pile fully with paddy straw, long grasses, gunny bags or cadjan for maximum insulation. Do not use polythene since it prevents the circulation of air.

Sticks can be used to keep cadjan in place if necessary.

14. When the pile is prepared, 1 or 2 sticks should be inserted into the pile to release heat generated from within the pile. These sticks also serve as gauges to monitor the temperature of the pile as this is the primary indicator that digestion is taking place. The maximum heat is generated in the first few days of making the pile.



Some tips….

- To increase decomposition and quality of the compost, the green material must be shredded or cut into small pieces.
- If you have access to cattle urine, dilute with 50% water and use alternatively with cow or other dung. If the dung is old then you need to water the pile well.
- Mix the minerals together and apply mixture thinly as a powder over the kitchen waste. Do not apply mineral powder directly over animal dung since wood ash in the powder disturbs earthworms and other soil fauna present in the dung.

Cutting banana pith, Shantha Malar's group

Adding the mineral mix

- If you do not have access to old compost you can use some good loamy soil.
- The heat generated in the pile will destroy the seeds of weeds that have been incorporated as green manure. This will happen if the temperature of the pile is kept between 50^{o}-70^{o}c within the first 2 weeks.

Managing the pile

1. Add water daily.
2. After 1 week, take the insulation materials placed on and around the pile and keep it aside much in the manner of 'taking a coat off'.
3. Take the sticks inserted into the pile out as well.
4. Turn the pile where the bottom materials are 'flipped' on to the top and vice versa.
5. Replace the insulation and sticks into the pile.
6. Turn weekly until the pile has decayed fully.
7. After 4-6 weeks you will have well decayed compost.

Basket Compost

Animals such as chickens, wild boar, porcupines and dogs could disturb compost piles when they are prepared at a home garden level. As an alternative, a method called "Basket Compost" has been introduced, that does not need turning and can be maintained by all members of the family.

Suitable places

- Shady area
- Close to cattle shed
- Close to kitchen

Items required

- 60 – 65 *Gliricidia* sticks 2 m in length and 2½ cm in diameter
- 8 – 12 sticks, 2-½ m in length
- Matured Bamboo tree, 3-4 m in length and 8-10 cm in diameter
- 6 rolls of thin coir rope
- Cattle manure - ½ pan
- Small stones or 50 – 60 coconut husks

Making a compost basket behind Shantha Malar's kitchen

Utensils required

- Knives
- Mammoties
- Crowbar

Preparation

1. Clean the selected area
2. Cut the *Gliricidia* sticks on both sides
3. Demarcate a circle of circumference 100 – 120 cm on the ground.
4. Fix the *Gliricidia* sticks on the round 2½ cm in between after leaving a space of 45 cm for the opening.
5. Construct the cage to the chest level height of the user.
6. Split the Bamboo tree and prepare bamboo splinters 2½ cm in length. The bamboo splinter is tough but elastic and can be moulded around the circle. If you do not have bamboo you can use a thin *Gliricidia* or any other stick that can be bent.
7. Tie the bamboo splinter onto the sticks with coir rope, both inside and outside of the cage, 10 cm from the top.
8. Tie the 2nd round, 60 cm above the ground using 2 bamboo splinters.
9. After completing the tying, cut the top of the sticks to an even level.
10. Leave a few sticks free at the bottom (to a width of 15 cm) without tying in order to retrieve compost. Lift sticks and retrieve compost.
11. In addition, place stones or coconut husks around the cage 45 cm away from centre.
12. To retain the moisture content of the compost basket, fix 4 sticks outside the cage and build a trellis that will provide shade.

Filling the Basket

1. Place the remaining pieces of the stick after making the rounds, at the bottom of the basket.
2. Fill up with old compost 2 ½ - 5 cm in height.
3. Fill the basket with waste material whenever available.
4. Compress the corners of the basket with a stick when waste materials are added.

Spinach growing from outside the basket

Management

- Add waste material continuously.
- Add water if it gets dry.
- If the sticks fixed round the cage have grown, cut the branches and add to basket.
- Re-fix new sticks if old sticks are dead.
- After the compost has matured, raise the gate and take the fertilizer.
- Plant green leafy vegetables like Spinach, Mukunuwenna or Gotukola in the space between coconut husks.
- Creepers such as Ridge gourd, Bitter gourd and Cucumber can be grown on the trellis. This will bring an additional income.
- This cage could be used for about 1-½ years if good sticks are used.

Benefits

- Suitable for small gardens.
- Could be used in wet and dry areas.
- No turning required.
- The decayed items at the bottom transforms to compost.
- Protected from animals.
- Fertilizer could be obtained after a short period of 1-½ months.
- The top and bottom of the cage can be used for planting.

Vermicompost

The culture of earthworms is referred to as vermiculture. Earthworms are good indicators of soil fertility since their presence supports populations of soil organisms, insects, spiders, millipedes and many other organisms that sustain healthy soils.

Earthworm casts contribute several nutrients in the form of nitrogenous wastes. They develop the binding qualities of soil, alter its porosity, increase the infiltration of water and thereby enhance the water holding capacity. In addition, earthworms transport nutrients to the subsurface layers of soil.

Earthworms that dwell on the surfaces of the soil (*Epigeic*) feed on and assist in the breakdown of leaf litter; they generally have little effect on soil structure. Those that dwell just below the surface of the soil (*Anecics*) feed on leaf litter and soil and produce faecal matter or vermin casts. Both, *Epigeic* and *Anecic* earthworms are used to convert agro waste to compost. This is referred to as vermicompost. The culture of earthworms also results in the release of cocoons leading to their proliferation when vermicompost is added to soil.

Epigeic and Anecic Earthworms

Dr. Sultan Ismail, well renowned expert on earthworms, has created the vermicompost recipe described here. I have used this recipe that produces fine vermicompost and would like to share it with you.

Collecting worms

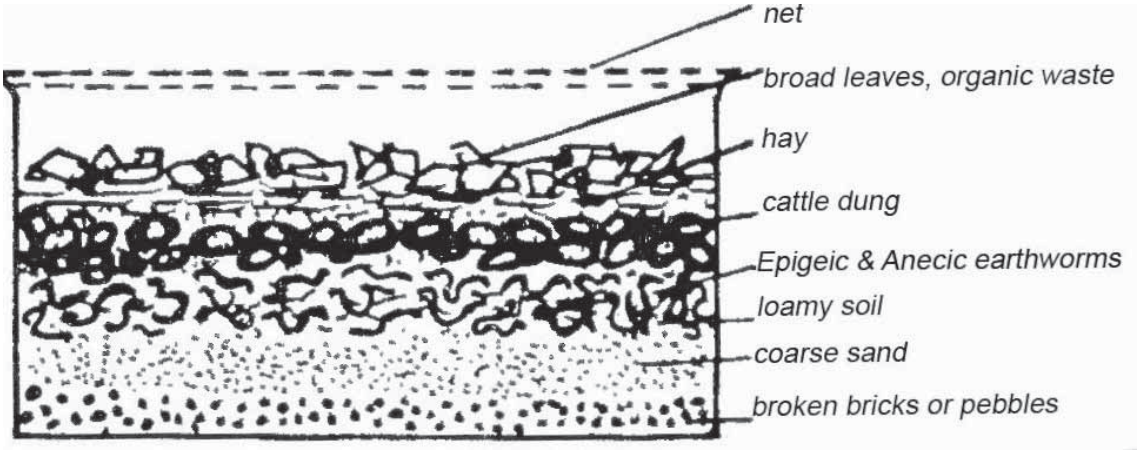
To make vermicompost, one must first collect local varieties of earthworms. You can do this by digging soil in a shady spot on your land or near a drain from the kitchen that transports organic wash water. Place handfuls of cow dung on one square metre area, cover it with straw or leaf litter and then cover that with a gunny bag. Moisten the bag regularly but do not waterlog the bag. Within two weeks you will be able to collect both *Anecic* and *Epigeic* earthworms from here. Important to remember is that earthworms should always be transferred with some quantity of native soil. This ensures their survival and also the passive inoculation of cocoons from the area of collection.

Vermibed

Making vermicompost

You can make vermicompost in a pit, concrete tank, well ring, wooden or brick lined bed depending of your situation. The ideal site is under shade in an elevated area to prevent water stagnation during rainfall. First place a basal layer of broken bricks to about 6-7.5 cm height to ensure proper drainage. After it has been moistened, place a layer of soil to a minimum height of 15 cm. Into this soil about a hundred locally collected *Anecic* and *Epigeic* earthworms may be inoculated. Small lumps of fresh or partially dry cow dung are scattered over the soil that is then covered by straw to a height of 10 cm. Water is sprayed liberally till the whole set up is wet but not waterlogged. The unit may be covered with a net, broad leaves like Coconut or Palmyrah fronds or even gunny bags. The idea is to prevent rummaging by birds. Do not use a plastic

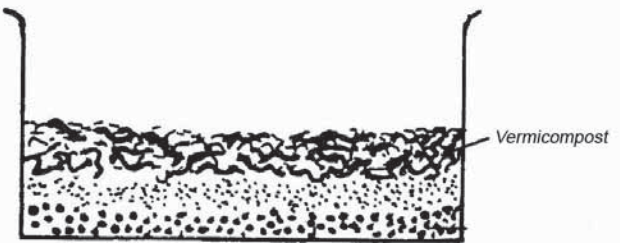
cover since it traps heat and gases. Watering and monitoring of the unit should continue for 30 days. Do not overwater. By this time, juvenile worms should appear and that is a healthy sign.



Organic refuse should be added on the 31st day. Please use locally available resources like kitchen waste, dried leaves, straw, rice husks etc. The refuse should be spread on the bed after the fronds are removed up to a height of 5 cm for each application. You can add organic refuse every day or even twice a week depending on the availability of your resources. Cover the bed with fronds after application and water as required. After a few applications of the refuse, only the refuse must be turned over with a pitchfork taking care not to disturb the bed. When the refuse has filled the unit leave it be for 45 days after which the compost is ready for harvest. However watering must continue till at least the 42nd day.

Vermicompost

Twin tank Vermicompost



This compels the worms to move into the lower end of the vermibed and facilitates harvesting of the compost without much damage to the worms. After the compost is ready it is soft, spongy, sweet smelling and dark brown in colour. The harvested compost may be placed in the form of a cone on solid ground in bright sunlight; this further compels movement of the worms into the lower layers where they can be recovered and transferred to new composting units. The compost may be sieved and packed in polythene bags to retain moisture.

For reasons of economy one can start a twin unit system.
A timetable for units measuring 2 m x 1 m x 1 m for a two-year period is seen below.

Effective Time Table for proper harvesting of vermicompost using Twin Tank system for two years

	UNIT 1	Unit 2
FIRST YEAR		
0	Vermibed	-----
30 days	Start loading	-----
45	-----	Vermibed
75	Stop loading	Start loading
120	(1) Harvest & cure	-----
125	Reload	Stop loading
165	-----	(2) Harvest & cure
170	Stop	Reload
215	(3) Harvest & cure	-----
220	Reload	Stop
265	------	(4) Harvest & cure
270	Stop	Reload
315	(5) Harvest & cure	-----
320	Reload	Stop
365	------	(6) Harvest & cure
SECOND YEAR		
370	Stop	Reload
415	(7) Harvest & cure	-----
420	Reload	Stop
465	-----	(8) Harvest & cure
470	Stop	Reload
515	(9) Harvest & cure	-----
520	Reload	Stop
565	-----	(10) Harvest & cure
570	Stop	Reload
615	(11) Harvest & cure	-----
620	Reload	Stop
665	-----	(12) Harvest & cure
670	Stop	Reload
715	(13) Harvest & cure	-----
720	Reload	Stop
This can continue… the number of harvest is shown in parentheses		

Reference: Ismail, Sultan A. (2009), The Earthworm Book, Other India Press, ISBN No: 81- 85569-66-5

Vermiwash

Foliar sprays are a part of plant growing practices. Worm worked soils have burrows formed by earthworms. Bacteria richly inhabit these burrows. Water passing through these burrows washes nutrients to the roots that are absorbed by plants. This principle is applied in the preparation of vermiwash that is a very good foliar spray.

Setting up a vermiwash unit

Vermiwash units can be set up either in barrels or in buckets or even in small earthen pots. It is the principle that is important. The procedure explained here is for the setting up of a 250 litre plastic barrel.

Vermiwash barrel

An empty barrel with one side open is taken. Make a hole on the side and place a tap as seen in the picture. The entire unit is set up on a short pedestal made of few bricks to facilitate easy collection of vermiwash.

Keeping the tap open, a 25 cm layer of broken bricks or pebbles is placed. A 25 cm layer of coarse sand then follows the layer of bricks. Water is then made to flow through these layers to enable the setting up of the basic filter unit. On top of this layer is placed a 30 to 45 cm layer of loamy soil. It is moistened and into this are introduced about 50 numbers each of the surface (*Epigeic*) and subsurface (*Anecic*) earthworms. Cattle dung pats and straw are placed on top of the soil layer and gently moistened. The tap is kept open for the next 15 days. Water is added every day to keep the unit moist.

Dung pats are placed on top

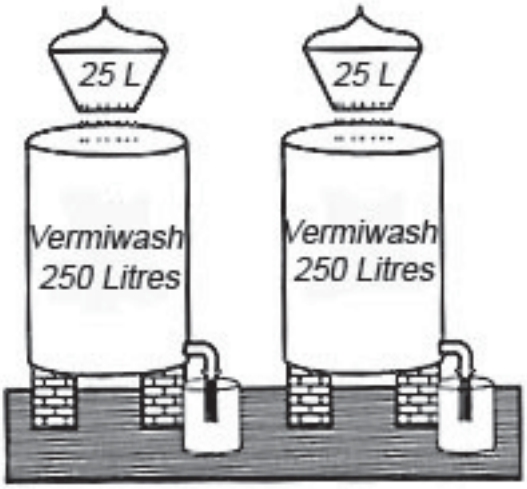
Straw placed on top as the final layer

On the sixteenth day, the tap is closed and on top of the unit a metal container or mud pot perforated at the base as a sprinkler is suspended. 5 litres of water (the volume of water taken in this container is one fiftieth of the size of the main container) is poured into this container and allowed to gradually sprinkle on the barrel overnight. This water percolates through the compost, the burrows of the earthworms and gets collected at the base. The tap of the unit is opened the next morning and the vermiwash is collected. The tap is then closed and the suspended pot is refilled with 5 litres of water that evening to be collected again the following morning.

Dung pats and straw may be replaced periodically based on need. The entire set up may be emptied and reset between ten and twelve months of use.

Vermiwash is generally diluted with water (10%) before spraying. This has been found to be very effective on several plants. If need be vermiwash may be mixed with cow's urine and diluted (1 litre of vermiwash, 1 litre of cow's urine and 8 litres of water) and sprayed on plants to function as an effective foliar spray and pesticide.

The casts formed on the surface of the unit may periodically be cleared and cattle dung pats and straw be replaced. Vermiwash can be collected and stored as such, or can be solarised, condensed and stored. This may be diluted before use, with a dilution factor that best suits the user. When the soil within the unit becomes excessively rich with organic matter and the earthworm density appears to dwindle, dismantle and reset the unit with fresh soil as before. The soil removed from the unit can however be used as manure for nurseries.



The valuable contribution made by earthworms to soil fertility has only very lately been recognized but there is yet a great deal to learn on soil management from the lowly earthworms.

Setting up a Vermiwash Unit.
Two barrels of 250 litres each can produce a minimum of 5 litres of vermiwash every day, after the 20th day of commissioning.

Liquid Fertilizer

Plants absorb liquid fertilizer easily. It can be made in a number of ways using cow dung, cow's urine, green manure, fish, rotting fruit or through earthworm burrows that are mixed with water and left to 'cook' for a number of days. Whichever the composition, the application of liquid fertilizer has a dramatic impact on the growth and vigour of plants.

The recipe presented here is for the preparation of liquid fertilizer made out of green leaves and cattle dung where the proportions are 2/3rd green leaves and 1/3rd animal dung. A number of other substances are also added to the mixture that enhances the quality of the final product.

Items required

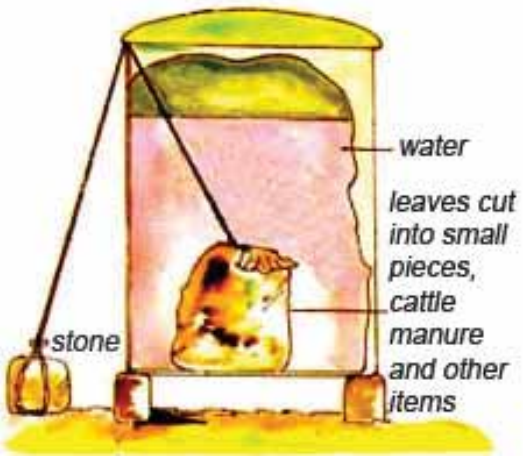
- Diverse green manure (Leaves of *Leguminous* and medicinal plants like Pavetta, Nika etc, Seaweed, Water Hyacinth, etc)
- Dung (Cattle, Goat, Chicken)
- Cattle Urine
- Minerals (Rock Phosphate, Dolomite, Wood Ash and Granite dust; Unit: half coconut shell at 2:1:1:1)
- Gunny/fertilizer bag
- Knife
- Rope
- Plastic Barrel
- Stone

Ingredients for making Liquid fertiliser

Macerating ingredients

Preparation

1. Cut the green manure into small pieces.
2. Mix this with the mineral powders that have been pre-mixed.
3. Add cattle manure to this mineral/green manure mixture and macerate well.
4. Place in a gunny or old fertilizer bag.
5. Immerse the bag in a plastic barrel filled with 50% water and 50% cow's urine.
6. If you do not have access to cattle urine add only water.
7. The level of water should cover the gunny.
8. Place a stone over the gunny to prevent it from coming up.



9. Half close the barrel to facilitate aeration.
10. Stir this solution or lift the bag up and down twice a day, morning and evening. This is done to aerate the mixture.

Method for use

After 14 days, the mixture from the first barrel is ready for use. It is also time to make your next batch of liquid fertilizer since that will take another 14 days.

When it is fresh you must dilute 1 part of liquid fertilizer with 7 parts of water.

Liquid fertiliser

You can use a sprayer or watering can to apply the solution. If you are going to spray the solution make sure to filter it since otherwise the nozzle of the sprayer will get blocked.

Apply the mixture at a minimum of once a week. Application should preferably be during the morning hours since it has the whole day to dry and be absorbed by the plant. You must then water your plants in the evening hours.

When you take out a certain volume of the mixture you must replace it with the same amount of water in order that the gunny is always submerged. Hence as you continue to use the mixture, its concentration will decrease with dilution. Therefore the volume of water added to the mixture before use will reduce with time. After about a month when concentration levels have dropped you may empty the contents in the bag into a compost basket or use it directly as a fertilizer.

Liquid fertilizer is most suitable for use in the cultivation of vegetables, specifically green leafy vegetables. Because the mixture is enriched with minerals its use during periods of flowering and fruiting ensures high quality fruit in terms of form, shape, taste and shelf life.

Advantages

- Low cost
- Easy to prepare
- Increases plant growth
- Increases resistance to diseases

Growth hormone, *Panchagavya*

Panchagavya consists of five products from the cow: dung, urine, milk, curd and ghee. When mixed and used, it has miraculous effects. It has been used in India for centuries and acts as a growth promoter and immunity booster. *Panchagavya* contains macro nutrients like nitrogen, phosphorous, potassium (NPK), 13 essential micronutrients necessary for plants, many vitamins, essential amino acids, growth promoting factors and beneficial micro-organisms like *azotobacter*, phosphor bacteria and *pseudomonas* in abundant numbers. It also contains some useful fungi and *actinomycetes.*

Ingredients

Fresh cowdung	5 kg
Cow urine	3 Litres
Cow milk	2 Litres
Cow ghee	½ kg
Cow curds	2 Litres
Sugarcane juice	3 Litres
Tender coconut water	3 Litres
Banana (ripe)	12 Fruits
Toddy	2 Litres

Source: Tamil Nadu Agricultural University

Mode of preparation

To prepare *Panchagavya*, you need a wide mouthed mud pot, concrete tank or plastic can. Metal containers should not be used. First put the fresh cow dung and cow's ghee into the container and mix it thoroughly twice daily for 3 days.

On the fourth day, add the rest of the ingredients and stir it twice daily for 15 days.

The *Panchagavya* stock solution will be ready after the 18th day. It should be kept in the shade and covered with a wire mesh or plastic mosquito net to prevent houseflies from laying eggs and the formation of maggots (worms) in the solution.

If sugarcane juice is not available, add 500 g of jaggery dissolved in 3 litres of water. Likewise, if toddy is not available, add 100 g of yeast powder and 100 g of jaggery to 2 litres of warm water. After 30 minutes, add this solution to replace toddy in *Panchagavya.*

Another method is, you take 2 litres of tender coconut water and keep this in a closed plastic container for 10 days. After fermentation, it becomes toddy. This solution can be prepared beforehand and used to replace toddy. When stirred twice daily, the *Panchagavya* solution can be kept for six months without any deterioration in its quality. Whenever the solution becomes thick due to evaporation of water over a long period, suitable quantity of water can be added to keep it in a liquid state.

Use

3 litres of *Panchagavya* to every 100 litres of water is the ideal dilution for all crops. A power sprayer of 10 litres capacity may need 300 ml of *Panchagavya* per tank. After dilution, the *Panchagavya* solution must be filtered before spraying.

In a flow system, *Panchagavya* solution can be mixed with irrigation water at 20 litres/acre, either through drip or flow irrigation.

For seeds/seedling treatment, 3% solution can be used to drench seed, soak or dip seedlings before planting. 20 minutes of soaking is adequate. Rhizomes of Turmeric, Ginger and cuttings of Sugar Cane need to be soaked for 30 minutes before planting. Seeds if dipped in a 3% solution can be dried and stored well.

Frequency of application

- Pre flower phase (20 days after planting): One/two sprays every 15 days depending on duration of crop
- Flowering and pod setting phase: Two sprays once/10days
- Fruit/Pod maturation stage: Once during pod maturation

Preparing Panchagavya, Sarath Chitrasena's garden

Reference: Natarajan K, (2008) *Panchagavya*, A Manual, Other India Press, Goa ISBN No: 81-85569-56 - 8

Growth hormone - *Amrithakaraisal*

Its uses are similar to *Panchagavya* though its preparation is easier and more economical. *Amirthakaraisal* improves soil fertility and gives a good yield.

Ingredients

Fresh cow dung	10 kg
Cow's urine	10 litres
Jaggery	250 g
Water	100 litres

Method of preparation

The above-mentioned ingredients should be added to a cement tank or large plastic barrel and mixed well. The extract will be ready for use the next day.

Use

10% of this extract can be used for direct spraying or with irrigation water in which case, 300 litres of this extract is required for one acre of the crop. For foliar spraying, 10 litres is required per acre of the crop.

Reference: Subhashini Sridhar, Arumugasamy S, Saraswathy H, & K. Vijayalakshmi (2007) Chennai Organic Vegetable Gardening Published by Centre for Indian Knowledge Systems.

CHAPTER 6
Pest and disease management

Introduction

In regenerative agriculture the main aim is not to eliminate or wholly control pests or diseases but instead to keep a balance in order that the damage caused by them is economically and ecologically tolerable.

Calotes versicolor, garden lizard

Of importance is the prevention of an attack.

Measures that could be adopted include:

- Combine and diversify crops. Do not engage in monocultures.
- Rotate your crops.
- Add organic matter to the soil (compost, straw, rice husk, maize waste, water hyacinth and other green manures).
- Increase natural vegetation by establishing buffer zones of indigenous plants along the fence or boundary of your field or around ponds or streams if any. Let weeds grow along roads and other uncultivated areas.
- This will create habitat for beneficial insects like ladybugs and spiders as well as for lizards, frogs, toads, birds and many other predatory creatures.
- Constantly be on the look out; you must observe, analyse and interconnect everything that is going on in your field and in the neighbouring fields since the field is not a homogenous environment. Instead it is a mosaic of different environments that are constantly changing. This is the challenge.

Vegetation around pond, Kularatne's garden

- If you have a serious attack by pests or disease use a biological control method instead of a chemical pesticide or fungicide.

Bufo melanostictus, common toad

There are several methods described here. Some of them are non-chemical methods while others are biochemical methods. Most of the methods have been tried and tested by the Centre for Indian Knowledge Systems in India and used by us in all ecozones in Sri Lanka. These methods are successful in the control of insect pests, bacterial and fungal diseases and some viruses. They include:

Non-chemical methods	Biochemical methods
Light traps	*Andrographis paniculata* decoction
Yellow Sticky traps	*Sida spinosa* decoction
Bird perches	Garlic, Ginger and Chillie mixture
Hand picking	Cow dung mixture
Fumigation	Cow's urine
Establishing buffer zones	Cow's urine and Buttermilk Mixture
Managing biodiversity	Neem based pesticides
Enhanced resistance through plant nutrition	Other biological pesticides

Non Chemical Pest Control Methods

Light traps

Light traps can be used to monitor and trap moths thereby reducing their populations. Some common light traps that could be used are bonfires, hurricane lamps and electrical bulbs etc. The adult moths have an inherent capacity to get attracted to the light.

This trap should be placed in the field after 5.30 p.m. A large vessel filled with kerosene mixed water is kept under the light trap. Moths that are attracted to the light fall into the water and die.

Yellow sticky traps

Grease or castor oil smeared on empty tins or plates that have been painted yellow are kept in the field. White flies get trapped on these sticky traps. These are wiped out every day, grease is applied again and traps are replaced.

Bird perches

Long dried twigs can be installed as "T" shaped bird perches at 15 – 20 perches per acre. Birds are attracted to these perches that serve as ideal places to spot insect pests that they then devour.

Embelia ribes

Hand picking method

This method of pest control is useful if the crop is in a small area. Pick up the larvae during evening hours and put them in a polythene bag that has kerosene in it. Pests can be controlled this way if their numbers are low.

Fumigation combined with other organic methods for disease control

10% cow's urine extract should be sprayed on crops that are affected by disease. On the same or next day, fumigation should be carried out in the evening. Seeds of False Pepper (*Embelia ribes*) are powdered well, placed in a wide mouthed

pot with burning charcoal and carried into the field in a direction opposite to the wind; 200 g of powdered seed can be used per acre. On the 7th day, after fumigation, 300 ml of Sweetflag (*Acorus calamus)* extract is mixed with one (1) litre of cow's urine. This is then mixed with 9.4 litres of water (measurement for one tank) and sprayed on the crop. Sweetflag extract is prepared by soaking 500 g of Sweetflag powder in 2 litres of water and then filtering the same. This method prevents wilting in plants.

Acorus calamus

Aloe with coconut sapling

Aloe (*Aloe vera*) saplings are planted near and around coconut saplings. By this method, termites and nematodes that attack the roots of coconut saplings consume the succulent flesh of the *Aloe* instead and thus the damage is kept under check.

Buffer zones

Buffer zone, Jane Nona's land, Maragalakanda

Since organic fields are like islands in the midst of conventional fields, they face many risks: the possibility of contaminated dust containing bacteria or fungi blowing into the field; contaminated water from irrigation; contaminants leaching into ground water; invasion from unwanted insects and now the contamination from wind blown pollen from genetically modified plants like Maize.

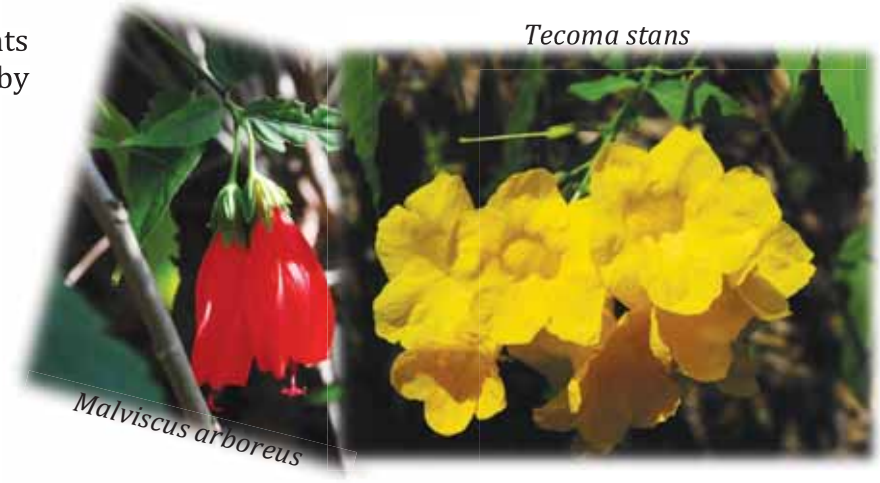
Hippasa greenaliae, Tube Wolf spider, Shreeram, M.V, 2011

There is thus the need to establish a 'buffer zone' between one's field and that of one's neighbor. A buffer zone is a valuable tool in forming a biological barrier against all contaminants. The extent of the buffer will depend on the availability of land and on the plant or shrub species used. A mix of indigenous plants with long and short rotations is best. If there is a forest already in place there is no need to establish a buffer zone. The presence of natural vegetation around cultivated fields provides habitat for predators like the Wolf spider that is the natural enemy of the brown plant hopper, a dreaded rice pest.

The establishment of riparian vegetation around a water source – a pond will provide habitat for biodiversity like frogs that are efficient predators.

Promoting and managing biodiversity
The more diverse an environment is the less chance that a single species will prevail. The more diverse an agroecosystem is and the less disturbed its diversity, trophic (food) links increase and synergic relations develop promoting insect population stability. Therefore the cultivation of a diverse array of both annual and perennial crops enhances the stability of your farm.

The use of trap plants attracts pests thereby preventing them from getting to the main crop. A good example is when Pepper is inter-cropped with Maize, the threat from aphid invasions is reduced.



Plant fragrant and brightly coloured flowers as well as aromatic plants since they offer food and shelter to beneficial insects like butterflies.

Inducing resistance though plant strengthening
Disease control is based on strengthening the plant with the aim of enhancing its self-defense. The use of compost tea enhances crop health and fertility and is simple to make. You need to get: 1 part very mature compost and 5 parts of water. Stir, leave for one day, filter and spray on crop. Soap may be added to improve fixation on leaves.

Soil conditioning has a direct influence on crops and vegetation. Healthy soils mean healthy plants that are able to defend themselves against pest attacks and disease.

Bio Chemical Pest Control Methods

Plant based Bio Pesticide

Andrographis paniculata decoction 3-5%
Heen Bin Kohomba (S)

This plant-based bio-pesticide is used to control the following pests most of whose larval forms are caterpillars.

Pest	Crop
Shoot Borer In young plants caterpillars bore into petioles and midribs of large leaves and young tender shoots. Insect droppings are seen at the entrance of the hole. Affected leaves and shoots wither and dry. At a later stage of growth, caterpillars bore into flower buds and fruits. Damaged flower buds are shed and fruits show circular holes. 	Brinjal, Ladies Fingers and Sugarcane
 *Fruit borer* The larvae feed on the leaves and bore into pods and fruits. They thrust only a part of their body inside and eat up the internal contents of the fruit thereby affecting yield.	Tomato, Brinjal, Ladies Fingers, Chillies
Stem borer Larvae are brown in colour with a flattened head. On hatching, they bore into the stem, tunnel inside and along the central pith eating surrounding tissues.	Maize, Rice, Sorghum, Kurakkan, Sugarcane, Ridge gourd
Hairy caterpillar The larvae are brownish black in colour with dense hairs and are seen in groups. They feed on leaves and also scrape the bark and feed on them. They are mostly nocturnal.	Green gram, Black gram (Ulundu), Groundnut and Murunga
Army worms These caterpillars attack leaves and fruits in large numbers causing widespread damage and are hence referred to as Army worms. They are dark or pale green with dark green stripes on their back. They eat the growing leaves and this gives an appearance as if the crop has been grazed. 	Rice, Maize and other cereal crops including Beans

Items required

Andrographis paniculata decoction 3-5 %	1 kg
Water	4 litres
Soap mixed water (Sunlight soap)	100 ml

Pushpa cutting Andrographis in Liyangolla

Method of preparation

- The whole plant (excluding roots) is cut into small pieces.
- 1 kg of cut plant is mixed with 4 litres of water and placed in a mud pot.
- This is boiled and reduced to 1 litre.

Filtering the decoction

Use

On cooling, 500 ml of this extract is mixed with 100 ml of soap solution and 9.4 litres of water and sprayed on the crop (measurement for one tank)

Frequency of use

Use the mixture once a week if the disease is at the early stages. If the disease has spread and in later stages, use the mixture once in two days, during the morning and evening sessions.

Plant based Bio Pesticide

Sida spinosa decoction 5%
Kottikan Bebila (S)

This plant based bio-pesticide mixture is used to control the following pests who suck the sap from leaves or buds of crop plants.

Pest	Crop
Aphids Aphids are very tiny insects, green or light yellow or black in colour. They are found in clusters around the tips of new leaves or buds. They suck the sap from the tips of young leaves and buds. This causes deformation of the plants. 	Papaya, Citrus, Groundnut, Sugar Cane, Beans, Cabbage, Cucumber, Melon, Peas, Potato, Pumpkin, Squash and Tomato.
Green plant hopper The nymphs and adults suck the plant sap from the leaves and cause curling of the leaves. Downward curling as well as upward curling is observed. The affected leaves start drying up and the vigour of the plant is reduced.	Ladies Fingers, Brinjal, Potato and Rice
Mealy bugs These are soft-bodied bugs fund as a cluster, covered with white wax. They are present on the lower side of the plant. Nymphs and adults suck the sap and cause yellowing and drying of leaves.	Citrus, Sugar Cane, Grapes, Pineapple, Coffee trees, Cassava, Papaya, Mulberry, Sunflower and Orchids.

	*White flies* Adults are tiny and moth like with a white body including wings that are covered with a white waxy bloom. Nymphs are oval, scale like and greenish white. On hatching, nymphs' start sucking the sap of the leaf and affected plants become yellow, leaves wrinkle, curl downwards and are shed.	Tomatoes, Beans, Cassava, Cotton, Cucurbits, Potatoes, Sweet Potatoes

Sida spinosa decoction 5% 1 kg
Water 4 litres
Soap mixed water 100 ml
(Sunlight soap)

Cutting Sida, Ranjithamalar's group, Central Camp

Method

The whole plant is taken excluding roots and cut into small pieces. 1 kg of this is mixed with 4 litres of water and placed in a mud pot. This is boiled and reduced to 1 litre.

Decoction on the boil……

Use

On cooling, 500 ml of this extract is mixed with 100 ml of soap solution and 9.4 litres of water and sprayed on the crop (measurement for one tank).

Frequency of use

Use the mixture once a week if the disease is at the early stages. If the disease has spread and is in its advanced stage, use the mixture once every two days in the morning. Water plants in the evening.

Bio Pesticide

Garlic, Ginger, Green Chillie Mixture

This mixture is a broad spectrum control device for the following pests that have already been described in the recipes for plant-based decoctions of *Andrographis paniculata* and *Sida spinosa.*

Shoot Borer
Fruit Borer
Stem Borer
Hairy caterpillar
Army worm
Aphids
Green plant Hopper
Mealy bug
White Fly

Mealy bugs

Items required

Garlic	18 g (outer cover peeled)
Ginger	9 g (cleaned)
Green Chillies	9g (stems removed)
Water	1 litre
Soap mixed water	100 ml (Sunlight soap)
Muslin cloth	

Mixing all of the ground ingredients together

Method

Each of the 3 ingredients, Garlic, Ginger and Green Chillies should be ground separately. The paste of each of the ingredients should be mixed thereafter. Then add 1 litre of water to the mixed paste, mix well and strain using muslin cloth. Store this solution in a 1 L (1000 ml) plastic bottle.

Measuring the soap solution

Adding water and storing the concentrate

Green plant hopper

Use

Mix 500 ml (½ the bottle) of the mixed solution (Garlic, Ginger and Green Chillies) with 100 ml of soap mixed water and add 9.4 litres of water. Mix the solution well and spray to the plants where the whole plant should be moistened.

Frequency of use

Use the mixture once a week if the disease is at the early stages. If the disease has spread use the mixture once in two days. Spray the mixture in the morning and water plants in the evening.

Mixing cow dung extract

Bio Pesticide
Cow dung extract

Cow dung extract is used in the control of the following pests.

Pest	Crop
Leaf beetle (Pumpkin beetle)  Leaf beetles are found throughout the country and prefer cucurbitaceous vegetables. Adult beetles have yellowish brown to yellowish red wings. They feed voraciously on the leaf and flowers by making irregular holes. Young seedlings may be killed.	Gourds, Pumpkin and Melons
Pod sucking bug Adults are brown or black. They suck the sap from the developing seeds through the pod wall. Pods show yellow patches on feeding sides; seeds shrivel and loose germination capacity. 	Long bean, Soybean, Green Gram and Pigeon Pea (Thoor dhal)
 *Epilachna* beetle They are common throughout Asia. Adults are spherical, pale yellowish brown mottled with black spots. Both adults and grubs scrape the chlorophyll from the leaves leaving the veins and veinlets to form ladder like windows.	Bitter gourd, Bottle Gourd, Potato, Tomato and Brinjal 

Items required

Cow dung	1 kg
Water	10 litres
Barrel	1
Gunny cloth	

Method

Take 1 kg of cowdung and mix it with 10 litres of water. Filter the extract with a gunny cloth. Add 5 litres of water to filtrate and filter again with the same cloth. The filtrate will be a clear solution. Spray filtrate on plants.

Use

Use the mixture once a week if the disease is in its early stages. If the disease has spread, use the mixture once every two days. Spray the mixture in the morning and water the plants in the evening.

Fungicides

Cow's Urine / Cow's Urine and buttermilk solutions

Cow's urine/ Cow's Urine and buttermilk solutions are used when crops suffer from fungal diseases as well as some viruses as described below.

Disease	Crop
Wilt Wilt is a dreadful disease of tomato and occurs in places where Tomato is grown continuously. Clearing of the veinlets occurs. The leaves lose their green colour and become pale yellow or white. Soon the petiole and leaves droop and wilt. The younger leaves may die in succession and the entire plant wilts and dies in the course of a few days. A fungus that survives in the soil causes this. Crop rotation with non-*solanaceous* crops and ploughing in the dry season reduces the incidence of this disease. Avoid using any *solanaceous* crop (Potato, Tomato, Chillies, Brinjal) in the rotation. Rotate with Ladies Fingers, Maize or cereals and grasses wherever possible. 	Tomatoes, Chillies, Brinjals, Potatoes
Fusarium wilt Generally, this fungal disease appears in localized areas of the field. The symptoms are an initial yellowing of the foliage and wilting of the upper leaves. This progresses in to a permanent wilt (with the leaves still attached) in a period of a few days. High temperatures and wet soil conditions favour disease development. It mainly occurs in poorly drained areas of the field. 	Chillies, Tomatoes, Potatoes
 **Cercospora leaf spot disease** This fungal disease attacks all vegetable crops. Irregular grayish brown spots appear on the upper surface of the leaf. The numbers of spots increase gradually covering the entire leaf surface. Young leaves wither due to the disease. Spots also appear on the pods of Field Bean and Cowpea etc., It ultimately affects crop yield.	Beans and Cowpea

***Alternaria* leaf spot disease** This is a common fungal disease among all vegetables. Small circular spots appear on the surface of the leaves. The spots coalesce together and become brown. Later, the leaves wither and are shed from the plants. It also affects fruits. Circular spots appear on the surface resulting in rooting symptoms.		Cabbage, Cauliflower, Mustard, Tomato, Cucurbits and most vegetables
	**Fruit rot** This is a fungal disease. Water soaked, dark green lesions appear on the upper surface of fruits. The spotted region gradually begins to decay. The affected fruit shows a white layer on the upper surface. Sometimes, this disease appears at the flowering stage itself.	All vegetables and fruits
Yellow Mosaic virus Affected plants show prominent light and dark green patches on the surface of leaves. Yellowish specks and mottling are also observed. This viral disease attacks all varieties of vegetables. The early symptom is vein clearing. The stem becomes short and the plant remains stunted. The White Fly transmits the virus.		Legumes - Mung bean, *Cajanus cajan;* Ladies Fingers Cucurbits - Cucumber, Squash, Water Melon, etc

Items required

a) Cow's urine solution

Cow's urine 1 litre
Water 9 litres

Cow's Urine

b) Cow's Urine and buttermilk solution

Cow's urine 1/2 litre
Sour Buttermilk 1/2 litre
Water 9 litres

Muslin cloth for filtering

Old curd

Filtering the solution of Urine and buttermilk

Method and frequency

a) 10% Cow's urine solution is sprayed once in 7 days.
b) ½ litre cow's urine along with ½ litre sour buttermilk or old curd is mixed with 9 litres of water. This is sprayed once in 7 days.

Distributing cow's urine solution to farmers in Central Camp

Other uses

For seeds or roots of seedlings, soak in mixture of Cow's urine and water (that is mixed in ratio of 1:2) for half an hour before sowing or transplanting.

If there is a disease attack in the seed nursery, add 10% cow's urine extract along with the water that is used to irrigate the nursery.

For fungal diseases, fumigation combined with the above methods produces better results.

Pest Control Methods using Neem

Neem is a well-known botanical pesticide based on the use of the Neem seed kernel. It is an excellent broad spectrum pesticide for the control of Aphids, White flies, Beetles, Caterpillars, Cutworms, Shoot and Fruit Borers in the cultivation of rice, vegetables, pulses, millets, fruit trees, sugar cane and on tea plantations.

a) Neem kernel Extract

Items required

Neem kernel 3–5 kg
Water 10 litres
Soap (Sunlight) solution 10 ml/litre or 100 ml/tank
Cotton cloth

Neem Seeds

Neem Seed Kernels

Filtering Neem seed kernel extract

Method

Remove the outer seed coat and use only the kernel of the Neem seed. 3–5 kg of Neem seed kernel is required for an acre. If the seeds are fresh, 3 kg of kernel is sufficient. If the seeds are old, 5 kg are required. Pound the kernel gently and tie it loosely with a cotton cloth. Soak this overnight in a vessel containing 10 litres of water. After this, it is filtered. On filtering, 6–7 litres of extract can be obtained.

Use

500 – 1000 ml of this extract is used for one tank (10litres capacity) that should be diluted with 9 ½ or 9 litres of water before spraying.

10 ml/litre or 100 ml/tank of soap (sunlight) solution should be added to help the extract stick well on to the leaf surface. The concentration of the extract can be increased or decreased depending on the intensity of the pest attack.

b) Neem leaf extract

Filtering Neem leaf extract

Items required

Neem leaves	10 – 12 kg
Water	20 – 24 litres
Soap (Sunlight) solution or 100 ml/tank	10 ml/litre
Cotton cloth	

Neem Tree – Azadirachta indica

Method

10 – 12 kg of Neem leaves are required for use in an acre of land. Pound the leaves gently and tie it loosely with a cotton cloth. Soak this overnight in a vessel containing 20 – 24 litres of water. After this, it is filtered. On filtering, 15 – 17 litres of extract can be obtained.

Use

About 500 – 1000 ml of this extract is used for one tank (10 litre capacity) that should be diluted with 9 ½ or 9 litres of water before spraying.

10 ml/litre (100 ml/tank) of soap (Sunlight) solution should be added to help the extract stick well to the leaf surface. The concentration of the extract can be increased or decreased depending on the intensity of the pest attack. The shelf life of this extract is one month.

Neem cake

The soap should soak overnight in water in order that the solution is sticky and thick in nature.

c) Neem as pest repellent

Take Neem leaves, Neem cake or Neem kernel. Pound it well and place in a pot. Add twice the volume of water and tie the mouth of the pot with a cloth. Leave it as such for 3 days. Then, place the pots on all 4 corners of a field. In the evening open the mouth of the pots. The foul smell emanating from the Neem products prevents entry of pests into the field.

d) Neem Cake for pest control and manuring

Place gunny bags filled with Neem cake along water canals. Neem cake dissolves in the water flowing along the canals and this water irrigates the field. This practice prevents the attack of pest and diseases affecting the roots and tillers of the crop. This bag should be replaced once in 15 days.

THINGS TO REMEMBER...

Neem Fruit Collection

The Neem tree yields fruits during May to August every year. The ripened fruits must be collected for processing by covering the ground below the tree with a cloth since fungi attack the carbohydrate-rich Neem fruits when they came in contact with soil. Such fruits may get infected with toxin and develop fungus that may damage the quality of the final products prepared from these fruits. Hence it is strongly recommended to avoid contact with soil. As the fruit ripens during the rainy season they must be de-pulped as early as possible. Avoid storage of fresh, wet fruits in plastic bags. Use bamboo baskets or gunny bags for storage.

Other biological pesticides

Plant	Part used and Pests controlled	Method of preparation
Tobacco	Leaf extract and oil acts as a repellent	Crush leaves in water, boil and extract
Tulsi	Repels insects, mosquitoes and snakes. Aqueous leaf extract prevents Leaf minor in Potato, Brinjal, Tomato, Chilli, Mustard and Onions	Crush leaves in water and extract
Pongam	Pongam oil has insecticidal and bactericidal properties and effective against many pests on all crops. Oil emulsion used as disinfectant and insecticide.	Oil directly used or as emulsion sprayed.
Marigold	Excellent nematode repellent. Crushed roots or root extract controls root rot, nematodes and brown rust in paddy and ornamental plants	Crush roots and leaves in water and extract.
Mee (*Madhuca longifolia*)	Mee oil prevents stem and root rot in Groundnut and Potato. Leaf extract effective.	Spray 3% emulsion in water.
Fenugreek	Fresh leaf extract effective against many agricultural pests.	Crush fresh leaves in water, boil and extract. Filtrate a pesticide.
Red Onion	Dust effective against fungal diseases and pests in Rice and fruit trees. When sprayed prevents leaf curl, powdery mildew and other funguses.	Clean bulbs and grind to powder. For extract crush bulbs in water, filter and spray.
Custard apple	Seed and leaf extract spray repels Diamond-back moth, Pod borer in Brinjal and Rice.	25 g seed or leaf extract in 1litre water used as foliar spray.
Datura	Leaf extract is an antifungal agent	Powdered dry leaf used as dust to

	effective against brown rust in rice. Good storage pesticide in grains.	prevent rust attack. Leaf extract in water is used as a spray. 10 g leaf dust per kg checks incidence of storage pests in grains.
Tea	Dried spent tea leaves used as manure/insecticide for rose plants	Grind dry spent leaves to powder and mix with soil.
Castor	Castor oil and oil cake repels weevil, aphids and caterpillars in Maize and other crops. Oil Cake a good manure	Mix castor oil with water to make emulsion and apply as spray.
Drumstick	Root and leaf extract an effective bactericide. Controls root rot in vegetables, fruits and ornamental plants	Crush fresh roots and leaves in water and boil for 5 – 10 minutes. Filter and apply
Fennel	Leaf extract repels many pests on vegetables and ornamental plants	Crush partly dried leaves and plants in water and boil to make strong tea. Filtrate used as pesticide.
Kankun	Leaf extract or dust effective against white fly, Sheath rot, Brown rust and burn spots for Paddy and Cotton	Grind dried leaves for dust. Leaf extract with water at 5-10% dilution can be sprayed.
Jatropha	Leaf extract effective against many pests in all crops. Oil cake is an excellent manure and insect repellent.	Fresh leaves are crushed in water, boiled and extracted.
Chrysanthemum	Aphids, White fly, Spider Mite, Mealy bugs	Make a strong tea using 500 g of fresh flowers and 4 litres of water. Cool, filter, add equal amount of water and 30 ml liquid soap and spray.
Beli	Leaf and fruit extract repels range of leaf eating and sucking insects.	Crush fresh leaves and fruits, boil and filter. Use as spray.
Lantana	Leaf extract effective against Leaf minor in Brinjal, Tomato, Chillie and Onion	Crush fresh leaves in water, filter and spray
Turmeric	Turmeric powder is a good storage pesticide. Its rhizome dust prevents root rot in paddy and vegetable crops.	Dried rhizome is ground to a fine powder.

Reference: Chandra K., Srivastha R.S.H., Greep S. and, S.R. (2004), Biofertilizer, Ready Reckoner Vision 2004, pp 42, RCOF, Bangalore, India

From left to right: Turmeric, Tea, Red Onion and Pongam – some other bio control agents

CHAPTER 7
Adding Value to your garden

Waste Management

Waste, if unmanaged emits green house gases like methane or carbon di oxide into the atmosphere. Green house gases are responsible for global warming that in turn is a primary cause for climate change.

Maize refuse insulates compost heap

On the other hand, waste, if managed could add value to your garden.

The waste generated from a farm garden takes many forms: sewage, waste or grey water and solid waste.

Sewage is managed through the construction of toilets. If there is no sanitation in your homestead this means that people have to answer the call of nature in the open causing a health risk.

Waste or grey water refers to the water that drains from the bath area, around a well, kitchen or after washing vegetables. If your homestead has no drains or if the drainage network in your farm garden is damaged or blocked with silt and leaf litter there is stagnation of water in many places. These stagnant pools are ideal breeding places for mosquitoes and are a cause for concern.

Waste water from the well bathing area being channeled towards a soak pit

Separation and collection of recyclable waste

Solid waste refers to degradable (kitchen, paper and crop) and non-degradable waste (polythene, glass, metal, etc.)

Chapter 3 described the construction of drains in your garden for the passage of rainwater.

Grey water is best managed through the construction of soak pits that filter it before it enters the main drainage network. You could also establish plants like Sweet flag (wada kaha), *Areca* (puwak*)* and *Pandanus* (rampe) around the soak pits to initiate bioremediation. If your farm garden is located next to a stream, riparian vegetation can be planted on one or either side of the banks.

In a farm garden the management of solid waste gains importance since much of it is degradable, crop waste. Do not burn organic waste since this releases carbon into the atmosphere. Instead, convert into compost. One can construct a compost basket or use it in pile compost (described in *Chapter 5*).

Non-degradable waste: polythene, glass and metal could be separated and stored in bags. The Central Environmental Authority has initiated a project using the network of Pradeshiya Sabhas in each Divisional Secretariat area to collect recyclable waste that is then sold to their agents located island wide.

Saving seed and collecting plant cuttings

Good seed and healthy plant cuttings are essential for problem free cultivation.

SEED

In order to acquire good quality seed, one should:

- Select a healthy plant.
- Select a plant that yields a large harvest.
- Select a seedling that is hardy and strong in appearance.
- Collect seeds in the appropriate period.
- Collect seed from the 2nd round of seed bearing.

Chillies being dried to collect seed

Seed collection

Seeds of vegetables like Ladies Fingers, Ridge Gourd, Long Beans, Green Beans, Maize and Winged Bean must be collected whilst in their pods.

Seeds of Tomato, Brinjal, Pumpkin and Bitter Gourd should be washed in clean water, the pulp around the seed removed, washed again and dried in a moderate climate.

Seeds of medicinal plants like Lime, Nika, Neem and Pavetta are best kept mixed with their respective dried leaves that are in powdered form.

Seeds can also be stored in a clay pot with wood ash and dry newspaper

Application of Neem oil on seeds that are stored in an airtight container will preserve them. However, most seeds lose their viability if they are stored for long. In best conditions, seeds that are conserved should be used within one year.


Gliricidia cuttings

CUTTINGS

In order to acquire good quality cuttings, one should:

- Collect planting material in the morning around 9.00 a.m. after the dew has dried on the leaves.
- Take cuttings from mature mother plants.

How to store cuttings

To preserve their moisture content, cuttings should be wrapped in moistened paper or cotton wool.

Apiculture


Apis cerana

For ages, colonies of the honeybee *Apis cerana* have provided mankind with honey, beeswax, as well as performing the invaluable service of pollination. On a single trip, a worker bee may visit as many as several hundred flowers of the same species, flower fidelity being very useful in cross-pollination. Moreover, since a honeybee colony consists of several thousands of worker bees, the number of pollinators readily available is great indeed. The most important factor that contributes to the usefulness of honeybees as pollinators lies in the fact that honeybees are usually kept in man-made hives and can be moved by the beekeeper at any time to areas in need of pollinating insects.


Checking hive in Kalmunai

In tropical Asia, however, where the staple diet consists of grains from self or wind-pollinated plants, the value of honeybees as crop pollinators has received little attention. This is regrettable since many species of tropical fruit trees, vegetables, oilseed crops, and nuts of economic importance can benefit from cross-pollination where yields can be improved both quantitatively and qualitatively through beekeeping. It is essential that agriculturists further explore these possibilities. However not all crops require or benefit by honeybee visits. Hence prior knowledge of the pollination requirements of crops is essential before making arrangements to obtain bees for pollination services.

The effectiveness of honeybees in crop pollination depends on many factors, such as the location of the hives, the attractiveness of flowers to bees and their behaviour in approaching flowers. Only strong colonies should be used in open field pollination.

Clay pot hive mounted on tree
R.W.K. Punchihewa, 2011

Though two-storey, hives are popular and need to be placed on stands, colonies of *Apis cerana* can also be kept in traditional, clay pot hives. It is important that the number of colonies needed per unit area be assessed in advance, for maximum efficiency. This number will vary according to the crop that needs pollination. For example, many fruit crops require several strong hives per hectare. To ensure that a large proportion of the flowers are visited, the bees should be moved to the area as soon as or before blossoming begins.

A number of factors can limit the efficiency of bees as pollinators: competition from nearby flowering plants, such as weeds; colony weaknesses brought about by the effects of pesticides, bee diseases and mismanagement during the pollen flow and the effects of poor weather. All these factors could prevent the movement of bees. Special emphasis should be placed on the danger of pesticides; while colonies of bees are in the field for pollination, toxic pesticides must not be used in the area, and in this regard, cooperation between growers and beekeepers is of the utmost importance.

Participatory Guarantee Systems of Certification

Today, you as a farmer who is producing a poison free crop and helping the environment **is able** to gain recognition for your efforts.

This is possible through the adoption of Participatory Guarantee Systems (PGS) that are locally focused, quality assurance systems. They certify producers based on the active participation of stakeholders. They are built on a foundation of trust, social networks and knowledge exchange.

PGS represents an alternative to conventional third party certification and is adapted to local markets and short supply chains. They enable the direct participation of producers, consumers and other stakeholders in the:

1. Choice and definition of the standards for organic cultivation
2. Development and implementation of verification procedures
3. Review and decision process to recognize farmers as organic

Participatory Guarantee Systems share a common objective with third-party certification systems in providing a credible guarantee for consumers seeking organic products. The difference is in the path to accomplish this. Third party

certification is based on reviews of applications, that include operator internal procedures such as organic system plans and annual visits for inspection by a trained independent inspector.

On the other hand, Participatory Guarantee Systems have a much more intensive interaction between the farmer and the guarantee organization and use different tools to maintain integrity.

PGS integrates capacity building and allow farmers and reviewers to help solve practical problems that will enable producers to follow organic standards. The direct relationship to the process, and the fact that it is owned by the farmers and related stakeholders, encourages more responsibility and active involvement in the design of production and certification processes. PGS offers the following benefits:

- Improved access to organic markets through a guarantee system for small-scale producers: in PGS, costs are mostly in the form of voluntary time involvement rather than financial cash expenses. Moreover, paperwork is reduced, making it more accessible to small operators.
- Increased education and awareness among consumers: by involving organic consumers in the review process, PGS help build a base of engaged and knowledgeable consumers who understand the benefits and challenges of organic production.
- Promote short supply chains and local market development.
- Empowerment: PGS are grassroots, non-profit, bottom-up organizations. Empowerment comes from the democratic structures of PGS and the fact that in PGS, the communities (producers and consumers) have the ownership of the conformity assessment system. It reinforces social capital and builds collective responsibility and capacity.

If you are interested in PGS, the first thing to do is to form a group with other farmers in your immediate area. Then one farmer must take leadership and others be selected to operate and monitor an internal control procedure where each farmer becomes equally responsible for product integrity. In addition, the volume of produce cultivated will justify the journey for collection and marketing.

Shantha Malar's Group

Ranjitha Malar's Group

Ranjitha Malar's group and Shanta Malar's group intend to obtain Participatory Guarantee Certification

Conclusion

Hopefully you are now keen to try regenerative agriculture. You may need to refer to the Manual from time to time as you go along. It will take some time to relate what you have just learnt with soil preparation, planting, cultivating and harvesting your crops. From our experience we have found that in terms of:

Productivity

- Organic fields produce just as much as conventional fields if the biological fertilisers described are used in the prescribed manner.
- While conventional farmers need to use more and more powerful chemicals to battle pests and diseases, organic farmers hold their own since their crops have developed greater resistance.
- Organic farms continued to be productive in the face of drought since they use compost that increases organic matter in soils. This results in more water being retained. Further the adoption of water conservation methods like mulching increases their resilience to drought conditions.
- With increased levels of biodiversity including mychorrhizal fungi, soils are able to uptake a greater proportion of mineral nutrients, e.g. phosphorous.

Jane Nona's 9 year farm garden on Maragalakanda

Economics

- Regenerative agriculture is significantly more profitable as the cost of production is low using inputs from your own land. Even if your produce is sold at the same price as that from conventional agriculture, you still earn more money because production costs are lower.
- The inclusion of diverse, tree and annual crops will enable you to obtain income from different crops throughout the year eliminating the risk from depending on only one or two crops.

Energy

- Energy consumption will decrease since you will spend less money on transport, as most of the inputs will be sourced from your garden or from the village that you live in.
- Your use of non fossil fuel based, biological fertilisers will decrease your energy consumption.

Human health

- Conventional agriculture relies heavily on chemical pesticides (herbicides, insecticides, fungicides, etc.) many of which are toxic to humans and animals. Numerous studies have shown how even low-level exposure to chemical pesticides and fertilisers are a threat to health. Such toxins are often not recognized in the water we drink, the food we eat and the air we breathe. For instance, water in wells in the Kalpitiya Peninsula have nitrate levels that are higher than those recommended by the World Health Organisation. We also know that pesticide residues have been found in breast milk and umbilical cord blood.

Drinking water that has been bioremediated

- Such dangers can be avoided through the practice of regenerative agriculture. Further, techniques like bioremediation that involves the planting of trees and shrubs around water sources acts as a buffer that removes dangerous concentrations of chemicals that threaten health.

Climate Change mitigation and adaptation

Leaf litter on a regenerated soil….

- Since you do not use nitrogen based, chemical fertilisers like Urea the emission of nitrous oxide (a green house gas) will be minimal. Further, the practice of composting all animal and other degradable wastes will reduce the generation of methane that is another green house gas.

- In addition, your use of trees in the landscape design will serve to sequester carbon as lignified tissue. The inclusion of organic matter in soils will increase biomass and lock carbon as soil carbon. The management of organic waste will further reduce your carbon footprint. All of these will contribute to reducing the impact of climate change even in a very small way.

If we want to engage in a truly sustainable agriculture, one that will feed our families with healthy food, increase the money we get in our hand and keep our land arable into the future, we must focus on the basics—soil health and water quality.

We must improve upon these natural resources in order that we return or regenerate as much or more than we take. By building and improving soil health through the use of organic practices, by increasing crop diversity and tree dominant vegetation in our farm gardens we can encourage biodiversity and ensure the sustainability of our land indefinitely.

Annexure 1

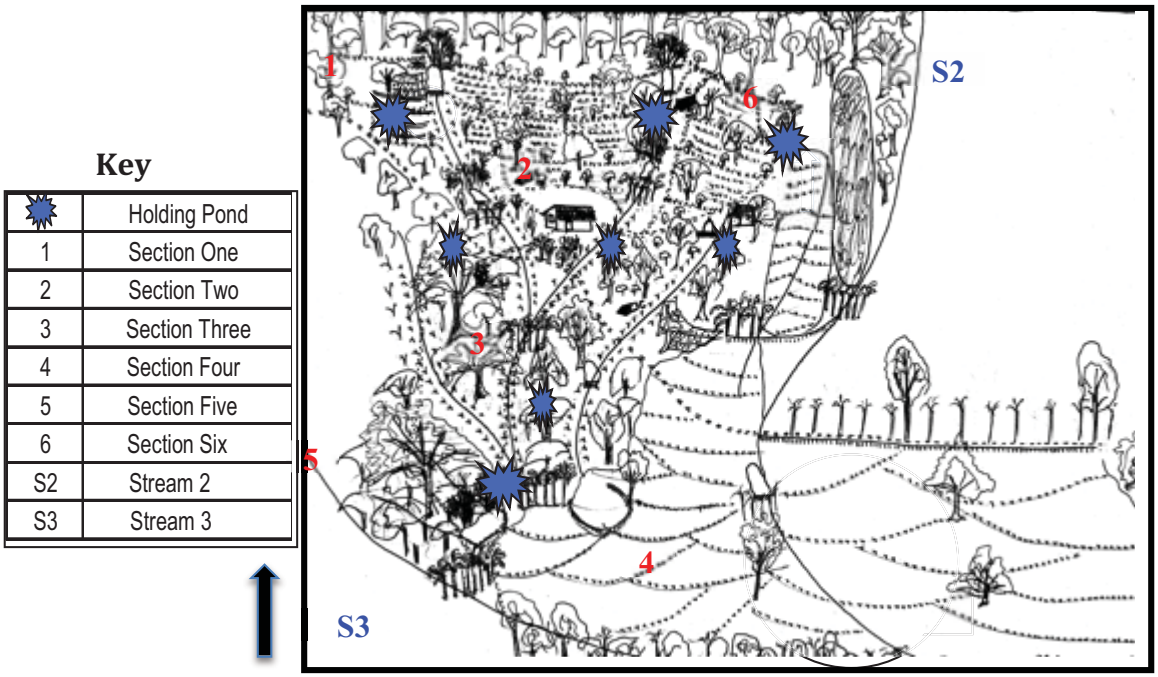
Designing landscapes of farm gardens for hilly regions of the Moneragala District

Jane Nona has 8 acres of land in the Aliyawatte area of Maragalakanda in the Moneragala District. This area is located on the tallest mountain in the range. In 2000, her farmland was bereft of any tree cover and had no shade. The land was bordered on two sides by secondary forest. There was no water source on the land but only three 'dead' gullies. Few animals and birds were seen. Two major streams, S2 and S3 ran proximal to the land.

The farmer used to cut down the forest every year during the time of the North East monsoon to cultivate her chena[1] since this was her only source of income. Her annual income in 2000/2001 did not exceed Rs. 7000.00! She has 5 children and could only afford to send her eldest child to school.

In 2001, NSRC initiated the ecological restoration of Jane Nona's land. The landscape design of Jane Nona's garden was drawn up that divided the land into 6 zones or sections on the basis of the physical features and the drainage pattern. Map 3 displays the overall zonation. The species used to landscape each of the zones are detailed below.

Map 4 - Landscape Design of Jane Nona's garden



Section 1:Buffer zone
Describes the border of the land that adjoins a small patch of disturbed natural forest. This area was planted using native species from the forest itself. Trees like Satinwood (*Chloroxylon swietenia*), Ebony *(Diospyros ebeneum),* Mora *(Dimocarpus*

[1] *Swidden agriculture*

longans,), Riti *(Antiaris toxicaria)* and Hama *(Tetrameles nudiflora)* were some of the species used.

Section 2: This is the main agricultural production area in the garden. Soil conservation practices like the planting of hedgerows and the digging of contour drains were engaged in. Further since there was no water source, water was diverted from the marsh area above the garden to feed a canal using the same flow pathways as the dead streams and networked through a series of holding ponds that were dug to store water. The ponds served to increase the holding capacity of water in the garden and since they were gley lined (made of organic matter and clay), they provided a good medium for the breeding of fresh water fish. Water from these ponds slowly seeped out into the surrounding soils and percolated into the ground thus re-charging the dormant aquifers.

The easy availability of water for agriculture resulted in the increase in the farmer's capacity to grow more crops and thereby increase her income. A vast array of crops was cultivated that Jane Nona did not grow before. The crops included both annual and tree crops that served a multitude of utility purposes. All the dry zone vegetable crops were grown using only organic regimes of cultivation that served to generate income in the short term. The farmer's family consumes a large portion of the vegetables and this enhances nutritional diversity whilst reducing expenditure. The perennial crops cultivated are:

For Food

Pepper - *Piper nigrum*

Pineapple (*Ananas comosus),* Passion fruit (*Passiflora edulis),* Goraka (*Garcinia quaesita),* Tamarind (*Tamarindus indica),* Mango (*Mangifera indica),* Papaya (*Carica papaya),* Rambutan (*Nephelium lappaceum),* Ice Cream Bean (*Inga diversifolia*), Coffee (*Coffea robusta),* Jak (*Artocarpus heterophyllus),* Breadfruit (*Artocarpus altilis*), Cinnamon (*Cinnamomum verum)* Cashew (*Anacardium occidentale),* Ceylon Olive (*Elaeocarpus serratus),* Custard Apple (*Annona reticulata),* Cocoa (*Theobroma cacao),* Ginger (*Zingiber officinale),* Cardamom (*Elettaria cardamomum),* Turmeric (*Curcuma domestica),* Pepper (*Piper nigrum),* Coconut (*Cocos nucifera),* Gal Siyambala (*Dialium ovoideum),* Pomegranate (*Punica granatum),* Kitul (*Caryota urens),* Katurumurunga (*Sesbania grandiflora),* Wild Date (*Phoenix farinifera),* Lime (*Citrus x aurantiifolia),* Orange (*Citrus sinensis*), Mandarin (*Citrus reticulata),* Pomelo *(Citrus grandis),* Uguressa (*Flacourtia indica),* Beli (*Aegle marmelos),* Wood apple (*Limonia acidissima),* Sapodilla (*Achras zapota)* and Jam fruit (*Muntingia calabura*).

For Medicine*:*

Pavatta (*Pavetta indica)*, Aloe (*Aloe vera),* Niyandha (*Sansevieria zeylanica),* Akkapanna, (*Kalanchoe pinnata)*, Tippili (*Piper longum),* Bin Kohomba *(Munronia pumila*), Lemon grass (*Cymbopogon citratus),* Nelli (*Phyllanthus emblica),* Bulu

(*Terminalia bellerica),* Aralu (*Terminalia chebula),* Himbutu (*Salacia reticulata)* and Arecanut (*Areca catechu).*

***Ornamental Plants**:*
Anthurium, Heliconia sp., Orchids, Kahakona (*Cassia spectabilis)*, African Tulip Tree (*Spathodea campanulata),* Tabobia (*Tabebuia rosea)* and Murutha (*Lagerstroemia speciosa).*

***Hedgerows and Soil Conservation**:*
Gliricidia *(Gliricidia sepium)*, Erythrina (*Erythrina lithosperma*), Pavatta (*Pavetta indica)*, Shoe flower (*Hibiscus sp*.), Vettiver (*Vetiver zizanoides*) and Lemon grass (*Cymbopogon citratus).*

Section 3: **Riparian areas that include dead gullies and ponds**
Species like Kumbuk (*Terminalia arjuna),* Mee (*Madhuca longifolia),* Munamal (*Mimusops elengi),* Malaboda (*Myristica dactyloides),* Eriya (*Horsefieldia eriya)*, Keena (*Calophyllum sp*.), Arecanut (*Areca catechu),* Kitul (*Caryota urens), Karanda* (*Pongamia pinnata),* Damba *(Syzygium assimile)*, Etamba (*Mangifera zeylanica),* Godapara *(Dillenia retusa),* Bakini (*Nauclea orientalis)*, Kotadimbula (*Ficus hispida),* Attika (*Ficus racemosa),*

Kokatiya (*Garcinia terpnophylla),* Goraka *(Garcinia quaesita),* Mangosteen *(Garcinia mangostana),* Yellow bamboo (*Bambusa vulgaris*), Wetakeiiya (*Pandanus kaiida)* and Nelu (*Strobilanthes sp*.)

Filter plants were used around ponds including:
Rampe (Pandanus amaryllifolius), Maha Aratta (*Alpinia zerumbet),* Heen Aratta (*Alpinia calcarata),* Pinna *(Clerodendrum chinense), Kohila* (*Lasia spinosa*), Sweetflag (*Acorus calamus*), Wal Anthurium (*Spathyphyllum pattini),* Thebu (*Costus speciosus)* and Diyaberanilla (*Jussueia repens)*.

Section 4: **Paddy field**
Traditional rice varieties -Kaluheenati, Suwandel and Rathdel were grown in the paddy fields using the 'Nawa Kekulama' method of cultivation. Traditional methods of pest management together with the re-creation of habitat for predators of rice pests were engaged in. Hedgerows were planted on the bunds using species

like Gliricidia (*Gliricidia sepium), Keppetiya* (*Croton laciferus),* and Pavatta *(Pavetta indica)* while trees like Mee (*Madhuca longifolia),* wetland species like Divikaduru (*Pagiantha dichotoma)* and Godapara (*Dillenia retusa)* were planted in and around the 'kamatha' (threshing floor).

Section 5: This area is downstream of Jane Nona's garden where ornamental trees like Flamboyant (*Delonix regia*), Tabobia (*Tabebuia rosea*) and Kahakona (*Cassia spectabilis)* were some of the species that were planted along the canal bunds that ran through the downstream 'walk' area. This area was to be developed into a potential ecotourist trail.

Section 6: Rocks

Maragala means literally 'big rock'. This very rocky area was planted with fast growing trees, vines and succulents in order to establish a cover over them. A rock that is exposed absorbs heat quickly whereas a rock that is covered with dense vegetation cools and becomes a repository for moisture. Trees like Kotadimbula (*Ficus hispida),* Mara (*Samanea saman)* Tamarind (*Tamarindus indica)*, Ketakela (*Bridelia retusa)* climbers such as Potawel (*Pothos scandens),* TitthaWel (*Anamirta cocculus),* Wewal (*Calamus rotang),* Passion fruit (*Passiflora edulis)* and succulents such as Aloe *(Aloe vera),* Niyandha (*Sansevieria zeylanica)* and Akkapana *(Kalanchoe pinnata)* were planted in between crevices of rocks.

Jane derives maximum income from harvesting pepper

Vegetable beds on the contour

Kokatiya (Garcinia terpnophylla)

Annexure 2

CONTACT DETAILS OF SUPPLIERS OF CONVENTIONAL AND ORGANIC VEGETABLE SEED, YAMS, TUBERS AND RHIZOMES

No.	Name and Organization
	Conventional Seed
1	Agriculture Department, Seed Centre, Gannoruwa
2	Rajgopal, Eastern Agro Farm & Seed House, Batticaloa
3	Isaac Stephen, Ceylon Agro Development Co. Ltd, Ratmalana
	Organic and Traditional Seed
4	K.M. Bandara Manike , Irrigation Road, Mahakalugolla , Siyambalanduwa
5	W.M. Gunasena, Welkatuwa, Mahakalugolla, Siyambalanduwa
6	M.H. Piyaratne, Welkatuwa, Mahakalugolla, Siyambalanduwa
7	Pathiraja Wijekoon, Chairman, Lanka Govi Sansadaya, Galkiriyagama, Anuradhapura
8	Yasapala, Chairman, Lanka Govi Sansadaya, Girandurukotte
9	K.M. Jayawardena, Udumulla, Dambawella
10	H.M. Bandara Meeyagolla, Dambagolla
11	R.M. Premadasa, Govipala, Nelumgama, Badulla
12	R. M. Gnanawathie, Madawankada, Ilukthenna, Badulla
13	U.B. Ratnayake, Kesel Sevena, Ilukthenna, Badulla
14	Nirmali Jayanthi, Pitapola Junction, Ridipana, Badulla
15	Indrani Dissanayaka, Pitapola Junction, Ridipana, Badulla
16	Thanasha Nilmini, Pitapola Junction, Ridipana, Badulla
17	Suwashakthi Sanwardena Sansadaya, 47th Mile Post, Dehigolla, Mahiyangana
18	W.M. Wasantha Kumara, Karanda, Galaba, Badalkumbura
19	Premalatha, Uva Wellassa Kantha Sanvidanaya, Handapanagala, Weherayaya
20	Nalin Hambantota, New Environmental Resources Alliance, Godawaya, Temple Road, Dehigahalanda, Ambalantota
21	Amara Gallage, Praja Surakeeme Madyasthanaya, Beheth Gabadawa Para Katchcheri Junction, Monaragala
22	Parisara Govipala, Meepitiya, Nawalapitiya
23	Soba Daham Govipala & Agri Fertilizer Centre, Sanasa Bank, Ukuwela
24	H.M. Ariyasena, Uhana, Ampara
25	Shakthi Saamuhika Sanvidanaya, Meegahayaya, Badalkumbura
26	Arunalu Saamuhika Sanvidanaya, Katugahagalge, Badalkumbura
27	J.M. Jayasekera, 49th Mile post, Beligalla, Padiyathalawa Road, Mahiyangana
28	J.M. Kularatne, Bimmalamulla, Kakulana, Mahiyangana
29	Damayanthi Godamulla, Community Development Centre, Nikapitiya, Heleswatta, Attapitiya, Ussapitiya
30	National Federation Conservation of Traditional, Seeds & Agro -Resource 10, Pragathi Mawatha, Homagama
31	Mihimaw Science Foundation, 10T, Horathuduwa Road, Polgasowita
32	Mihithala Mithuro Environment Development Foundation, 4th Lane, Pinnakolawaththa, Gonapola Junction
33	Saruketha Movement Galabadayawaeheha, Mathugama
34	Sabaragamuwa People's Foundation, Old Rest House Road, Ratnapura
35	Siyath Foundation, 42/9, Rosmead Place, Colombo 7
36	Biodiversity Reaserch Information & Training Center (BRIT), 4/A, Water Tank Road, Hindagoda, Badulla
37	Community Development Centre, Kalavana Kanda Uda, Aranayake
38	Organic Coconut Growers Society, 163/6, Kumaranathunge Mawatha, Colombo 15
39	Ekabadda Praja Sanwardhana Kantha Maha Sangamaya, Weligepola, Balangoda

Annexure 3

CONTACT DETAILS OF NURSERIES FOR FOREST AND UTILITY SPECIES

No.	Name and Organization
1	H.L. Kulathunga, Nadee Chathura Plant Nursery, Koslanda
2	Prasanna Rajapakse, Munamalwatte Estate, 84, Dutugamunu Mawatha, Serukele
3	K. Ravichandra Das, Lemastota Estate, Dikkapitiya watte, Nikapotha
4	Sunethra Marasinghe, Human & Env. Development Foundation, Tangalla
5	A.A.G. Swarnalatha, Wedikumbura, Monaragala
6	K.M. Bandara Manike, Meekanda Pattiya Gedera, Mahakalugolla, Siyambalanduwa
7	H.M. Tikiri Banda, Mukalanyaya Road, Yakkala,Ibbagamuwa
8	Sameera Nuwan, Ranawiru Mawatha, Galketigama, Ibbagamuwa
9	R.A.P. Ratnayake, Arunodaya Nursery, Minuwangoda
10	Mr. K.M. Thushara Nuwan Wattegedera, Yapalla, Ibbagamuwa
11	Forest Department, Forest Nurseries in your area
12	Hadabima Nursery, Gannoruwa Road, Peradeniya
13	Coconut Cultivation Board, Ampara

Annexure 4

FOR ADVICE ON BEE KEEPING

1 Dr. Wasantha Punchihewa, ThiSaBee-Bee Technology

(A Beekeeping Development Initiative in Sri Lanka),

Tel: 011 2717642

Office: 15 Waidya Road, Dehiwala, Sri Lanka.

Workshop: 5/21 CWE Road, Homagama, Sri Lanka

Tel: 011 2855088

2 Mr. Ranjith Weerakkody and Mr. S.J.K. Kulasinghe,

Randuma Production, Bindunu Wewa, Bandarawela

Tel: 072 9075797 and 072 3889187

3 Agriculture Department, Bee Keeping Division, Bindunuwewa

Tel: 057 2222537

Mylwaganam's land in February 2011, at the start

Mylwaganam's land in February 2012, one year later

(Photo taken of the same view)

About the author……..

Kamal Melvani has been engaged in the restoration of watersheds from 1992. She is the Managing Director of the Neo Synthesis Research Centre that specializes in ecological restoration.

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