

# **Nature Farming**

*Integration of traditional knowledge systems with  
modern farming in rice*

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## PREFACE

The ecological farming in rice or Kekulama is an excellent example of indigenous knowledge (IK) in nature management schemes practiced in ancient Sri Lanka. However the modernization of rice farming which began with green revolution with the main objective of increasing the productivity for ever increasing population, IK of rice farming knowledge was discredited and disregarded.

The state of mind and behavior is often specific to farmers which are linked to their farming way of life, religion, the methods and goals. The system however evolves as traditions, fed by their religion, music and traditional believes.

The goals of indigenous farmers were clear and specific. It is definitely not maximizing yield by any means. It was not the agenda of traditional farmer. The goal was farming for their offspring's and for the mankind. The farming practices adopted or the objectives their in did not change whether the land he farmed was owned by him or rented (tenant farming). It was based on the concept derived from religion amply fed with generation old rituals and believes. The traditions and the rituals were the result of holistic approach for conservation of nature for the future generations. This demanded both sound concepts and skills.

The basic concepts of ecological farming, which is compiled here in this book as nature farming, considers the nature as a partner not as a competitor in farming and is sustained dominantly and go hand in hand with religion, believes and rituals. The Buddhist approach was to impart skill of nature farming to practitioner, the farming community from early childhood days, within the noble eight fold path presented by Buddha. However today's approach appears to be eclectic: "a catholic in views or taste" i.e. pick and choose from the various traditions whatever seems amenable to our needs, integrating different practices and techniques into a synthetic whole. "*The great spiritual traditions themselves do not propose their disciplines as independent techniques that may be excised from their settings and freely recombined to enhance the felt quality of our lives. They present them, rather, as part of an integral whole, of coherent vision regarding the fundamental nature of reality and the final goal of the spiritual quest. A spiritual tradition is not a shallow stream in which one can wet ones feet and then beat a quick retreat to the shore. It is a mighty tumultuous river which would rush through the entire landscape of one's life*" (Bhikku Bodhi, 2005, Noble eight fold path: Way to the end of suffering, page 3, BPS, Kandy, Sri Lanka).

Among the disciplines required to develop correct attitude and skill for Nature farming are the right livelihood and right action with specific and regular training in Loving Kindness inculcated from childhood.. Right action- Abstaining from the taking of life – of any

“sentient being” i.e. living being endowed with mind or consciousness; i.e. humans, animals and insects is pivotal to both Buddhist philosophy and the farming systems of the ancient Sri Lanka. The positive counterpart to this is the development of kindness and compassion for other beings. Right livelihood – one should acquire wealth without coercion or violence in ways which do not entail harm or suffering for others.

Right action and right livelihood guide the farmers to cultivate without killing or violence. This is done with the discipline achieved throughout his life influenced by the religion. The need to sustain nature through no interference is practiced. Farmer is aware that all organisms in an ecosystem are important links of a cycle or in modern term “food webs. This is evident in the activities undertaken from land preparation to harvesting in rice. Nothing is removed from the land. This ensures the sustainability of the existing ecosystem. The weeds on the land strips around the rice plots “wanatha” or bunds are not disturbed. The early infestation of these weeds by pests is the key to pest management in the subsequent rice crop in quiet contrary to modern agriculture. The parasite would multiply in shallow nectar source flowers carrying weeds especially in the family *Compositae*. The correct approach could be easily developed by religious means, by propagating loving kindness rather as a response to pest infection than as a reaction to it. The usual response to early pest infestation on early flowering graminaceous weeds is to apply “Pirith chanted water” chanted with Metta sutta. The expected skill that the farmer would exhibit is stated in the “Metta Sutta” as 15 different skills. As in the loving kindness Sutta such a person would maintain loving kindness as “**let all creatures be joyful or let them be safe or let their heart rejoice**” by applying nature farming practices which is beneficial to all forms of life on earth

I have made an attempt to record the impact of deviating from ecological farming, on the environment and humans, with suggestions to rehabilitate by integrating holistic nature farming techniques of ancient Sri Lanka with modern farming methods using a case study "Nawa Kekulama" .

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## Introduction

Mahawanse<sup>1</sup> in the admiration of the noble concepts of duties of a ruler King Parakrama Bahu the great, states

“ having thus reflected, the King thus addressed his officers:

*In my kingdom are many rice fields, cultivated by means of rain water, but few indeed are those which are cultivated by means of perennial streams and great tanks.*

*By rocks and by many thick forests, by great marshes is the land covered.*

*In such a country, let not even a small quantity of water obtained by rain, go to the sea, without benefiting man....”*

(translation by L. de Zoysa-as stated in Brohier,R.L<sup>2</sup>. Ancient irrigation works in Ceylon,1934).

It is obvious that the farming system prevailed at the King Parakrama Bahu (1153-1186 AD) time was one that is undoubtedly sustainable. Siriweera (2005)<sup>3</sup> on comparing drought periods and agriculture productivity from 3<sup>rd</sup> century BC to 13<sup>th</sup> century AD, reported farming system prevailed in *Rajarata Civilization* (Present north central Province under Mahaweli irrigation scheme) was amply adequate and sustainable even to feed a very large population of Buddhist monks who did not participate in any production process. The advanced Irrigation Technology adopted by the main service providers to farmers especially in the location of ancient wewas (reservoirs), distribution of irrigation water for farms and rice fields, management of water sheds and reservoirs is a good indication of sustainable agriculture in the ancient Sri Lanka.(Gunawardena,1971<sup>4</sup>). The sustainability of the ancient agriculture is of course due to the high yield obtained as stated by Siriweera (2005)<sup>3</sup>, where the reported yield by the farmers in 13<sup>th</sup> and 14<sup>th</sup> Century is eighty units (Bushels) for each one unit sown. Although in modern Sri Lanka we cultivate only two seasons a year namely *Yala* and *Maha* based only on irrigated water, ancient farming system was based on both rain fed and irrigated fields cropped three seasons a year namely " *Pita dada hasa (Maha)*, *Akala hasa (Yala)* and *Mede hasa (in between)* as evident from Tonigala Rock Inscription of the 4<sup>th</sup> Century AD–*Epigraphia Zeylanica*, III No. 17<sup>6</sup>, which may have contributed to self sufficient village communities (Siriweera, 2005<sup>3</sup> and 1982<sup>5</sup>). The self sufficient village based on Asiatic mode of Production could have been successful due to low input agriculture that was practiced. Ancient Sri Lankan Agriculture was more of low input agriculture truly a organic farming system that closely merged with the ecosystem without strict boundaries. They adopted simple equipment that did not disturb the land and they practiced *Kem* and rituals strongly as reported by literacy works in 13<sup>th</sup> Century namely *Poojawaliya* and *Saddhmaratnawaliya* (Siriweera, 1978)<sup>7</sup>.

## Indigenous Farming System of Sri Lanka.

The indigenous farming system of Sri Lanka was a close integration of livestock management (especially cattle and goat), mixed home garden system, upland dry farming of rice, other grains, oil crops and vegetables (Kekulama) as a component of "Chena"-shifting cultivation, and lowland rice-paddy cultivation with a very well organized centrally planned water shed and water management system. This is a good indication of farmers being fully occupied and gainfully employed as compared to today's rice farmers who are finding it very difficult to manage day to day expenditure.

### Land Use and Management Patterns

For centuries farmers adopted a sustainable farming system in Sri Lanka (Siriweera, 1978)<sup>7</sup>. This farming system was described by Abeyratne (1956)<sup>8</sup> as threefold system of *Velyaya-Gangoda and Hena*. Lowland rice farming commonly called paddy fields in a village are well interconnected and irrigated with a well managed irrigation system is referred to as *Velyaya* ((*Vela*= paddy field; *Yaya*= collection of fields in one ecosystem). *Gangoda or Gamgoda* (Gam= villages, goda= many or collection) is the village settlement, and the upland slash and burn rain fed cultivation of different types of grains including rice and vegetables is called *Hena* or Chena.

### Upland land use: Chena cultivation

Chena cultivation, Sri Lanka's oldest farming system, still continues, primarily in the islands relatively dry regions. Chena farming involves systematic forest clearing and cultivation for two or three seasons, and abandonment to fallow which allows regeneration of forests. However the Chena farming system is not haphazard but follow good ecological principles and soil conservation strategies. Almost all upland rain fed agriculture could have been under Chena farming system. It is estimated that about 1.2 million ha are under Chena cultivation (Nat. Resources of Sri Lanka., 1991)<sup>9</sup>. Chena became a land settlement controversy during the period when the island was under British rule especially in forceful acquiring of village and Chena land by the British. This created major change in agricultural practice after the Crown Land Encroachment Ordinance in 1840 enacted by British, claiming Crown ownership of all Chena land. British reinterpreted the Chena farming as primitive and uneconomic form of cultivation. By the mid 19<sup>th</sup> century British colonial policies caused clearing of many Sri Lanka's tropical montane forests in order to plant coffee and cinchona. Plantation coffee covered 20,500 ha in 1847, increased to about 32,400 ha by 1857 and 110,500 ha by 1873. Approximately 20,200 ha were Chena land seized from Kandyan villagers (De Silva, 1981)<sup>10</sup>.

In ancient days cultivation and fallow cycles were long enough about 12 years for the regeneration of native vegetation and soil fertility levels. Chena cultivation adopted an ecologically sound system based on rituals and traditions. The selection of land for the slash and burning was done systematically by the elders based on the topography and existing vegetation. Slope of the land is clearly the main criterion used to avoid erosion after clearing in the following *Maha* rainy season. The type of existing vegetation is the next most important criterion in selecting the land. The vegetation present is a good indicator of the degree of the soil fertility and probably level of recovery from previous Chena practice. Perera *et al.*, 1983<sup>11</sup>, stated that traditionally five different types of land are recognized based on fertility levels as indicated by the existing vegetation. They are namely:

- Mukalan Hena* : Primary forest land—with highest fertility level
- Navadeli Hena* : Dense forest land.
- Athdandu Hena* : meaning vegetation is mostly trees with a girth about the size of a fore arm of an adult man. Secondary forest which are about 8–10 years old, or just completing recovery period of 10 years from the previous cultivation.
- Landu Hena* : Chena in the jungle.
- Illuk Hena* : Area mostly covered with Illuk (*Imperata cylindrica*) grass, a definite sign of infertile soil probably due to heavy erosion. However other more luxuriant grass types are found in certain low land called *Deniya*. Some farmers used the term *Deniya Hena*, which is not a common acceptable upland *Hena*.

Land clearing in Chenas is done according to specific system guided by rituals in the following order.

Clearing undergrowth (*Mulwal keteema*)

Slashing small plants at the ground levels using a long-handled bill-hooked knife (*kette*)

Pruning tall bushes

Cutting of twigs and small branches of tall bushes at eye level leaving arm size branches

Lopping of tree branches

Lopping of branches of tall trees using an axe

The three-tier clearing system is practiced to harness a definite advantage in recovery process of the ecosystem. It facilitates fast tree growth, It rejuvenates forest and Soil coverage is ensured within a short time (Fig 2 & 3).

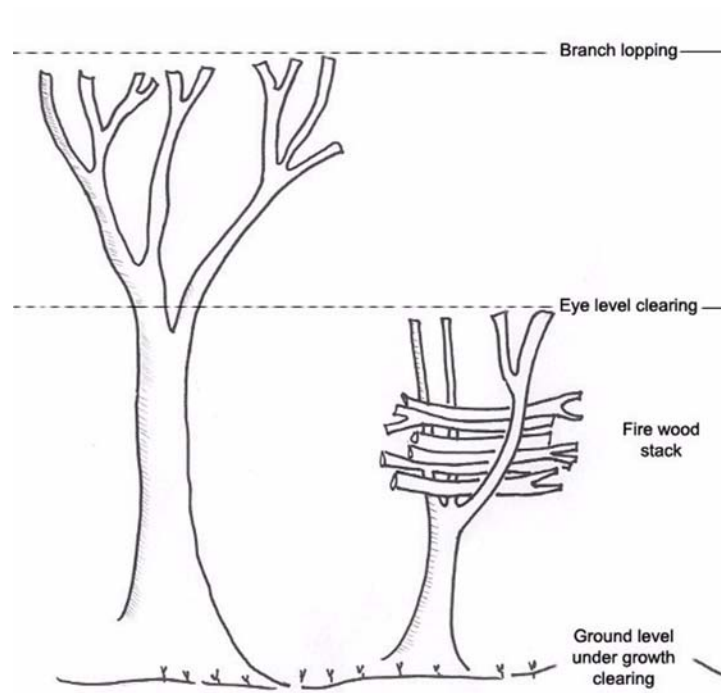


Fig. 2

*Three tier system of lopping of branches in trees in the land clearing process adopted in chena farming.*



Fig. 3

*Lopped branches during land clearing in chena cultivation are stacked on for future use as firewood (fore ground) Phot: Goonasekara and Gamage 1999*

The rituals connected with the commencement of land clearing are typical of all farming systems. It starts with a loud addressing of gods/deities and making vows

before the deities and asks for protection. This is usually done with much loud noise generated with specific drums and other instruments, and addressing deities loud by a specific leader or elderly farmer. Usually the most gigantic trees are not removed from the land. One such tree is consciously kept untouched and used as the centre of rituals and worshipping, implying the deities would reside there. At the base of the tree trunk farmers offers alms and flowers and light lamps made of clay containing coconut or gingerly or *Maduca* (*Mee*) oil. Farmers address the deities and request them to be forgiven for clearing the jungle and removing some of the trees especially stressing that the whole process is carried out for looking after their families. Very often green twigs are attached to the big tree trunk, often at the entrance to the Chena. This appears to be that the farmer is aware about the possible destruction it may cause in slashing and burning and would like the deities to forgive for his action if damage to the environment is done. However, Goonasekara & Gamage, 1999<sup>12</sup> quoting Gelbert description of Chena rituals state that the tree that is used for worshipping is also felled and burnt. In our observation such actions were not observed as the farmers have the greatest regard and probably some element of fear towards the deities as such they are reluctant to cut or damage such trees. This also observed in the difficulty of hiring any tree cutter to even lop branches of "Bo" (*Ficus religiosa*) trees, due to fear of punishment by deities.

Burning rituals take the form of an auspicious occasion where all the other farmers gather. Usually it is started at the fire centre called *Ginimula*. Generally it is done at the upper end of the Chena with respect to wind direction. Firing is done during the month of *Nikini*.

The obvious expression before firing as a ritual of begging pardon from wild animals for firing and creating a stressful environment for them, indicate it is not a process of destructing ecosystem. He pleads loud enough and creates effective vibrations near the ginimula–firing point by thrashing piece of wood on the land,, to chase away any creeping, serpents, small animals like rabbit, rats and mongoose who live in the bush before firing commences.

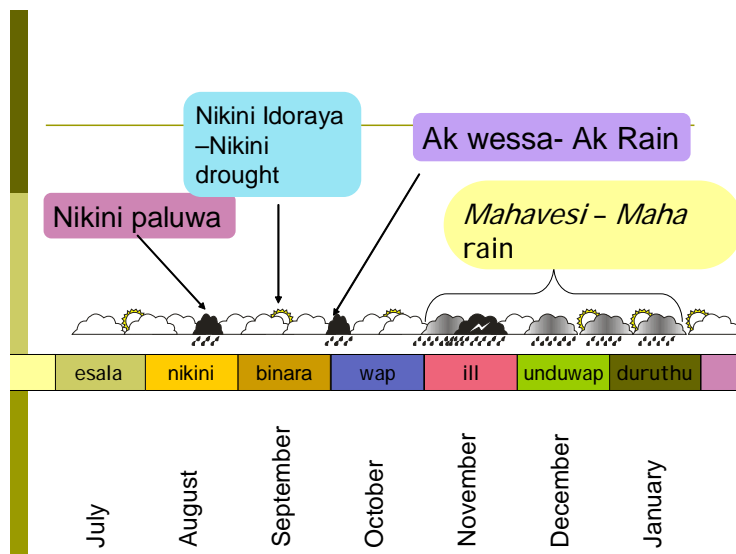


Fig. 4

Timely cultivation practices adopted by Sri Lankan farmers for Maha-NE monsoon season. (Source Upawansa, G.K. 2005)

Once the Chena is burnt, there will be a lot of unburnt debris (pieces of short logs, sticks, partly burnt charcoal etc). Logs and sticks that could be used as fire wood would be stacked between the forks of standing trees. The rest is piled as ridges, diagonally across possible water flows (*Kadamulang veti*) Left over debris is piled up around lower end of boundary to arrest further erosion. Portions of felled timber and thorny brush wood is stacked as a fence as "Dandu Weta" along the boundary to keep the large animals damaging the crop. Danduweta is layed at an auspicious time usually select a period referred to as "Divi karana"—period that belongs to Tiger to protect his crops from wild boar, rabbits and deer etc.

**Crop diversity** is the most important weapon in pest management used in upland Chena farming. Some of the crops sown/planted in Chena are:

The most common **cereals** used are rice (*Oryza sativa*), Kurakkan—Finger millet (*Eleusine coracana*), Meneri—Millet (*Panicum miliaceum*), Amu-Kodo millet (*Paspalum scrobiculatum*) Sorghum (*Sorghum bicolor*), Thanahal—Italian millet (*Setaria italica*), Iringu—Corn (*Zea mays*).

The common **oil crops** are gingelly (*Sesamum indicum*), mustard (*Brassica juncea*). Mostly used **Pulse crops** are Cowpea (*Vigna unguiculata*), Black gram (*Phaseolus mungo*), Green gram (*Phaseolus aureus*). Kollu—Horse Gram (*Dolichos biflorus*)

**Root crops:** Sweet potatoes (*Ipomoea batatas*), Manioc (*Manihot esculenta*), yam (*Dioscorea alata*). *Katu-ala*—Buck Yam (*Dioscorea pentaphylla*)

**Vegetable crops** include vines grown on support trellises, or left over tree trunks and also along the fences, or allow to grow on land are mostly cucurbits such as *Pipinga-Cucumber* (*Cucumis sativus*), *Alupuhul-Ash pumpkin* (*Benincasa hispida*), *Peni komadu-Water melon* (*Colocynthis citrullus*), *Heen-Kekiri* (*Cucumis melo var conomon*), *Wattakka-pumpkin* (*Cucubita maxima*), *Diya labu- Bottle gourd* (*Lagenaria siceraria*), *Weta kolu-Ridged gourd* (*Luffa acutangula*), *Niyan wetakolu-Sponge gourd* (*Luffa cylindrica*), *Karawila-Bitter gourd* (*Mormordica charantia*), *Thumba karawila-Mormordica dioica*), *Pathola-Snake gourd* (*Trichosanthes anguina*).

Other **leafy vegetables** that are allowed to grow on from natural vegetation are *Wel Penala-Cardiospermum microcarpum*, *Anguna-Dregea volubilis*, *Mucunuwenna-Alternanthera sessilis*, *Neera mulliya-Asteracantha longifolia*, *Maha Sarana-Trianthema decandra*, *Heen Sarana-Trianthema portulacastrum*, *Kura tampala-Amaranthus viridis*,

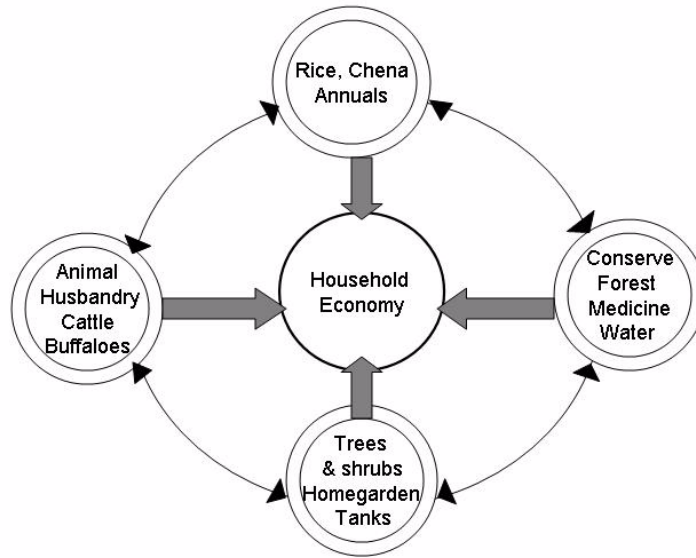
**Vegetables fruits:** *Ela Batu-Solanum surattense*, *Titbatu (Solanum indium)*

Other commonly found crops especially **beverages and spices:** *Polpala-(Aerva lanata)*, *Karapincha-(Murraya koenigii)*, *Kottamalli-(Coriandrum sativum)*, *Chilli-(Capsicum annuum)*, *Kochchi-Bird chillies (Capsicum frutescens)*, *Nimiris (Capsicum annuum var fasciculatum)*.

Crops are grown as intercrops that mature at different times of the season as such harvesting is also staggered. The objective of use of wide diversity of crops in a Chena is to maintain more nature like ecosystem for effective pest management and also for regular ground cover to prevent erosion during the NE monsoon rains in addition to meet the needs of the family in terms of carbohydrate, proteins, beverages, spices and also fruits.

In the ancient Sri Lankan farming systems a complex interrelationship occurred among the Village tank-Wewa, irrigated paddy fields (Wel yaya), Homegarden and Chena & the forest for sustainability. Ulluwishewa, 1992, as reported by Goonasekara and Gamage, 1999<sup>12</sup> summarized the time tested sustainability in this complex system of farming using a comprehensive flow diagram (Figure 5). The sustainability of the ancient (*Purana* village) village that was self sufficient was derived by this complex system of ecosystem management. .

Fig 5  
Sustainability of the ancient (Purana village) village that was self sufficient was derived by a complex system of ecosystem management



Interrelationship of Ancient Village with tank, rice fields, forest and Chena

Farmers traditionally, complete sowing and planting in Chena first before the commencement of lowland rice farming. This during the month of July –August (*Nikini*) much before the late October Maha rains. The term *Wap* is used to designate the rice sowing month (See figure 24 on timely cultivation). More detail discussion will be done under *Wel Yaya*–lowland rice field management.

### Homesteads-Gamgoda.

The farming in ancient Sri Lanka is truly an **Agri-Culture**, where farming, religion and other community activities were all in one single package. It is very commonly stated as *Wewa- Dagoba- Gamgoda* (= Tank-Temple-Village) in the ancient *Rajarata* civilization (*Raja* = Royal, *Rata* = city/region), where the farming activities were well coordinated by the temple. The community of homesteads or Village (= *Gamgoda*) is located in the neighborhood of the tank which provided higher water table and as such ample ground water for homestead cultivation and maintenance of livestock. Tank provided the irrigation water for lowland rice farming if an when required to supplement rain fed farming. In *gamgoda*- village settlement is also unique in its character and the architecture. The houses were never built in isolation. They were more of the extension of the existing parents' house truly representing the concept of extended family. Houses are built around a common compound (Figure 6, as given in Goonasekara and Gamage, 1999<sup>12</sup>). However the grain storage is earthen silos called *Bissa* in located closer to the houses but often in the front yard. Around the housing complex, a narrow belt of cleared land is maintained, where the boarder runs up to the jungle. The cleared land belt is refereed to as "*This-bamba*" approximately 60 meters circular belt from the houses, which harbor the cattle and buffaloes in the night. The pasture land for the cattle and buffaloes is near the tank–*Wewthaula*, where they are released free for grazing during the day.



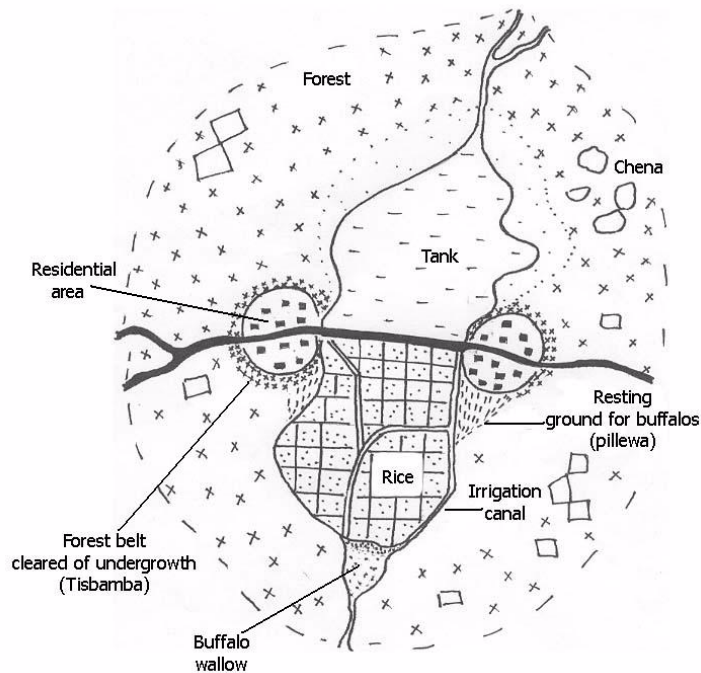


Fig 6

Typical layout of crop fields, home-steads and chena around the reservoir (wewa).

### Lowland Rice Fields- *Welyaya*

Lowland rice fields were grouped on the basis of efficiency and ease of water management especially by the degree of proximity to the tank. The fields closer to the tank has better access to irrigation water during drought period. The fields were categorized as *Pangu* or share of tank water they have access to, during irrigation process (Gunaratne and Maddumabandara,1990)<sup>13</sup>. Farmers right to use tank water thus earmarked according to the share they are entitled for. This lead to a unique system of land allocation to farmers based on soil fertility gradient and availability of water during drought periods, which is administered by the chief farmer refereed to as *Gamarala*. In some areas it was done by the person appointed by the royalty to gives orders to fellow farmers regarding land use, management of wewa and irrigation canals or *Welvidana*, literally translated to English as rice field commander. The traditional allocation of rice fields, thus carried specific terms the filed near the tank bund is called "*Udapotha or Mulpotha*", the middle area is called "*Peralapotha*" and the fields in the farther lowest region is called "*Aswaddumpotha*". The village leader who manages these land use patterns and the irrigation system is entitle to specific benefits such as a strip of land in the *Mulpotha* area closest to the tank bund and is called *Gamvasam panguwa* (share of land for management of village), two or more portion of land located at lower portion called *Kurulu Paluwa* (one left for the birds). Farmers collectively managed the tanks in the wild (*Kuluwewa*, *Kulu* = Wild *Wewa* = reservoir or tank), main tank, Tank bund and the irrigation canal and the waste water canal that carry water with sediments resulting from de-silting (*Mada ela*, *mada* = silt, clay and

*debris suspended in water, ela = canal*) on the direction and advice of Gamarala or Welvidana during British regime (Ausadhahamy, 2004)<sup>14</sup>. The share of the responsibility depends on the share of land owned by the farmer. Use of several irrigation management techniques depending on the rainfall pattern is used by the farmers. More detailed account is given by Goonasekara and Gamage, 1999. It appears that the de-silting process of reservoirs was done in a very organized manner. The waste water canal never entered the main irrigation canal that take water to fields or any land that crops was grown. The waste water canal ends in a marshy land meant for growing plants used for other purposes other than food. For example the plants use for making carrier bags, mats for sleeping and other domestic use such as drying rice and food, and even for thatching roof, species of family *Typhaceae*, e.g. *Typha javanica* were extensively grown in the marshes. It is very well known that these plants absorb heavy metals and other toxic compounds from soil. The main other plants grown in these are some non edible *Xanthosoma* species and *Nelumbo nucifera* (lotus). Nelumbium is known to absorb at least five different heavy metals from water and is an excellent phyto-remediation agent (Bandara.,2006)<sup>15</sup>. Bandara (2006)<sup>15</sup> and Tennakoon (2006)<sup>16</sup> also reported the use of several trees on either side of the main canal that brings water from the fields to the reservoir. The common trees are Kubuk (*Terminalia arjuna*) (figure 14. tree grown near the drain out canal middle of the picture), Wal beli, Milla, Walindi etc.

Use of irrigation water during drought periods is also organized according to traditional practice of "Bethma cultivation", where only a portion of the rice fields are cultivated. This is also selected in the "mulpotha" region nearer to the tank bund probably to exploit any water seepage (*Ulhollanawa*) into the fields.

Several indigenous techniques of pest management are used in rice farming. However most methods used are based on rituals as mentioned under Chena cultivation systems. The mechanical devices used needs appropriate mention as they could be utilized even today. The water Ghost (Diya holmana) which makes a noise to scare rats and birds at a variable interval of time based on the rate of water flow at the water outlet of the field. The other such devices used are takaporuwa or Kotipeththa are well described by Goonasekara and Gamage,1999. It is also interesting to note the techniques used for mechanical removal of insect pests during severe outbreaks of insects in rice fields by trapping them in sticky latex. This is done by dragging a domestic winnower (Kulla) applied with sticky latex of plants such as *Artocarpus heterophyllus* and *Maduca longifolia* over the ripening rice panicles to trap insects feeding on immature grains, this is generally referred to as *Bokuganawa*-dragging the winnower, (Kahandagama,1995)<sup>17</sup>. However, common folk poems normally sung by the farmers during transplanting, harvesting and threshing operations as a group indicate that the farmers are very reluctant to do such methods of eradicating pest. For the sake of completeness I reproduce below the sections of the folk songs and its translation in English. (See video presentation on Rituals and folk songs in rice faming in Sri Lanka. Bandara and Abeysinghe,2007)<sup>18</sup>.

එහෙමට බැරි උනි නම් අපි කුමක්	කරනවා
කොහොමට උන නමුත් හොඳයි බොකු	ගානවා
උනමට එකඟව බැලුවොත් එය	වරදිනවා
බොහොමට පවිලබ ගොදුරක් නැත	නිමවනවා

*If the pest damage prevails what could we do  
It may be best to drag winnower (Boku ganawa)  
But, in accordance with the religion, it is not correct  
no sense in securing food by acquiring sins of killing.*

අපොයි එපා ඔය හැටි පව් අප	නො කරන්නේ
කැනයි තමා සත නැසුමෙන් දිව්	නො රකින්නේ
සැපයි තමා හට තෙරුවන් ගුණ	සල කන්නේ
කෙතයි මෙමා මෙන් කුළුණෙන් සෙත්	සල සන්නේ

(Wanasinghe,1999)<sup>19</sup>

*Oh No! we would not engage in such sins  
It is a shame to earn living by destroying life  
Joyful when you are assured of the blessings of the triple gem  
(Buddha, Dhamma and Sanga).  
So, my field of crop would be better if I express loving kindness to all living forms..*

Farmers prefer loving kindness to killing any form of life and expect both blessings of the Dhamma and benefits from maintaining ecosystem. The intrinsic nature of the traditional system of farming is that it is based on a holistic concept and none of the factors that we have discussed so far whether it is biodynamic, ecological or rituals are independently had any major effect. But all factors are additive and cumulative in the final impact on sustaining the dynamic equilibrium of ecosystem. This holistic approach demands friendlier approach to components of the ecosystem especially animal component. This was achieved with the religious base in which the holistic concept was based on, namely friendliness towards all animals big or small, visible or invisible generally referred to as Metta or loving kindness.

Concept of ecological farming is based on "Loving Kindness" (*Metta* in Pali, the language of Buddhist scripts), no destruction of life at any time. In most religions loving kindness is practiced. However in Kekulama it is traditional that the farmers adopted Metta-loving kindness without any concern for the size of the animal they deal with. A brief encounter with Metta Sutta practiced by Buddhist will explain the principles used in adopting Metta in farming. Some of the virtues expected from a farmer to practice Metta are no doubt useful to any person. However for the benefit of the readers I wish to reiterate some that are more relevant to farming. One who wishes to practice loving kindness must have the following virtues.

- i) He would be gentle, Malleable/flexible.
- ii) He would not be proud or arrogant.
- iii) He is content with what there is.
- iv) He is easy to support / sustain.
- v) He is unbusy.
- vi) His way of life is light (Frugal/economical).
- vii) He has faculties that are serene. His faculties (six senses) are un-agitated.
- viii) Knowledgeable, intelligent, possessed of understanding.
- ix) He is not impudent. He is modest.

*What is described so far is the action–modes of the mind bent on skill (sakko) necessary for the practice of loving kindness.*

In most religions loving kindness is practiced. However in ancient Sri Lankan *Agriculture* it is traditional that the farmers adopted Metta- loving kindness without any concern for the size of the animal they are dealing with.

Loving kindness can be maintained in being thus: " Let all creatures be joyful" or " Let them be safe" or " Let their heart rejoice"

Frail- those with craving and those with fear,  
Firm- (Arahants) who have abandoned craving and fear.

Those seen or unseen whether dwelling far or near that are or that yet seek to be let every creature's heart rejoice .

Those that are—that have been born or generated  
That yet seek to be—creatures that are uterus–born or egg born, those that yet seek to be.

Let one another not do, or slight or at all anywhere, let them not wish each other ill with provocation or resistive thought .

Loving kindness, extended towards all life forms in the crop ecosystem protect one's crop—is the basic concept of natural pest management exerted by nature to maintain the balance of life forms in a ecosystem. The good practice of planning or culture of farming towards maintaining dynamic balance in the ecosystem leads to a sustainable farming system with minimum effort. Such a system is more suitable to be termed as ecological farming or nature farming..

However the low input farming system “ seek to optimize the management and use of internal production inputs (i.e. on-farm resources)... and to minimize the use of production inputs (i.e. off farm-resources), such as purchased fertilizers and pesticides, wherever and whenever feasible and practicable, to lower production costs, to avoid pollution of surface and ground water, to reduce pesticide residues in food, to reduce farmer’s overall risk, and to increase both short- and long term farm profitability” (Edwards,1990)<sup>20</sup>.

## Modern Farming

The prevailing farming system which is often referred to as modern farming or modern agriculture or industrial farming (in USA), was the most dominant factor that contributed to the Green revolution of the past decade. The tremendous gains in productivity and efficiency have led to increase in food production during the past 50 years. The world bank estimates that the abundance of inexpensive food was mostly due to high production per acre than increase in acreage under cultivation.

Modern farming system for obvious reasons varies from society to society and country to country. But it is still based on

- Rapidly changing innovative technology.
- Economies of scale.
- Specialized farming of specific crops growing season after season.
- Huge capital investments for the application of new technology.
- Use of genetic material mainly selected for higher yields.
- Extensive external inputs for all factors of production labor, capital and management where pesticides, fertilizer, water and energy takes a prominent position.
- High labor involvement and efficiency.

Involvement of livestock in farming system is in general as a separate industry, in confined, concentrated systems with homogenous breeds mostly selected for high and rapid yields.

Figure 8 represents the summary of activities and inputs involved in the modern farming, in a nutshell. In agricultural science it is common to consider that the process of land preparation is vital for better establishment of the crop, with a view to provide an advantage for the crop in comparison to weeds etc. The modern land preparation is therefore aimed at denaturing, and removal of all beneficial components of the nature in the field. In general all big trees are removed in the pretext of removing those that interrupt free access to sunlight by the crop. Hedges are cleaned to avoid any build up of pests both insects and vertebrates. Existing bunds or newly established bunds are usually clean weeded to avoid any buildup of weed population. All these acts of land preparation, amounts to eliminating biodiversity, thus minimizing benefits of ecosystem for the farmer in the management of pests and diseases.

Other aspects of land preparation involves, total disturbance of natural drainage patterns and water input-irrigation. Usually deep drainage systems are laid by digging deeper into soil. Irrigation channels are laid by rearranging contours for the convenience of the implement and vehicular movement. Soil is then ploughed deep working soil several times. The process virtually disturbs the dynamics of the soil ecosystem

that may have taken long years to build up. This disturbance provide great opportunities to erode the soil from its own resources of nutrients and organic matter which would eventually oxidized due to heavy soil disturbances at deeper levels.

In addition to the non natural acts we do add artificial synthetic chemicals to the ecosystem especially to the soil ecosystem. These mainly soil fumigants, weedicides and some times pesticides along with seeds. The effects of these chemicals are very selective and very often eliminate or eradicate a selected forms or species of life which is an all important component of the natural food web. Incidentally the fumigation is aimed at eradicating all life forms which create an entirely alien environment for the crop that is to be subsequently planted. Crop will be in total isolation. Therefore the next step of the establishment of crop in the field demands a rectification of the altered facts of environment. An overview of this is given in figure 8 as crop establishment. Now it is not removal but addition of every thing we have removed in the previous step

### Nature as a Competitor

It appears that the philosophy behind the application of technology involved in modern agriculture is to consider the **nature as a competitor** that need to be overcome!

Strangely enough even primeval farming practices were to go against the nature to separate a selected plant as a crop and concentrate in selected areas, leading to unending evolution of larger farms that depopulate both plants and animals including farmer communities.

It is natural to overlook the friendlier aspects of the nature when the nature is considered to be a power to be overcome for higher achievements in farming. It is probably the man's craving for taking control of nature however, the interaction between farming system and ecosystem are complex. Most environmental problems are invariably linked with political, cultural, social and economical forces which are external to agriculture. The interest based monetary system is playing an important role in this as it is forcing farmers to compete with each other for highest financial return on capital. Money will flow to the forms of and innovations in farming that are financially most promising (e.g. biotechnology instead of low-external input agriculture). The necessity of poor farmers to depend on local resources is critical. Coein Reijntjes, 2006<sup>21</sup>.

### Economical Aspects of Modern farming: Negative side effects

Jules Pretty (2001)<sup>22</sup> reported that the damage cost of modern farming is two folds

- Treatments or prevention costs incurred to clean up the environment and restore human health to comply with legislation.
- Administration cost incurred by public agencies monitoring environmental pollution.

Pretty, estimated in U.K. the annual total external costs in 1996 for corrective measures and cleaning up of environment as £2.34 billion. The detail breakdown is given in table 1.

**Table 1:**  
**Annual total external cost of U.K. Agriculture 1996 (for the adoption of corrective measures in the U.K. in million sterling pounds (Pretty, 2001)<sup>9</sup>).**

<b>Cost Category</b>	<b>£ Million</b>
Pesticides in water	120
Nitrate in water	16
Phosphate in water	55
Cryptosporidium	23
Damage to wild life habitats	124
Damage from gas emission	1113
Soil erosion/loss of org. C	96
Food poisoning	169
BSE	607

## Organic Carbon in Soil

The impact of modern farming on the residual quantity of organic carbon in soil and the water quality is very conspicuous. Let us take the organic carbon in soil first. The organic carbon content of the surface layer of the soil may range from 0.5 to 10%. Organic matter content of soil varies depending on the soil type. In the decomposition of organic material, a prominent role is played by the higher organisms such as insects, termites, earthworms and man and his domestic animals. The partly decomposed material left on soil in the form of excreta by large animals is further decomposed by micro-organisms. However the decomposition of organic material is not a simple and straight forward process. The decomposition or the complete breakdown of organic material occurs as a result of action of various enzymes produced by the agents of decomposition. The final result of the total breakdown of organic material is the production of minerals. Therefore the process is often referred to as mineralization (Fig.9).

Fungi are the principal agents of organic material decomposition in forests. Bacteria are the dominant decomposers in agricultural land. Most of these organic matters are dead buried roots. The end products are carbon dioxide and water with smaller quantities of simple mineral salts like  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , methane etc. The breakdown of carbon occurs at a higher rate under tropical conditions we experienced soil such as in Sri Lanka especially when aeration capacity is higher with restricted rain fall. However, even in a small island like ours, the weather patterns determine the rate of decomposition of

organic material in soil. In the lower elevations, in the dry zone soils reserves of organic matter is low due to higher rate of decomposition. In the higher elevations, for example in Nuwara Eliya (Lower temperature and higher rainfall) soil is rich in OM and soils are darker and acidic.

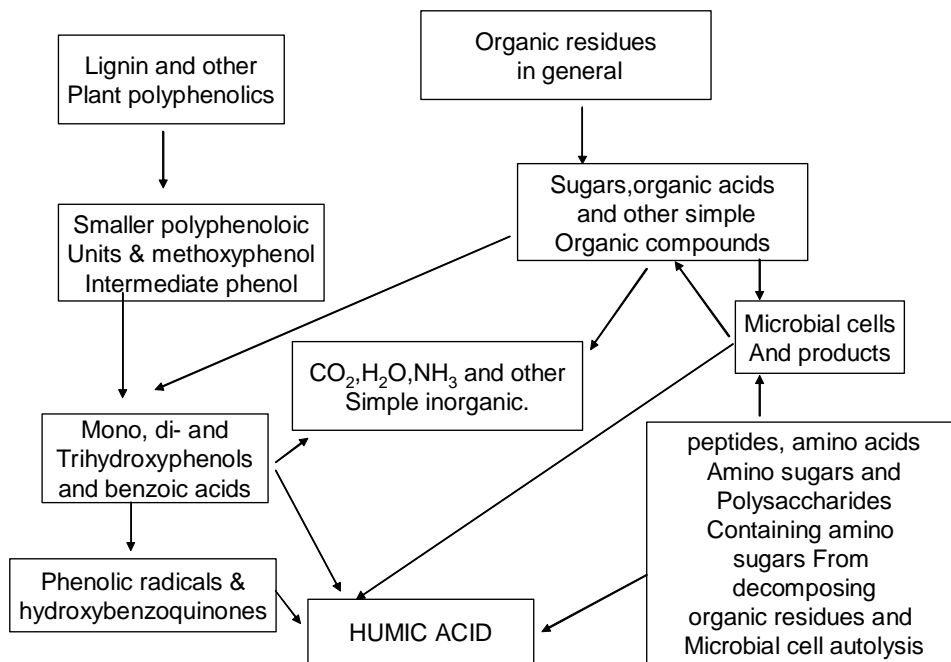


Fig. 9. Organic matter decomposition in soil

Pretty (2001)<sup>22</sup> reported that average reduction of organic matter in British soils is half in the past 20 years. Effectively British farmers have been converting soil fertility to yield. This can not go on for ever. If organic carbon is used without replacement as practiced by the modern farming by mere addition of inorganic mineral fertilizer only, agriculture would be soon not practicable in those lands. The most damaging effect on the environment is the conversion of organic carbon to carbon dioxide that releases to the atmosphere. Therefore it is important to view this in terms of atmosphere pollution that carbon fixed in organic carbon in soil is carbon that is removed from the atmosphere. Therefore it is important for farmers to favor farming techniques that increases soil organic matter in order to change the present trend in global warming.

### Impact of Modern Farming on Water Resources.

Impact of modern farming on water resources is becoming a world wide problem of great concern. Pretty reported, in 1966 in the U.K. 25 million kg of pesticides is used in each year for farming. Some invariably ended up in water resources. (Figure 10.)



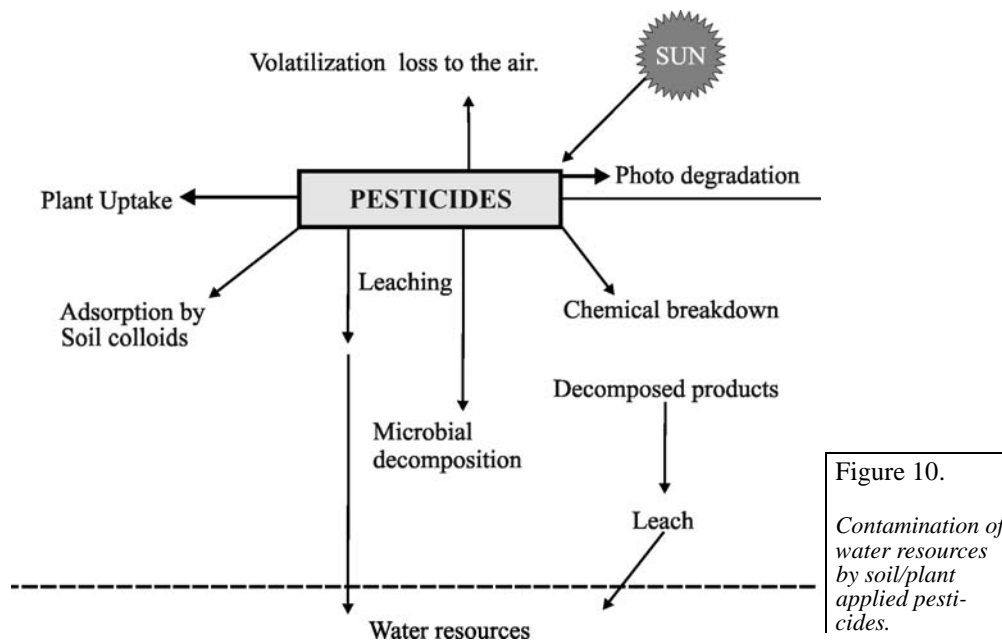


Figure 10.

*Contamination of water resources by soil/plant applied pesticides.*

By definition, environment pollution is “the changes in quality of water, food, land and air which affects the human health, comfort, aesthetic senses, efficiencies and capacities of people to attain satisfactory social adjustment” (www1).

Clean water is absolutely essential for healthy living. It is a basic need for all human beings on earth, yet it is known that millions of people world over are deprived of this. The fresh water resources that are truly scarce are threatened by the very activities of the man. Farming is the main widespread activity that influences the quality of water. Not only ecological degradation but also over exploitation and poor management has threatened the fresh water resources of the entire world. The most obvious source of fresh water pollution is the addition of excessive untreated waste to water ways. These are mainly, the industrial effluent entering water resources and the run-off and seepage from agricultural fields.

Many reservoirs of water are now contaminated with heavy metals, persistent Organic pollutants (POP) and nutrients that have an adverse effect on human health (Figure 10).

### Pollution by Pesticides.

Pesticides are poisons used to kill insects, plants, fungi, worms and mites etc. When pesticides are sprayed only about 1–2 % reach the target and rest is released into the environment to eventually to affect unintended victim. What is released to environment usually ended up in our water resources (figure 10.). Most pesticides that are troublesome are the persistent type. The chemical structure of the persistent pesticides does not break down even once taken in by animals or plants. These chemicals are usually persistent in human

systems too. Some types are bio-accumulative, means the chemical is stored in the fatty tissues of the living organisms' just like the mercury that accumulates in tuna fish in the sea surrounding Japanese islands. Some pesticides are known to interrupt hormone functions in humans and other animals. Such chemicals are usually interfering with reproduction, immune response and also in behavior of humans. The most striking of them all is the one that cause death upon exposure are referred to as toxic chemicals.

### Children are Not Little Adults.

The most vulnerable are of course the children and elders to these pesticides that get incorporated into the environment as an impact of farming. Children are the most vulnerable to pesticides in the environment because they do differ in their physiology and stage of development than adults. It is imperative to understand that the child is not a small version of a human adult. Child is different in every aspect such as their growth and development, the physiology and metabolism and their unique diet and behavior. With a normal diet of mostly water each day more than million children age 5 and under ingest doses of organophosphates pesticides which exceeds EPA's adult reference doses. Exposure to pesticides before birth that is during development at prenatal stage can cause horrible consequences and even irreversible damage to fetus.

Accumulation of farm applied pesticides on sorbant surfaces of toys have been reported to be significant. In a study conducted in USA, in 1998, Gurnathan *et al.*<sup>23</sup> reported that chlorpyrifos with known toxicity to brain and nervous system was found to accumulate in toys for at least two weeks after application. Some of the favorite children foods like grapes and apples are reported to carry high levels of toxic residues from pesticides.

National academy of Sciences report, "Pesticides in the diet of infants and children-1993" stated that children due to their small size, greater intake of air and food relative to body weight, developing organ systems, are at higher risk than adults to pesticides.

### Children are more sensitive to pesticide residues than adults.

Most pesticides are known to pass through placenta and interact with the developing fetus. Most chlorinated pesticides that we use in agriculture are known to affect the hormonal system of animals and humans. Estrogen is known to occur in herbicides and pesticides. Even as trace quantities estrogen could interfere in the developing young infant. Breast milk and semen tend to store pesticides. Some mother's milk has been reported to carry pesticides than is allowed in cow's milk.

Pesticides we used in farming some times although do not directly damage DNA they encourage abnormal cell proliferation. The "xenoestrogens" acts as hormones. Some endocrine disrupting chemicals such as atrazine, cyanazine, 2,4,5-T and the common pollutant PCB and dangerous Dioxin are notorious carcinogens.

As reported by National Academy of Sciences USA, 1993, when it comes to exposure to pesticides because their environment is contaminated, they are the least protected population group.

However it appears that we are yet naïve about the potential threat expressed by the agriculture based pollutants on the human race. Extensive pesticide application in the environment has reduced the viability of human sperms and fertility has been reduced. Besides the low fertility the young humans are the most affected.

In a study conducted in the teaching Hospital, Kandy, Sri Lanka, in the Urology unit it was observed that more than 53% of the bladder cancer patients were either farmers or farm occupants where chemicals are used as pesticides (Wickramaarachchi, 2005)<sup>24</sup>. Cost of decontamination of water resources that is used for drinking purposes is immense. It is around 120 million sterling pounds per year in U.K. Although in Sri Lanka we do not adopt such technology nor has any regulation to comply or meet standards, the hidden expenditure on health could be worse.

Wickramaarachchi, 2005, observed occurrence of pesticides namely Propanil and Chlopyrifos in water samples collected from main tank where the supply was from other tanks and irrigated water that passed the paddy fields in cultivation (*vel pahu watura*) in the dry zone of Sri Lanka, where irrigated agriculture is practiced. Table 2 and figure 11.

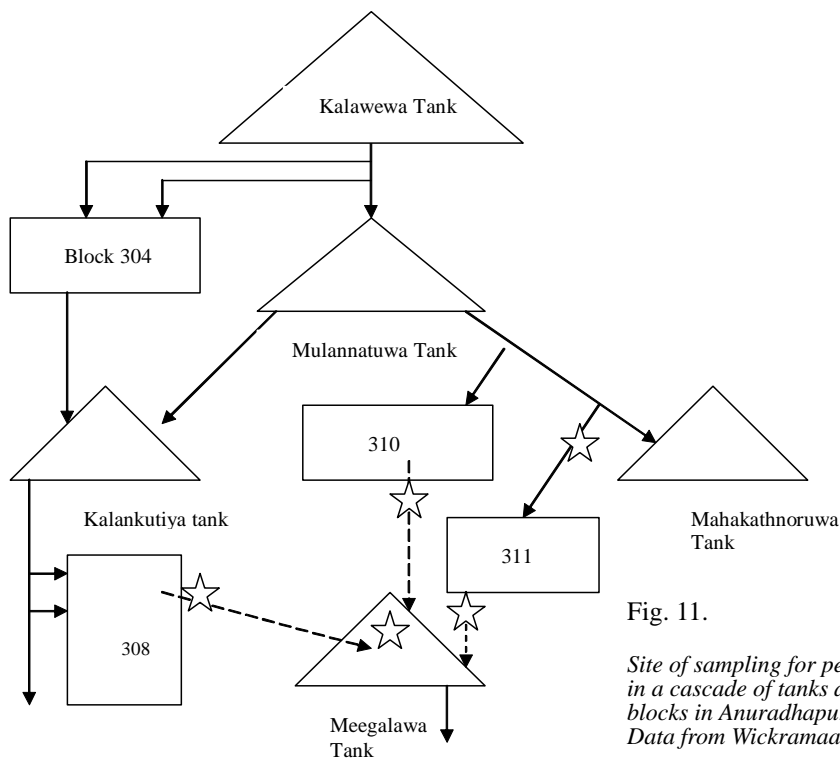


Fig. 11.  
*Site of sampling for pesticide analysis in a cascade of tanks and rice farming blocks in Anuradhapura, Sri Lanka. Data from Wickramaarachchi, 2005*  
 ☆ = Sampling sites

**Table 2:**  
**Analysis of (Meegalawa) tank for pesticides. Note the position of the Meegalawa tank in the cascade in figure 11.**

Sampling site	Propanil Ppm	Chlorpyrifos ppm
Tank centre	1.02	2.80
Main Channel	1.18	6.77
Field channel	0	1.45

In this study tests were done for three of the most commonly applied pesticides in rice farming, namely Dimethoate, Propanil and Chlorpyrifos. Presence of commonly used pesticides in the field channel, main irrigation channel linking tanks and also in the tank it self is a serious pollution concern. The quantities detected are very high in a rice farming area where modern farming is practiced.

Although this as the first reported data in Sri Lanka, over the past decade there has been increase in awareness about non point source pollution and its linkage to modern agriculture. Nevertheless observation of frequent occurrence of pesticides in lakes and streams near agriculture lands is never a isolated incident. Coupe *et al.*<sup>25</sup>, as far back as 1995, found Atrazine concentration exceeding 3µg/L during water discharge to Mississippi river. Scribner *et al.*<sup>26</sup>, in 1996 working on reservoirs in Midwest USA reported only in few reservoirs that pesticides could not be detected. Startling finding is that the concentrations exceeded the drinking water standards.

No further evidence is needed to say that it is the modern agriculture that is responsible for most of the non point source pollution of water resources with pesticides. The detection of pesticides in surface water of Mississippi and Midwest reservoirs are therefore the direct impact of pesticide used in agriculture. Midwest studies further elucidate the fact that five to six most frequently detected compounds were metabolites of atrazine and cyanazine. It suggests that the degradation pathways and products of pesticides could add to the health hazards in drinking water.

Fawcett *et al.* 1994<sup>27</sup>, found that surface runoff of applied pesticides is the primary path of movement from farms to water. Therefore improper watershed management could leads to severe water pollution. Modern agriculture, the techniques of contour farming etc. has not address this issue of pollution pathway by surface runoff. The arrangement of fields within a watershed, the climate do the watershed, the topography, the geological feature of the landscape in all the “nature” is not to be ignored.

The presence of chlorpyrifos in reservoirs in Sri Lanka is a serious concern especially when these reservoirs are the only source of drinking water used without adequate decontamination techniques. The gravity of such contaminants is of grave concern as it

is a compound with known toxicity to the brain and nervous system. David Wallinga MD<sup>28</sup> in a report to USA- EPA expressed concern of the toxicity of pesticides pollutants on growth and development of children.

### Water Pollution by Farm Applied Fertilizer.

We are using more and more chemical fertilizer now, without any concerns to subsequent profitability of the yield gained or water pollution caused by the surface run off from farms. The fertilizer subsidies are a definite incentive to water polluters. **The total amount of Urea fertilizer used by Sri Lankan rice farmers in 2004 was 220,000 metric tons compared to 193,000 metric tons in the year 2000. Based on the total rice production in both Yala and Maha seasons of cultivation the paddy production per metric ton of urea used is 14.82 in year 2000, where as in the year 2004 it is 11.94 (metric tons).** The fertilizer application in the region has been steadily increasing. It is also true for Sri Lanka (Table 3.). Most chemical fertilizers are made up of nitrogen (N), Phosphorous (P) and Potassium (K) in the form of various mineral salts that releases these mineral ions into the environment when in contact with water. Although these are the major nutrients needed for plant growth more minerals which are needed in trace quantities are needed for better plant growth. When plants are provided with these easily available nutrients, in easily available forms (readily dissolved in water), they grow faster and placid. This unnatural escalation of growth results in watery tissues, depleted protein quality and are of course very much prone to diseases and pests.

Inorganic chemical fertilizers are made from high cost petroleum products and are expensive to manufacture. Colossal sums of money are used to purchase them in addition to subsidizing the costs of fertilizer. The phosphate fertilizers are made from rock minerals after treating them with acids to make them more water soluble. When synthetic chemical fertilizers are added to soil, they get dissolve in soil water and enter the clay fraction etc. and tend to combine with the natural minerals that are already there in soil. These will be taken in large amounts into the plant and overload the plant. What ever that is left in the soil the usual contaminant minerals, heavy metals etc that would be added with fertilizer will stay in soil and become poisonous.

Excess nutrients such as nitrogen and phosphorous compounds come mainly from farm surface run off. Fertilizer applied in fields especially lowland rice fields (paddy fields) are the main source of water pollution with nutrients. Through the drain canals, irrigation channels and “*vel pahu watura*” (water drained through the paddy fields) fertilizer mainly nitrates and phosphates enter water bodies cause excessive growth of aquatic plant life which then dies and decays. This depletes the water of dissolved oxygen and suffocate aquatic life especially fish. Associated with such contamination are usually the bacteria of coli-form type *E.coli* and *Salmonella*.

Movement of nitrate- nitrogen from the farms to the stream or irrigation canal, and then to the reservoirs or water table is through the natural water flow that link the field and the stream as part of the hydrologic cycle. In USA, Madison and Burnett<sup>29</sup>, as far back as 1985 after sampling 123,656 wells detected 6.4% of the wells were carrying more than 10mg/litre of Nitrate. Pionke and Urban, 1985<sup>30</sup> working on a nitrogen budget for a 7 square kilometers watershed in Pennsylvania, USA found that there was excess nitrate in the root zone which eventually leached into the ground water. It was estimated that the nitrate nitrogen loading to the water shed in general amounts to 40% of the amount of nitrogen fertilizer applied (Jaynes and Hatfield,1994)<sup>31</sup>.

Polluting water resources by surface runoff of added fertilizer nitrate nitrogen in upland fields, could be managed to achieve minimum pollution level, however the situation in lowland rice fields are unmanageable due to inherited direct linked with water resources through natural drainage system. The efficiency of the management of applied nitrogen and subsequent reduction of impact on water quality lies in the selection of farming system. The unreserved advantage of proper nitrate nitrogen management in rice farming with mulching would be discussed under Kekulama.

However, some areas to be taken into consideration in the improvement of efficiency of the nitrogen use and reduction of nitrogen losses and subsequent pollution of water resources depend on:

- a. Increase in soil organic matter content during farming and the impact of tillage practices used on nitrogen recycling.
- b. Understanding the impact of nitrogen management strategies on environment.
- c. Increased understanding of the relationships among soil types, soil organic matter, soil microbial population, nitrogen dynamics and weather patterns and maintenance of the ecosystem favorable for nitrogen conservation.

Nitrate pollution in Kalpitiya peninsula of Sri Lanka is a well known example. Kalpitiya is a low-lying sand peninsula in Sri Lanka which has a closed aquifer and is intensively cultivated with food crops. Coconut plantations although the principal crop grown in Kalpitiya, in recent years intensive agriculture for the cultivation of Onions, chillies (*Capsicum annuum*), potatoes and vegetables such as gherkins, okra and Brinjal (egg plant) are also grown. Kalpitiya peninsula consists of regosols 13 overlying some 15-20m of fine coarse sands of marine origin.

**Table 3: Annual use of nutrients by all crops in Sri Lanka 1971–2003 (000MT)**

Year	N	P2O5	K2O	MgO	Total
1973	56.8	22.7	31.6	-	111.1
1974	55.3	15.3	31.3	-	101.9
1975	40.1	10.8	21.5	-	72.4
1976	52.3	14.5	28.5	-	95.3
1977	65.4	22.4	23.8	-	111.6
1978	80.9	28.7	30.8	-	140.4
1979	77.2	26.1	34.3	-	137.6
1980	91.6	31.4	46.1	-	169.1
1981	75.6	27.4	41.2	-	144.2
1982	79.4	30.4	45	-	154.8
1983	82.5	31.1	48.1	-	161.7
1984	96.1	36.2	55.3	-	187.6
1985	101.2	37.2	56.2	-	194.6
1986	104.1	40.2	55.6	-	199.9
1987	103.7	38.3	59.2	-	201.2
1988	106.1	39	62	-	207.1
1989	108.5	41.4	61.6	3.2	214.7
1990	92.3	29.2	49.5	3.2	174.2
1991	95.7	30.9	50.5	2.7	179.8
1992	102.2	30.4	51.1	3	186.7
1993	115	39.8	58.5	2.3	216.2
1994	119.5	35.5	59.5	2.8	217.4
1995	116.1	35	56.4	2.7	210.2
1996	117.3	35.2	58.4	2.8	213.7
1997	122.7	30.7	56.1	2.8	212.3
1998	142.4	29.6	62.4	3.3	237.7
1999	164	34.2	62.3	2.9	263.4
2000	157.2	30.4	59.1	3	249.7
2001	158.6	31.8	54.8	2.1	247.9
2002	188.5	34.6	62.2	3	288.4
2003	150.9	36.8	61.8	3	252.8

Beneath the sands are clays which in turn overlie a Miocene limestone. A thin fresh water lens occurs in the sands and is present at depths of 1–3m over most of the peninsula. The aquifer is extensively taxed for both irrigation and potable water supplies, as it is the only source of fresh water available in the peninsula. Recharge is by direct infiltration from both rainfall and return irrigation flows. The soils here are highly permeable, mainly composed of 90-98% sand. Soils are therefore well drained.

However due to the intensive cultivation throughout the year, a large amount of chemical fertilizer is used by the growers. The ever increasing application of nitrogenous fertilizer in a closed aquifer, the population of the area is in danger of consuming

potentially harmful concentrations of nitrates through their food and water. The nitrate content in water and food items consumed by the people living in the Kalpitiya peninsula have been reported to be extremely high.(Table 4.).

**Table 4: Nitrate content in drinking water at Kalpitiya**

Nitrate Concentration. Category (mg/l)		No	% of wells	Mean nitrate + SD content (mg/l)
low	<50	116	51.56	31.30±10.03
intermediate	50-100	68	30.22	72.66±13.18
high	101-150	22	9.78	121.40±12.93
very high	151-200	11	4.89	175.65±16.85
	201-250	4	1.78	228.31±12.61
	251-300	3	1.33	283.33±24.73

Source: Liyanege et al<sup>32</sup>., 2000. *J. Natn. Sci. Council of Sri Lanka* 2000 28(2): 101-112

### Nitrate content of food items

Table 4& 5 shows that the high nitrate content in water in a cultivation area, is not only toxic to inhabitants but also to the consumer community that depends on the produce. The vegetable produce from high nitrate contaminated water is a potential hazard in general for both on farm and out farm populations.

**Table 5: Nitrate content of vegetable products grown in the Kalpitiya peninsula**

Vegetable	Nitrate concentration	
	dry weight (mg/kg)	wet weight (mg/kg)
Sweet potatoes	928.1	193.7
Onions	4217.6	923.5
Potatoes	2869.3	466.2
Gherkin	1,9660.0	884.7
Anguna leaves	1,4449.2	2714.7
Kurathampala	1,8069.7	3252.4
Long beans	1,0387.6	1142.5

Sweet potato--*Ipomaea batatas*, Kurathampala- *Amaranthus viridis*,  
Gherkins-*Cucumis sp*, Anguna leaves- *Timonius jambosella*,  
Red onions- *Allium cepa*, Long beans-*Vigna cylindrica*)

Source: Liyanege et al., 2000<sup>32</sup>. *J. Natn. Sci. Foundation of Sri Lanka* 2000 28(2): 101-112



The potential health implications of the contamination of drinking water by nitrates are primarily due to methaemoglobinaemia. The elevated nitrate levels resulting from leaching of nitrogenous fertilizers from paddy lands and intensively cultivated soils and a correlation between nitrate concentration and infant mortality rate has been suggested. In the Kalpitiya peninsula, monitoring of irrigation wells showed a clear correlation of ground water quality with land use. Groundwater within the intensively cultivated area typically had nitrate concentrations in the range of 10-15 mg l<sup>-1</sup> compared to 0.2 mg l<sup>-1</sup> within the non-cultivated lands.

### Fertilizer residues in Water reservoirs:

Kotmale Reservoir of Sri Lanka is presently the upper most reservoir of the chain of upland hydropower and irrigation reservoirs built under the Accelerated Mahaweli Development Project. The reservoir was commissioned in 1986. The upper Kotmale, the catchment area of the Kotmale reservoir is mostly under intensive tea cultivation with heavy fertilizer application. In a study to evaluate limnological status of the reservoir along with monitoring of nutrient loading process via its upper Kotmale catchment done during 1986 -1991, Piyasiri<sup>33</sup> reported that the reservoir was covered with a thick bloom of *Microcystis aeruginosa*.

- The Kotmale Oya tributary brought in the highest load of nutrients through the upper Kotmale catchment.
- During the rainy season, the nutrient were trapped in the bottom hypolimnetic region of the reservoir and were not available for surface bloom formation due to thermal stratification.
- The upstream region of the reservoir that received high nutrient loads through the Kotmale Oya tributary had significantly higher levels of Nitrates.
- During droughts, when the water level drops below 15m in the upstream region, mixing of nutrients was facilitated and the reservoir reached eutrophic status.
- High nutrient concentration (Phosphate and Nitrates), high temperature and high light intensity during droughts were favorable for the initiation of bloom formation in the upstream region and later covered the entire reservoir.

Eutrophication (*Increase and enrichment of nutrients in lakes and water bodies, leading to an overproduction of algae and a decrease in dissolved oxygen level*) in “Parakrama Samudraya” reservoir, located further down in the Mahaweli irrigation system, in Polonnaruwa was observed in 2000. Zoysa, 2002<sup>34</sup> reported the total nitrogen and phosphorus content at inflow and centre of the tank (Table 6)

**Table 6:**  
**Total Nitrogen and Phosphorous content in Water of Parakrama Samudraya, Pollonnaruwa.**

<b>Sampling Location</b>	<b>Mean Total N mg/l</b>	<b>Mean Total P mg/l</b>
At inflow	22.66	0.064
Tank Centre	25.46	0.098

The inflow from the surface run off through paddy fields brings in heavy levels of nitrogen and phosphorous which resulted in eutrophication stimulating *Anabena* bloom.

The normal range expected in Phosphorous level is 0.05-0.17 mg/l. The eutrophication results when total N and P content exceeds 0.3mg/l and 0.1 mg/l respectively. In Parakrama Samudraya eutrophication resulted in death of fishes due to oxygen deficiencies and toxic water causing skin irritation of people who used the reservoir for bathing. The Nitrogen and Phosphate content in Parakrama Samudraya was excessively high. The nitrogen levels were found to be higher than the rest of the reservoirs in the area. The N content at the water inflow at Ambanganga (River) inlet i.e. at Angamedilla indicating that the pollution is higher due to heavy nitrogen fertilizer use in the upper watershed of Ambangnaga.

Soil acidity seems to be the main cause in regulating the movement of toxic metals into ground water. The most dangerous additions, over and above the excess Nitrate –Nitrogen, added to soil along with synthetic fertilizer are the heavy metals.

### Heavy Metals.

Composts produced from urban waste carry excessive amounts of heavy metals. Sewage sludge that is added as fertilizer is the main cause of heavy metal pollution in farming in the western world. Heavy metals are elements having atomic weights between 63.546 and 200.59 and a specific gravity greater than 4.0. Living organisms require heavy metals only in trace quantities. For examples some of the heavy metals are cobalt, copper, Iron, Manganese, Molybdenum, Vanadium, Strontium, and Zinc. Heavy metals are released to environment from a wide range of natural and anthropogenic sources. Very often rate of addition of these heavy metals exceeds their natural process of removing as a result accumulates in the environment. Aquatic ecosystems are normally at the receiving end. (Matagi *et al.*,1998)<sup>35</sup>. Heavy metals are dangerous because they tend to bioaccumulate: i.e. increase in the concentration of a chemical in plant or animal over time, in comparison to that of environment. Compounds accumulate in living organisms any time they are taken up and stored, because their breaking down process or metabolism or excretions is very low.

Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soil and releasing heavy metals into streams, lakes, rivers and ground water. Very often aquatic resources are at the receiving end.

One of the most prominent examples of excessive accumulation of heavy metal arsenic in the alluvial deposits and subsequent release into ground water by bacterial activity was recently reported in Bangladesh. Sources of heavy metals in water table is not only agriculture many other activities of man. Coal burning plants, smelter, and other industrial facilities releases Cadmium and arsenic, waste incinerators is known to add Mercury and cadmium, pesticides and wood preservatives adds arsenic and chromium, fertilizer usually contaminants of manufacturing process in impure fertilizer add many different types of heavy metals especially cadmium is a notorious addition through phosphate fertilizer (Loganathan *et al.*,1995)<sup>36</sup>.Cadmium is toxic due to its chemical similarity to zinc an essential micronutrient for plants, animal and humans. Cadmium is bio-persistent and once absorbed by an organism, remains resident for many years (over decades for humans) although it is eventually excreted.

In man, long term exposure is associated with renal disorders. High exposure can lead to obstructive lung disease. Cadmium may also produce bone defects (Osteomalacia and osteoporosis) in humans and animals. Among the fertilizers of N.P and K the Phosphorous fertilizer are the notorious agent that adds cadmium to soil. Gray *et al.*, 2003<sup>37</sup> reported that Phosphate fertilizer in pastures of New Zealand increases the Cd accumulation in kidney and livers of sheep's and other grazing animals. Majority of cadmium when added to farm soil it remains in the top soil or easily taken into water reservoirs by surface run off. It is important to note that New Zealand researcher's reports on cadmium stated that cadmium concentration in pasture and cadmium concentration in soils were the same. However when the organic matter content in soil is higher the cadmium uptake by the plants were reduced.

It was reported that in Japan “*Itai Itai*” disease due to cadmium toxicity was a problem caused by addition of cadmium to water by an industrial accident, resulting high level of cadmium in irrigation water of rice crops. Rice grain absorbed the cadmium which resulted in poisoning consumers resulted in kidney failure and death (McKean, 1999)<sup>38</sup>.

Long term exposure to heavy metals may result in slowly progressing physical, muscular and neurological degenerative process that mimic Alzheimer's disease, Parkinson disease, and muscular dystrophy and multiple sclerosis. Allergies are common and repeated exposure may cause cancer (PSR, 2001). The average daily intake for humans is estimated as 0.15 µg from air and 1µg from water. Smoking a packet of 20 cigarettes can lead to the inhalation of around 2-4 µg of cadmium but levels may vary widely.

A base line study report presented (2003) by a research team of the Faculty of Medicine, University of Peradeniya lead by Drs. Thilak Abeysekera and Athuraliya<sup>39</sup> stated that the chronic renal disorder CRD not associated with diabetes and hypertension was

very much higher in the north central province of Sri Lanka. Among 4107 people screened for proteinuria a sensitive indicator of renal diseases, 152 were positively diagnosed as CRD patients. This amounting to 3.7% of the population was affected by CRD. In Madawachchiya alone the predicted CRD cases were 1450. It was observed that the CRD cases were different to what is reported in other countries. The underline pathological process would appear to be complex and could be due to many risk factors.

In view of the prevailing situation at North Central Province with regard to obvious pollution of water resources, the heavy metal pollution in major water reservoirs in Anuradhapura and Madawachchiya was studied by Dassanayake, 2004<sup>40</sup>. Five major reservoirs “Wewas” were studied. They were selected on the basis that they are not fed by the Main inlet from Mahaweli system, but their catchments were localized. Reservoirs were isolated from one another, belonging to different irrigation schemes. The reservoirs studied were Alankulama, Karapikkada, Kubichcankulama, Thuruwila and Ulukkulama.

Karpikkada was very close to Madawachchiya where large number of CRD patients was reported. A set of six samples each of wewa water, *Nelumbo nucifera* rhizomes (Lotus roots), soil from wewa bottom and soil from wewa periphery was analyzed for heavy metals. Wewa water samples collected using a column sampler in S shaped pattern at specific depth were analyzed for heavy metals. Lotus rhizomes were harvested by experienced lotus root harvesters from the bottom of the wewa for analysis. The heavy metals tested were cadmium, cobalt, chromium, copper, iron, lead, and zinc using atomic absorption spectrophotometry is given in table 8.

**Table 7:**  
**Mean heavy metal concentration in wewa (tank) water in comparison to Maximum contaminant level recommended by WHO for drinking water.**

Metal	MCL (ppm)	Mean Concentration (ppm)				
		Kumbich.	Alan.	Thruwila	Kara	Ulluk
Cd	0.003	0.051	0.040	0.057	0.056	0.032
Co	N/A	0.222	0.143	0.038	0.145	0.142
Cr	0.050					
Cu	1.000	0.023	0.024	0.025	0.015	0.017
Fe	0.300	0.203	0.793	0.470	0.630	1.277
Mn	0.050	-	0.181-			
Pb	0.010	0.030	0.006	0.022	0.032-	
Zn	2.000	0.100	0.099	0.065	0.106	0.099

Data from D. M. R. S. B, Dasanayake., 2004 .

It was evident from the results that the surface water in wewas tested carried detectable levels of seven heavy metals tested except for Cr. Concentration of Cd 14.7 times, Fe 1.25 times and Pb 0.8 times higher than the maximum contamination levels defined. by WHO.

Concentrations of copper and zinc were not significantly higher. Concentration of Mn is marginally closer to MCL. Each of the wewas carried at least two metals at toxic concentrations.

Nelumbo appears to extract heavy metal from water and store in rhizomes. Cd, Zn and Co is stored relatively higher concentrations in lotus rhizomes compare to that available in soil. Dassanayake 2004<sup>40</sup> reported that over 250.ppm of Cd, 230 ppm of Co, and a 400 ppm of Zinc and 8000 ppm of Fe was detected in lotus rhizomes. Chromium was not detected in lotus rhizomes. This shows that growing lotus is an ideal phyto-remediation technique adopted by traditional farming system to maintain the purity of the wewa water. However the rhizomes must be harvested and incinerated rather than consumption by humans.

**Table 8: Heavy metal concentration per 100g of edible lotus rhizomes.**

<b>Metal</b>	<b>mg/100g ** Wet weight Lotus rhizome</b>	<b>RDA * mg/day</b>
Cd	4.53	0.03
Co	4.26	0.003
Cr	N/A	1.0
Cu	0.86	0.9-3.0
Fe	142.75	0.9
Mn	10.36	2.5-5.0
Pb	0.29	0.1
Zn	26.17	15

RDA Recommended Dietary Allowance

\*\*-Data from Dassanayake, 2004<sup>40</sup>

It is evident from the data presented above on the type and degree of pollution of water resources by modern irrigated rice farming. The water resources, surface storage or ground water resources are continuously fed with agrochemicals both fertilizer and pesticides by the surface runoff and percolating chemicals. Along with these toxic byproducts and toxic heavy metals get accumulated in drinking water or in fish, meat, milk or other agricultural products, which eventually cause serious chronic health hazards to humans.



Fig. 1 *Mix cropping in the home garden to harness the benefit of the environment*  
(Pictures from Mr. G.K.Upawansa)



Fig.7. *Lowland rice culture, upland home garden and cattle rearing is done as a single farming system which is typical of Sri Lankan Agriculture*

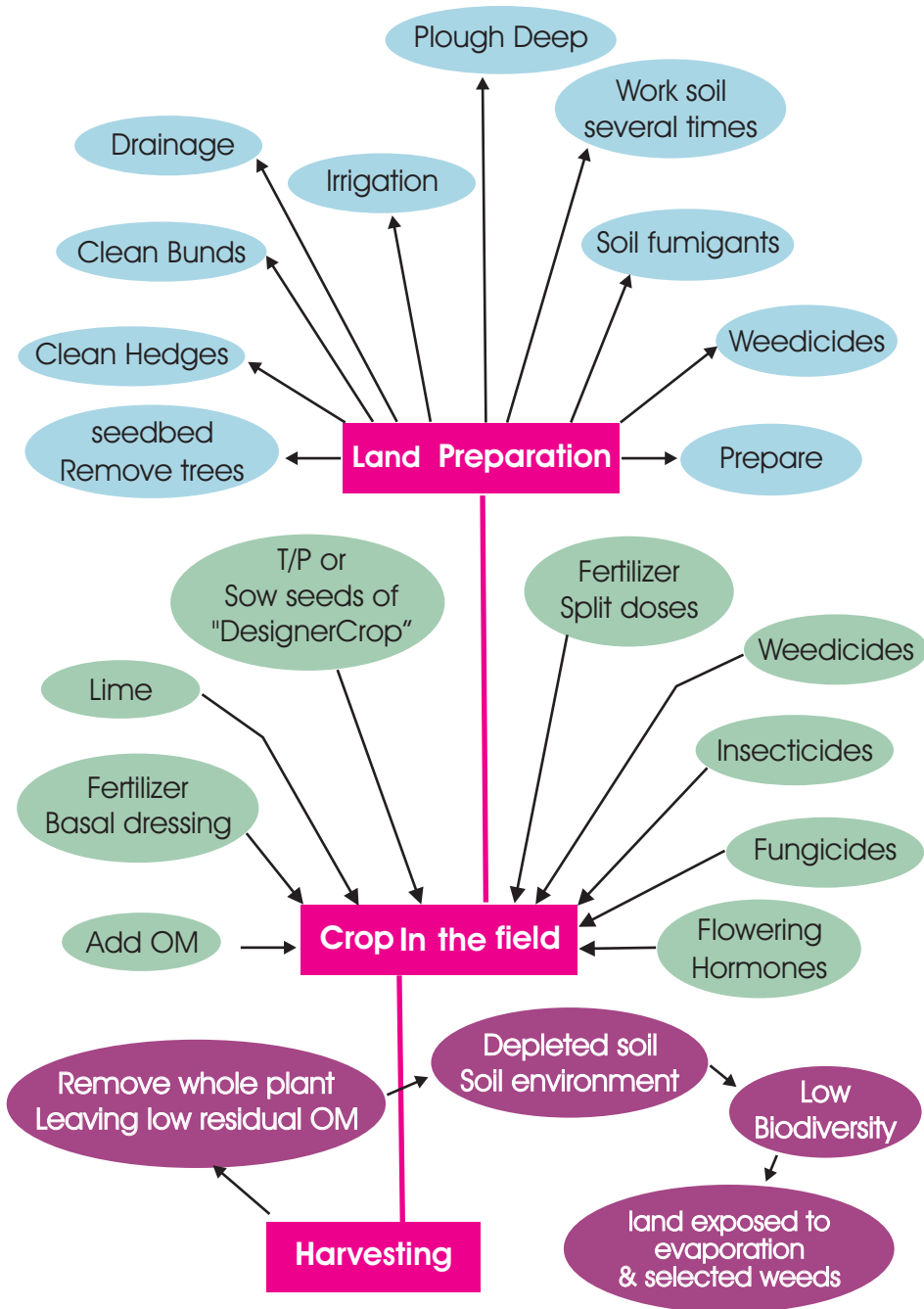


Fig.8. Events and inputs in Modern farming

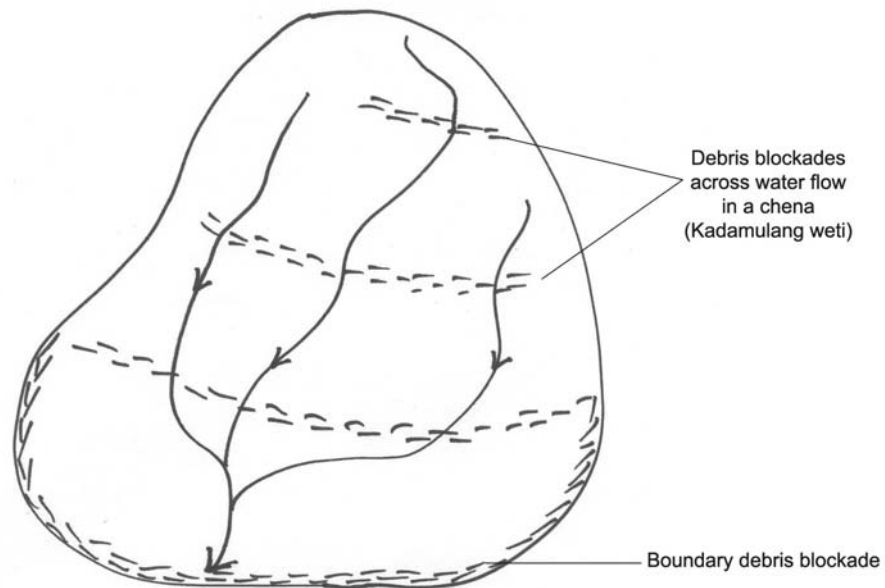


Fig.12. Soil conservation practices adopted by upland farmers after cleaning the land for sowing.  
Photo: G.K.Upawanse



Fig.13 left.

Use of nature as a partner to merge with the nature in traditional chena cultivation (Left- Photo: G.K.Upawanse) and rice farming (right- Note the conserved *Terminalia arjuna* trees in the background along the main drainage channel)  
Photo: Gamini Abeysinghe.



Fig.13right.

Use of nature as a partner to merge with the nature in traditional chena cultivation





Fig.14. *Merge with the nature and use the environment to its maximum for the benefit of farming especially pest and disease management, background shows a typical Kandyan mixed garden system of many different types of crop plants.*



Fig.15. *Minimum land preparation with light wooden ploughs (see Fig.16) was employed in indigenous agriculture to prevent excessive loss of nutrients during land preparation. (note the birds that feed on earth worms an indication of pesticide free environment, land covered with common weeds on the upper section of the photo - Wanatha is kept un-cleared, bunds are not cleared of weeds) Photo: Gamini Abeysinghe*

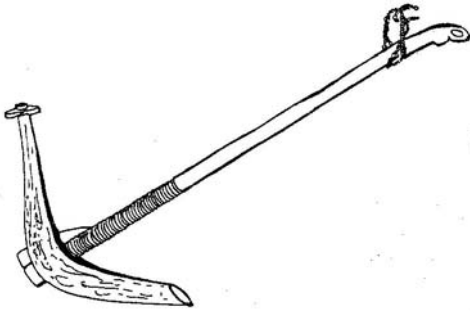


Fig 16. *A traditional light plough used in the land preparation of rice fields (left) (Source: Goonasekara and Gamage, 1999)12, and the way it is traditionally used with a pair of buffaloes for the first ploughing (right) Photo Gamini Abeysinghe.*



Fig 17: *Control draining of excess water from the seed bed using very light hand implements made of wood. (Operation of these is possible if the soil structure is improved with mulching) Photo: G.K. Upawanse*



Fig 18. Ritual fencing to keep large wild animals (Elephants, wild boar etc.) from crop fields. Left: Offerings and loud request from deities for protection with a vow to be fulfilled after harvest. Right: symbolic fencing.



Fig 19 Adukku Pooja after harvest : fulfill the vow on harvesting a good yield as promised



Fig 20 The labor intensive weed control practice adopted in rice farming in Sri Lanka, where a separate nursery of rice plants is maintained and they are subsequently transplanted to well prepared beds. Transplanting was used to practice in both wet and dry zone rice fields, but now abandoned due to break down of the community "Aththam" practice in traditional agriculture with gradual depletion of farm/family labor (mostly women) in agriculture. Transplanting wet zone paddies on hilly landscape (Left). Typical community get together for transplanting rice paddies. (Right). Photo : Gamini Abeysinghe.



Fig 21 *Left: Rice seedlings just beginning to emerge through straw mulch after irrigation of rain  
Right: Well emerged 10 days old rice seedlings in Nawakekulama.*



Figure 22. *Left: Rice plant under Nawakekulama. Right: Modern farming*



Figure 23. Root growth in rice: Left: Modern farming, Right: Nawakekulama

In 1981, Liyanage<sup>43</sup> reported an interesting study on rubber mildew control. Complete eradication of mildew on rubber young leaves and flower buds lead to bursting increase in bark rot caused by *Phytophthora*. He explained it is best not to disturb the mildew population that causes damage to flowers and reduced the fruit set. When mildew population was reduced more fruits are set and provide an ideal breeding/multiplication site for *Phytophthora* which eventually spread across the rubber estate to damage the tapping panel. An interesting interaction of two pathogens if left to nature would reduce the damage to the crop than application of chemicals for management of the pathogenic fungi.

## Nawa Kekulama

Technology used by the society today evolves regularly. Telephone is a good example. People are ever willing to throw away the old bulky mobiles to present day handy multipurpose mobiles, often irrespective of the price. Farming systems are also subjected to the same phenomenon. However the main criteria to consider are that they should be ecologically, economically and socio-culturally viable and therefore sustainable. Indigenous technology has been ecologically viable. For the sake of completeness it is fair to assume that only those ecologically viable systems had survived the test of time. The oldest records in Sri Lanka on use of fertilizer for rice farming is in "*Buthsarana*" written in 12<sup>th</sup> Century A.D., However, it is not certain when exactly such inputs in agriculture was commenced (Siriweera,2005<sup>3</sup>). Although, the ancient farming system and land use pattern was a well organized sustainable system, it was subjected to severe strain by the political changes in the region, where major influence was the invasion by south Indian tribes Cholas who ruled major areas under irrigation during 1017-1070 A.D. According to Siriweera,2005<sup>3</sup> by mid 13<sup>th</sup> Century irrigated farming system began to disintegrate. Many farmers moved towards the wet zone lowland upcountry areas. However the remnants of irrigation based farming system was not easily destroyed. The chenas and irrigated rice field cultivated with improperly managed tanks and canal systems still prevailed. The workmanship of the tanks has been excellent as stated by Tennent,1859<sup>44</sup> with respect to Minneriya tank in the year 1848. with respect to Kaudulla tank which was still strong in the year 1680. There were pockets of villagers fed by the surviving tanks and they continued to farm using chena and rice farming system until they were severely affected by Malaria epidemic, most probably due to dismantled irrigation systems. In order to seek solutions and alternative to overcome the bad impact of modern farming technology it is desirable to integrate the beneficial aspect of indigenous technology to the modern farming systems. Nawa Kekulama, a modern dry farming system of rice farming, with straw mulching, substituting the practice of impounding water for weed management, was selected to meet the need of sustainable rice farming system. Traditionally rice farmer in Sri Lanka practiced both paddy –lowland rice farming system and upland dry farming system. Rice farmer is essentially a part-timer, who is also involved in many other activities for their livelihood. The total man day's requirement for an average rice farm of 1.5 acres is 43 (this estimate was done with the assumption of sharing labor with others in the village). Taking into account the variability of land and labor a comfortable estimate of 50 man days per season, only a hundred man days are needed for two crops per year out of 365 days. It is not practicable or economical to expect rice farming alone could maintain a family at least of five members. Traditionally all Sri Lankan farmers were maintaining mixed home gardens and were involved in other several activities such as wood crafting, carpentry, metal crafting, music or dancing or even pottery, or other professions such as teaching, treatments of snake bites, general health problems,, setting fractures, eye ailments, burns, skin problems or Psychotherapy and treatments of animals. However, trading and farming were never seems to be coexisted livelihood in ancient Sri Lanka.

Answer to all this is the use of farming system with a holistic approach which is not design to compete with nature but coexist or merge with nature in harnessing nature's way for the benefit of farmer. Traditional farming practices such as Kekulama or upland rice farming with mulching, Chena cultivation or Kandyan mixed farming systems techniques were using time tested ecological farming practices. Traditional dry sowing–Kekulama or upland rice farming practices in ancient Sri Lankan agriculture used minimum tillage practices and timely cultivation procedures for sowing of germinated or un-germinated rice seeds with mulching. Chena cultivation practices used methods that caused minimum damage to the environment and activities that are really well merged with the ecosystem (environment) to explore the pest and diseases management practices of ecosystem.

The Nawa Kekulama (NK) a farming system of rice, a more modern interpretation and an adaptation of traditional practices. G.K. Upawansa<sup>45</sup> proposed a more modern design incorporating most beneficial practices of dry farming of rice and paddy farming practices, as a farming practice for rice that integrates indigenous knowledge for the benefit of all Sri Lankans. NK has been now gone through a process of evolution by collective tests done by farmers and also by the University. Nawa Kekulama is adopting all the excellent features of indigenous knowledge that can be intelligently integrated for the practice of timely cultivation of rice for efficient use of water for higher yield per unit of water. The main objectives in designing the rice farming system based on indigenous farming techniques are To:

- Conserves soil — low land disturbance
- Conserve Organic Matter. OM-Mulching
- Conserve water- Do not use excessive water for weed control
- Conserve N — Inhibit denitrifying bacteria — Neem cake use
- No heavy doses of synthetic fertilizer application-Water Quality (WQ) not affected.
- No pesticide application — WQ and Air Quality preserved.
- Use of ecosystem /Biodynamic and astrology to harvest their benefits in farming and conserve environment
- Pest Management by Ecosystem management.
- Sustainable: Low cost of production

## What is Nawa Kekulama

### **Kekulama–Nature farming:**

Kekulama is a cheaper simpler and low input ecofriendly farming system for rice. Salient features of the rice farming system practiced by Mr. G.K.Upawansa are

- (a) No cleaning of bunds or rebuilding of bunds involved.
- (b) Minimum working of soil, almost no tillage or ploughing is necessary.
- (c) Mulching with paddy straw of the previous season, immediately after sowing.



### **1. Maintain Bunds.**

It is important to repair the damage areas of the bunds especially those caused by burrowing animals and trampling by large animals. As a curative action for natural erosion of surface soil by rain or surface runoff it is advisable to take about 2 inches of soil from the inner bottom of the bund and place them on the top of the bund. This should be repeated every season. Process is referred to as "*Dette gahanwa*" in the traditional farmer's terminology in Sri Lanka. This process strengthens the bun with regular land preparations over the years.

### **2. Land Preparation.**

Tillage and ploughing takes a very small place in Kekulama. Land preparation is very easy and it is incidentally a process of minimum tillage. If the soil is a loam soil ploughing once even without water is sufficient. Second ploughing could be done prior to seeding. What we really need is a sough surface free of clods. If the field is "Bog soil type", second ploughing 10-14 days after first ploughing would keep the weeds down. However it is important to maintain a well drained field prior to the commencement of ploughing mostly to prevent fertile soil drained off as a surface runoff during and soon after ploughing process. What is required is more a tilled soil with small aggregates that allow mixing of air with soil. Aeration will increase the active soil depth which is needed for a better root system.

### **3. Sowing and mulching.**

For both dry of we land preparation, it is expected to have tiny clods of soil on the surface after second ploughing. Therefore leveling of the field could be done using a simple implement like a mamoty. Drainage canals could be opened up with the mamoty in order to prepare the beds for sowing. If the bed is dry, sow dry seeds without pre-germination.

Pre-germinated seeds can be sown on to puddle soil within two days of sowing. Mulching is done with previous season straw. Although the quantity of paddy straw needed depends on the thickness of the mulch applied it is sufficient to use straw collected from one acre of rice field to cover one acre of sown beds. If irrigated water is available, as soon as the mulch is complete, straw could b soaked in water for about 6-12 hours.

### **4. Fertilizer application.**

A minimum quantity of urea fertilizer is recommended for application to farm just being converted from modern farming practice to Kekulama. Add not more than 7kg per acre as follows. Crush 2kg of neem seeds to make a fine powder. Mix the 7 kilograms of Urea with 2 kg of Neem seed flour. Mix it thoroughly using a motor and pestle. Collect about 2-3 bags of compost or humus/cow dung

mixture sufficient enough to evenly apply to an acre of land. Mix the urea neem flour mixture in to this compost at about 3.30 pm and keep it well covered in the shade for about 2 hours. Broadcast it to the field after sunset. This could be applied as a basal dressing or 10 days after sowing and also 20 days after sowing. It is by about the third season the use of urea in the compost mixture could be avoided with out any harmful effect on the crop, in a field where inorganic fertilizer has been used regularly. However neem seed compost mixture must be applied regularly. In about four years time the crop could be considered totally naturally (organically) farmed.

### **5. Irrigation.**

If there is good drainage in the field it is acceptable to sow/mulch while there is slight standing water in the field. About 15-20 days after mulching/soaking it may be required to wet the straw mulch again depending on the rate of drying of soil under mulch. This is absolutely essential to maintain a good weed control. After 2 or 3 wettings it could be left to dry and irrigate as and when necessary like a normal upland crop. Two months before maturity of ear heads, soil should be at field capacity.

### **6. Pest and disease management**

There is no specific plant protection methods applied in Kekulama. However the pest and disease management is inbuilt in to the farming system. It is a eco-friendly integrated plant protection system. Objective is to encourage the natural protection by increase in biodiversity to attract predators or parasites for pest and disease control or management.. Methodical and comprehensive nutrient supply program adopted by Kekulama, strengthen the crop to resist pest and pathogen attack.

Timing of planting, Kems and use of astrological practices, pirth and charms are also used to protect the plants in case of sudden and explosive pest and disease explosions.

Use of biodynamic for plant protection is exploited . The concept of Biodynamic agriculture, or biodynamic comprises an ecological and sustainable farming system, that includes many of the ideas of organic farming. Dr. Rudolf Steiner<sup>46</sup>, introducing the philosophy and practice of biodynamic farming emphasized that many of the forces within “ living nature” especially in the making of compost within the farm unit, stressing the fact that the farm being a self sustaining self sufficient unit. Steiner forwarded the idea that the quality of food is degraded due to the use of artificial fertilizer and pesticides. Steiner stressed the fact that this degradation is not only due to addition of synthetic agrochemicals but also due to spiritual shortcomings in the farming system adopted.. Steiner, however considered the world and everything in it as simultaneously spiritual and

material in nature where the activity of living matter was different from dead matter. The term "biologically dynamic" or "biodynamic" was coined later by followers of the concept proposed by Steiner. The salient feature of biodynamic is that the farm as a whole is seen as an organism, and therefore should be a closed self-nourishing system. This very same concept is reflected in the consideration of the main *Wewa*—the reservoir of water and the associated smaller reservoirs—*Kulu Wewa*, meaning smaller tank units located in the forests, mainly the watershed and the irrigation channels, waste water channels, sluice gates and the whole water distribution system and the farmers and farms as "living system" in ancient Sri Lanka Ausadhahamy, 2004<sup>14</sup>. Biodynamics used in the Nawa Kekulama is similar but not the same as compost making and other activities prescribed by Steiner namely the eight different preparations for fertilizers which were allowed for use in biodynamic agriculture, 500: (horn-manure), 501, 502: Yarrow blossoms (*Achillea millefolium*), 503: Chamomile blossoms (*Chamomilla officinalis*), 504: Stinging nettle (*Urtica dioica*, and the whole plant in full bloom), 505: Oak bark (*Quercus robur*), 506: Dandelion flowers (*Taraxacum officinale*), 507: Valerian flowers (*Valeriana officinalis*)

### Cosmic Rhythms

The light waves of the stars, our star the sun, moon and other planets are received by the plants in regular rhythms. These in turn regulate and influence the growth and quality of the plant. This is seen clearly in the harvesting of medicinal plants and parts of medicinal plants in Ayurveda—the traditional medicine-pharmacology. The plant parts are harvested according to the movement and position of the moon in order to extract the correct active ingredients needed. (Nugawela, 2005)<sup>47</sup> Similarly by understanding the gesture and effect of each of rhythm, we can plan and time our land preparation, sowing, cultivating and harvesting to the advantage of the crops we are raising.

The correct cosmic rhythms are trapped by following the specific auspicious time or *Nekatha* and specific dates etc. Requesting support from regional deities, use of pirith, charm and kems are included as a ritual practice adopted prior to the commencement of land preparation as community activity. These activities are usually regional based and are carried out as recommended by the elders in the respective community and the religion. In general it involves:

1. Prior to commencement of the cropping season as a community activity, held in the field:
  - a. Boiling cows milk and allow it to overflow from the pot (in the field)—a ritual to symbolize success. Commonly practice at the beginning of a major event like commencement of construction work, moving into new premises, commencement of business or even at the commencement of the New Year.

- b. Rituals and offering to regional deities (consecrate process: *Pooja*) to satisfy the deities expecting favors from them for the success of the event that is to begin.
  - c. Vows–Offerings to deities as a vow to perform specific predetermined ritual or offering of flowers/food etc. after the fulfillment of the requested favor from the deities.
  - d. Hanging a coconut or placing it prominently on a strong wooden pole – (Establish *Kapa*) : It is the commonly used indicator that make it visible to every one in the community that a vow has been made an entered into an agreement with the respective deity to fulfill on the successful completion of the farming procedure. It appears that such reminders are prominently displayed so that the vow would be duly satisfied on time. The common belief is that the failure to do so will anger the deity which cause erupting viral diseases such as chicken pox, measles, mumps among the villagers.
  - e. Vows performed by rapping a cleaned coin in a clean white piece of cloth with contemplation for success and promise to offer food and flowers or lighting of lamp to specific deities. The wrapped coined acts as a reminder of the vow.
2. During the cropping season held in specific temples for deities (devale):
- a. Perform ceremonies for requesting higher yield and crop protection from wild animals and pest.
  - b. Special offerings or *Poojas*.
  - c. Spreading pirith chanted sand, water or wood ash in the field or in field boundaries.
  - d. Spread sand chanted with Specific mantra.
  - e. Hanging areca nut flowers in around the field.
  - f. Hanging or burring chanted talisman in the field.
3. End of the cropping season.
- a. Boiling milk in the filed.
  - b. New rice (rice harvested from the current season crop) ceremony.
  - c. Specific all night dancing ritual ceremonies offered to deities.
  - d. Sports like events linked closely to rituals offered to deities: *An adema* or *pora pol* (Pora pol= villagers divided into two teams play, game where, one of the player is expected to crack open a coconut thrown at him by a another player from the opposite camp using another coconut. The coconut with the thicker nut and the eyes would survive the force. Once all the coconuts brought by the player s are cracked open it is transported to the temple or the temple of the deity concerned for extracting coconut oil for burning lamps at the temple. dancing steps according to specific steps played by drummers are taken to crack coconuts thrown at one of the player by the opponent).

4. Use of cosmic energy and biodynamic forces for crop protection.
  - a. Start fencing at a auspicious time based on *Sinha Karana* (Lion Karana) to protect crop from wild elephants
  - b. Start fencing at a auspicious time based on *Divi Karana* (Leopard Karana) to protect crop from other wild animals such as wild boar, porcupine and rats etc.
  - c. Avoid use of auspicious time based on *Gawa* (cattle) or *Ooru* (pig) Karana to Commence any work to prevent damage caused by cattle/wild buffaloes and wild boar.
  - d. Select the relevant auspicious time according to the crop used I the field.
  - e. Select auspicious time to enhance yield.
5. Other methods:
  - a. Minimum or Zero tillage
  - b. No tilling or disturbing of soil
  - c. Mulching
  - d. Mixed cropping
  - e. Planting multipurpose trees within the field
  - f. Fallowing at regular intervals
  - g. Use of green fence
  - h. Use liquid fertilizer as recommended by ecological farming practices and biogas compost.
  - i. Use of compost.

In a field experiment conducted in a complete randomized design, with rice at Aralaganwila, Polonnaruwa, Sri Lanka, in 2001 we compared the integration of Indigenous knowledge in rice farming as Nawa Kekulama with modern farming. Experiments were conducted in farmers' fields of size half an acre. We used improved rice varieties BG 300 and HG 352 with a traditional variety Samba. Modern practice of extensive land preparation, clearing of bunds and application of basal and top dressings of synthetic fertilizer and weed and insect pest control by chemical application were done.

Nawa Kekulama: Aralaganwila 2001 was done as follows.

Commenced on auspicious "*Hora*"

Field boundaries demarcated with "*pirith*" chanted water

Rituals and rites were done according to the region farms were committed to "*Gambara deity*".

Special *Kap Pooja* was done before commencement.

Fertilizer application was done as described in item 4 in Nawakekulama Box.(above)

Germinated rice seeds were sown and the seeded field was covered with straw mulch.

Ecosystem management.

Bunds and *Wanatha* (uncultivated upland, around the field were left un-weeded

**Table 9:**  
**Comparison of profit gain per acre of lowland rice using Kekulama and modern farming.**  
**(Based on 2001 price)**

<b>Farming system</b>	<b>Per acre Mean Rice yield Kg *</b>	<b>Income in Rs (@Rs 12/kg)</b>	<b>COP Rs</b>	<b>Profit/acre Rs.</b>
Nawa Kekulama	1877	22,524.0	7,600.00	14,924.00
Modern farming	2258	27,096.00	16,610.00	10,486.00

\*Mean yield of three farmers

Source : Samarasinghe, 2001<sup>48</sup>

- Chemical applied fields were devastated with paddy bugs *Leptocorisa acuta*. Wherever weedicides applications were not carried out, early development of paddy bug populations were very obvious in flowering weeds. However at the flowering stage of rice crop, paddy bug population were at a minimum and no damage was recorded (Samarasinghe, 2001.)<sup>48</sup> in plots where no weed control was practiced. It was evident that the early development of paddy bug population in weeds encouraging build up of parasites that eventually protected the late flowering rice crop.

Nawa Kekulama uses indigenous knowledge in conservation of water. In year 2003-2005 in a series of experiments conducted at Hurluwewa we measured the quantity of water we could save using Nawakekulama in rice farming. The water use efficiency as amount of water used per g of dry matter produced was estimated for Nawa Kekulama and modern farming method. The amount of water required for NK was 14993.33 cubic meters per ha compared to 73,804 cubic meters per ha in modern farming. The water use efficiency in NK was 2.36 cubic meters per g of dry matter produced in comparison to 5.147 cubic meters per g of dry matter produced by modern farming. The benefits of NK in rice farming are immense. It is mainly in the improvement of soil structure and thereby the root growth pattern of rice plants. It appears that we could meet the requirements stated by Wayne Meyer of Australia. World is now eagerly searching for a rice and, other crop varieties that produces high yields with less water. But the task seems to be more laborious and expensive. I wish to quote Wayne Meyer of CSIRO, land and Water Division, Adelaide, Australia” We need a quantum shift in the amount of carbohydrate we can produce per unit of water. It is got to be seen as the equivalent of putting the man on the moon”.

We observed that in the Kekulama fields there was more diverse fauna and flora both on the undisturbed bunds and hedges. The role of Ants (*Solenopsis geminata*) in the destruction of weed seeds available in the field was very much visible. Most weed seeds from the post harvest fields are collected by ants and stored in their hills for future use and as such kept away from the field. Close observation of the ant hills showed that they were full of weed seeds. In the modern farming the cleaning and slashing of the surface soil into the field tend to re-inoculate fields with these collected weed seeds that are stored in the ant hills. Such reseeded would lead to eruption of large population of weeds in the field.

We observed 27-29 parasites and predators in the Kekulama fields. A list of predators and parasites we have observed in ecologically farmed rice fields are given below. It was evident that such diversity was not present in fields where modern farming practices were adopted. Table 10 shows the impact of one season of ecological farming in a field that was continuously on agrochemical use during the past decade in Mahiyangana in 1999 on the occurrence of some selected predators and parasites.

### **PREDATORS.**

Spiders:*Argiope catenulata*

*Atypena spp.*

*Oxyopes spp.*

*Phidippus spp.*

*Tetragnatha spp*

*Ophionea indica*

*Harmonia octomaculata*

Micraspis spp

Hemiptera:

*Cyrtorhinus lividipennis*

Hymenoptera:

*Panstenon spp.*

Odonata:

*Agriocnemis pygmae*

### **PARASITES**

Hymenoptera:

*Macrocentrus homonae.*

*Opius sp.*

*Phanerotoma sp.*

*Brachymeria sp.*

*Elasmus homonae.*

*Copidosoma sp.*

*Tetrastichus schoenobii*

*Charops brachypterum & C. erythrogaster*

*Xanthopimpla punctata*

*Anagrus sp.*

*Telenomous triptus*

*Oligosta sp*

*Gryon sp*-egg parasite of paddy bug

*Platygaster oryzae*-gall midge parasite

*Platygaster sp.* gall midge parasite

*Euritoma sp*-gall midge parasite

*Gohatocerus sp.*-Egg parasite of leaf hoppers

*Paracentrobia sp*-Egg parasite of leaf hoppers

**Table 10:**  
**Parasite, parasitoid and predator population as number per square meter in "Palitha Morayaya" rice field after a single season on ecological farming which was earlier on agrochemical use for the past continuous ten years.**

Parasite or predator	Kekulama Farming	Modern farming
Carabid beetle	0.3	0
Damsel fly	0.3	0
Epilacna beetle	-	0.3
Hymenopterans	16.3	6.3
Dipterans	22.6	7
Oxyopidae	0.6	0

Data from : Impact of ecological farming on rice ecosystem: A Sri Lankan case study; Bandara, JMRS, Upawansa, G.K, Abeysinghe Banda, D.M.G. and K.L.Santh Silva. Report submitted to PASASA.1999.

The occurrence of different pest in the same field (Farmer Palitha-Morayaya) in 1998 given in table 11 provide ample evidence even in a single season of ecological farming adequate protection from pests could be obtained by natural predators and parasites.

**Table 11:**  
**Occurrence of pests as a mean number per square meter in rice fields cultivated as Kekulama and using modern farming practices at maturity at the field of Palitha Morayaya, Mahiyanganya in 1998.**

Pest	Kekulama Farming (No chemicals)	Modern farming (Pesticides applied)
<i>Nephotettix cincticeps</i>	19.6	112
<i>Oxya chinensis</i>	1.6	1.3
<i>Leptocorisa acuta</i>	-	1.3
<i>Nezara sp.</i>	-	1.0
<i>Nilaparvata ligans</i>	82	257
<i>Recillia dorsalis</i>	13.3	16.3

Data from : Impact of ecological farming on rice ecosystem: A Sri Lankan case study; Bandara, JMRS, Upawansa, G.K, Abeysinghe Banda, D.M.G. and K.L.Santh Silva. Report submitted to PASASA.1999.



## Mulching with Straw

Figures 21, 22 and 23.. shows the effect of mulching on the weed population in Kekulama fields. The drastic reduction in infield weed population was evident and made life easier for the farmer. No chemical or manual weeding was practiced in any of the Kekulama fields. Some of the left over weed plants in the field almost always flower earlier than the rice crop and thereby harbor paddy bug *Leptocorisa acuta*. This fact was making most farmers scared at the very first attempt to use Kekulama. Soon it was obvious that the breeding of *Leptocorisa* in weeds either in fields or on bunds and hedges invited quick build up of parasites and predators that eventually arrested any pest attack on the rice crop that would mature after the weeds.

In a field trial conducted at Mahaweli river diversion scheme system B in Pollonnaruwa during early days of evaluating Kekulama, I was scared to see the weed growth on the bunds and some times a light undergrowth in the rice field. Mr. Upawansa who was well experienced with Kekulama farming at that time promptly noted my distress and build my courage to tolerate weeds. The traditional training in Agriculture, I have received made me to think that all plants other than the crop (non-crop plants) are a threat to the well being of the rice crop, therefore have to be destroyed. The concept of " nature as a competitor" must be abandoned. One must understand the role of other plants in the ecosystem and the farm environment in protecting and supporting the rice plant. Learning to appreciate the value of weeds and their contribution towards maintaining dynamic equilibrium of the system is an imperative process in ecological farming. Alteiri (1987)<sup>49</sup> stated that the presence of weeds in the crop fields can not be automatically judged damaging and need of immediate control". Weeds should not be alarm bells of disaster, but they are signs of status of the field. Very often the nutrition status and organic matter reserves are indicated by the types of weeds prevalent in a field. Good ecological farmer should observe the types of weeds and familiarize what they are expressing. However in rice fields weeds serve many purposes. They protect the soil surface. Some serves as transient nutrient reserves which are otherwise lost to the atmosphere. In rice fields dicotyledons weeds that possesses deep root systems access nutrients from below the root zone of the rice plants and return them to the neighborhood of the rice root system. They also provide a diversity of habitats to predators and parasites. For example weds of the family *Umbiliferae* with a shallow nectar source serve as the food source for the predator wasp, parasitic insects and ants.

## Incorporate organic carbon and N

Effect of mulching on the incorporation of organic manure was very evident. However it was shown that the N incorporation was significant when rice straw mulch is used in lowland rice culture.

Nawakekulama aims at improving N fertility of rice soil by improving and conserving

- \* N content in soil
- \* N transformation in soil
- \* N absorption by rice roots.

N content in rice soils were improved by the addition of rice straw as mulch in Kekulama. Ponnampuruma 1984<sup>50</sup>, working at IRRI fields showed that the yearly N gain by addition of Straw is 77-113 kg/ha.

**Table 12:**  
**N gains in lowland rice soils due to straw incorporation over 7 years Ponnampuruma,1984.**

No. of rice crops	N %		Yearly N gains kg/ha
	Straw removed	Straw added	
14	0.1880	0.2150	77
14	0.1787	0.2183	113

The observed N gain was caused by N<sub>2</sub>-fixation, not by a reduction of soil N loss. Straw enhanced N gain at the rate of 2–4 mg per g straw. However, this gain was not observed when soil N availability was high. Dry fallow between rice crops decreased the N gain. Santiago-Ventura *et al.*, 1986.<sup>51</sup>

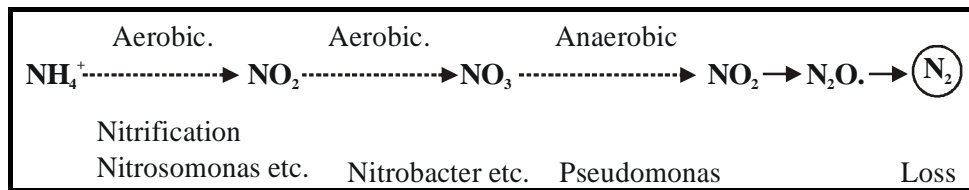
Similarly the Kekulama favors N absorption by improving soil C level by regular mulching. N availability and uptake by rice depends on soil C. Research report from IARI in 1989 on lowland rice fertilized as NPK with or with out farm Yard Manure in Hyderabad and Pantnagar, studied over period of 16 years from 1971-1987 showed that N uptake was significantly higher in rice fields fertilized with both NPK and Farm yard Manure. Table 13.

**Table 13:**  
**Changes in N uptake in rice. IARI,1989**

Site	Fertilizer	N uptake kg N/ha/crop	
		71-85	1985-87
Hyderabad	NPK	78	59
	NPK+FYM	96	92
Pantnagar	NPK	124	92
	NPK+FYM	139	128

Improved soil structure achieved by regular mulching in Kekulama favored shallow ploughing. Since there was no necessity for deep ploughing, energy on land preparation could be saved in addition to prevention of soil erosion and loss of richer surface soil during land preparation activity.

Efficiently sustained N status of soil by maintaining a balance between N loss and N gain by BNF (Biological Nitrogen Fixation) by rice root associated *Azospirillum* and *Beijerinckia* spp. is an aspect Kekulama farming which enhances nutrient status of soil. In addition to encouraging BNF by providing well aerated soil structure, N loss during first 4 weeks was reduced by adding Neem to compost or urea (See Box on Kekulama). Vyas *et al.*, 1993<sup>54</sup> showed that Neem could increase rice yield by 35% by the reduction of denitrification. Although in anaerobic soils denitrification is higher, in our studies in Pollonanruwa-Aralganwila we observed that addition of Neem prior to mulching, reduced denitrification. The process of converting Ammonium to gaseous nitrogen which is subsequently loss into the atmosphere is a common problem in anaerobic rice soils. However the maintaining at stage possible for intake into plants that is as nitrate is vital. Nitrate is liable to loss as gaseous nitrogen in the presence of *Pseudomonas* spp. in anaerobic-reduced soils. The role of Neem is to suppress this denitrification process. (Samarasinghe, 2001)<sup>48</sup>.



In a modeling study in wetland plants, Kirk and Kronzucker, 2005<sup>52</sup> reported that substantial quantities of  $NO_3^-$  can be produced in the rhizosphere of wetland plants through nitrification and taken up by the roots under field conditions. The rates of  $NO_3^-$  uptake can be comparable with those of  $NH_4^+$ . They also showed that rates of denitrification and subsequent loss of N from the soil remain small even where  $NO_3^-$  production and uptake are considerable. Nitrate uptake by wetland plants may be far more important than thought hitherto. This has implications for managing wetland soils and water. Therefore application of neem for suppression of denitrification bacteria though not significant would be an essential component in nitrogen management in rice soils.

For a field where 15-25 kg of urea/acre was added, NK add about 7kg of urea per acre along with 2kg of Neem seed cake in 2-3 bags of compost. It is now known and Neem is also available as a commercial product (Nimin) that inhibit N loss when urea is added to field. Neem as a Nitrification inhibitor was tested by Vyas *et al.*, 1993<sup>54</sup>. 1 part nimin+100 parts urea wt/wt- reduce N through denitrification by 30-35% and increase yield by 35%: Vyas *et al.*, 1993<sup>54</sup>. Neem urea coating agent-Nimin containing 5% Neem bitter tetranortriterpenoids which probably the denitrification agent, which we observed to suppress denitrification bacteria in the laboratory test of soil collected from Kekulama fields from Aralaganwila.

## Rituals in Kekulama

The intrinsic nature of the traditional system of farming is that it is based on a holistic concept and none of the factors that we have discussed so far whether it is biodynamic, ecological or rituals, are independently had any major effect. But all factors are additive and cumulative in the final impact on sustaining the dynamic equilibrium of ecosystem. This holistic approach demands friendlier approach to components of the ecosystem especially animal component. This was achieved with the religious base in which the holistic concept was based on, namely friendliness towards all animals big or small, visible or invisible generally referred to as Metta or loving kindness.

Concept of ecological farming is based on "Loving Kindness" (*Metta* in Pali, the language of Buddhist scripts), no destruction of life at any time. In most religions loving kindness is practiced. However in Kekulama it is traditional that the farmers adopted Metta-loving kindness without any concern for the size of the animal they deal with. A brief encounter with Metta Sutta practiced by Buddhist will explain the principles used in adopting Metta in farming. Some of the virtues expected from a farmer to practice Metta is no doubt useful to any person. However for the benefit of the readers I wish to reiterate some that are more relevant to farming. One who wish to practice loving kindness must have the virtues describe in Metta Sutta..

In most religions loving kindness is practiced. However in Kekulama it is traditional that the farmers adopted Metta- loving kindness without any concern for the size of the animal they are dealing with. Although Buddha did not specifically mention about farming, he stressed the importance of extending *metta* or loving kindness to all living being in practicing one's livelihood. The specific methods are stated in the *metta sutta* in several stanzas. I give below the complete stanzas as compiled by Prof. Indira De Silva.2005<sup>53</sup> (what is stated in italics is Pali text followed by its translation in English). With Same stanzas water is chanted many times to be sprayed on to crops for pest damage problems.

### Stanza 1

*Karaniyam atthakusalena yam tam santam padam abhisamecca  
Sakko uju ca suju ca suvaco cassa mudu anatimani*

Meaning: To have attained (*abhisamecca*) the extinction –state-of- peace (*santam nibbana–padam*) he knows with mundane understanding the extinction state (*nibbana –padam*) to be one of peace (*santam*), and when he wants to arrive at it, then what (*yam*) should be done (*karaniyam*) by him is (*tam*), which should be done by one with skill (*kusala*) in good (*attha*).

One who desires to abide in the state of peace, after having contrived to attain it, or who, after contriving to attain it with mundane understanding, is practicing the way finally arrive at it, would be able to penetrate the truths.

- 1) *Uju*: Being able, he would also be with possession of honesty and sincerity. (all action entered upon with an upright mind end in success)
- 2) *Suju*: Thoroughly right instead of being content with being right, repeatedly promoting non laxity as long as he lives. *Suju* is the degree of uprightness which enable one to withstand forceful disturbing factors (*kleshas*) arising from within and remains unshaken in the face of obstacles however great. He is right with abandonment of crookedness of body and speech and upright with abandonment of crookedness of mind.
- 3) *Suvaca*: He would be meek, easily speakable to, pleasant in speech and accepting others advice
- 4) *Mudu*: He would be gentle, Malleable/flexible.
- 5) *Anathimani*: He would not be proud or arrogant.

## Stanza 2

*Santussako ca subharo ca appakicco ca sallhukavutti  
Santindriyo ca nipako ca appagabbo kulesu ananugiddho*

- 6) *Santussako ca* : He is content with what there is—abandoning of approval and resistance with respect to the desired and undesired.
- 7) *Subharo ca*:. He is easy to support / sustain. He needs no assistance from the external world to keep him happy.
- 8) *Appakicco ca*: He is unbusy. He is not occupied with many kind of busied ness.
- 9) *Sallahukavutti*: His way of life is light (Frugal/economical). He is able to engage himself in the usual mundane activity with a light mind, without being a burden to him. He works in a relax mind.
- 10) *Santindriyo ca* : He has faculties that are serene. His faculties (six senses) are un-agitated by lust for desirable objects or ill will towards undesirable objects. It denotes a non- agitated, relax and disciplined state of the sense organs in their reaction with the external world.
- 11) *Nipako ca*: Knowledgeable, intelligent, and possessed of understanding. He is possessed of understanding about guarding virtue. This enable him to arrive at correct decision, based on wise judgement (*Nepakkha panna*)
- 12) *Appagabbo*: He is not impudent. He is modest. He is devoid of bodily, verbal and mental impudence. Disciplined state of body, verbal and mental action. Pure action becomes the habit.
- 13) *Kulesu Ananugiddho*: Whatever families the bhikkus approaches, he does not fawn (flatter) upon them. He is not one who sorrows with them and relishes with them. In lay life non attachment to variety or diversity that is not in conformity.

Loving kindness can be maintained in being thus: " Let all creatures be joyful" or " Let them be safe" or " Let their heart rejoice"

### Stanza 3

*Na ca khuddam samaccare kinci, yena vinnu pare upavadeyyum  
Sukhino va khemino honyu, sabbe satta bhavantu sukhitatta.*

When he is thus doing what should be done, he would do no slight thing (*Na ca khuddam samaccare*), and in not doing it, it is not only the small things but also anything bad at all (*kinci*), he would not do even as much as a little. He would not do things what wise men might deplore. (*yena vinnu pare upavadeyyum*). Wise men are described as those who, after inquiry and investigation, speak in dispraise of what deserves dispraise and praise what deserve praise.

To those who are not wise, however good an action may be, it becomes unpalatable, so long as it is not in keeping with their wishes or caters to their own self-interest. It is because they hold ideals dictated by minds that are full of impurities.

*Sukhinova* (possessing pleasure) *khemino* (Having safety fearless) *Sabbe* (every/without remainder) *satta* (breathing things) *bhavantu sukhitatta* (heart rejoice, have a pleased self)

Let all creatures be joyful or let them be safe or let their hearts rejoice.

### Stanza 4

*Ye keci panabhutatthi-tasa va thavara va anavasesa  
Digha va ye mahanta va-majjhima rassaka anukathula*

Whatever (*Ye keci*) breathing beings (*panabhutatthi*) there are, no matter whether frail (*Tasa*) or firm (*thavara*) with none exempted (*anavasesa*), those beings with long (*Digha*), big sized (*Mhantha*), medium sized (*Majjhima*), short (*rassaka*), small (*anuka*) and thick bodied (*thula*)

*Frail- those with craving and those with fear;  
Firm- (Arahants) who have abandoned craving and fear.*

### Stanza 5

*Dittha va ye va addittha-Ye ca dure vasanti avidure  
Bhuta va sambhavesi va-Sabbe satta bhavantu sukhitatta*

Those seen (*Dittha*) or unseen (*addittha*), whether dwelling far (*dure*) or near (*avidure*), that are (*Bhuta*) or that yet seek to be (*sambhavesi*), let every (*sabbe*) creature's (*satta*) heart rejoice (*Bhavantu sukhitatta*).

Those that are—that have been born or generated

That yet seek to be—creatures that are uterus-born or egg born, those that yet seek to be.

## Stanza 6

*Na paro param nikubbetha natimannetha katthaci nam kanchi  
Vyarosan patighasanna nannamannassa dukkham iccheyya*

Let one another not do, or slight or at all anywhere, let them not wish each other ill with provocation or resistive thought .

## Stanza 7

*Mata yatha niyam puttam ayusa ekaputtam anurakkhe  
Evampi sabbabhutesu manasam bhavaye aparimanam*

Thus as a mother (*Yatha mata*) might guard (*anurakke*) her son (*niyam puttam*) With her life (*ayusa*), her only child (*ekaputtam*), thus (*evam pi*) would he maintain (*bhavaye*) unboundedly (*aparimanam*) his loving kindness thought (*manasam*) for every living being (*sabbabhutesu*).

## Stanza 8

*Mettan ca sabbalokasmin manasam bhavaye aparimanam  
Uddham adho ca tiriyan ca asambadham averam asapattam*

His thought (*manasam*) of love (*metta*) for all the world (*sabbalokasmin*), he would maintain (*bhavaye*) unboundedly (*aparimanam*), above (*Uddham*), below (*adho*) and all around (*tiriyan*), unchecked (*asambadham*) no malice with (*averam*) or foe (*asapa-ttam*).

He would maintain his thought of loving kindness for all the world, in the three divisions of above (formless state), below (avici–lowest hell) and all around, when it had reached excellence in maintenance–in–being and is unchecked since it finds opportunities every where, has no malice since his own annoyance with others has been removed, has no foe since others' annoyance with himself has been removed.

## Stanza 9

*Tittham caram nisinno va sayano va yavatassa  
vigatamiddho etam satim adhittheiyya  
Brahmam etam viharam idha-ma-ahu*

This is divine abiding here, they say, it is foremost abiding, they say, and consequently, he would pursue mindfulness constantly, continuously and uninterruptedly, whether standing or walking, seated too, or lying down the while drowsing.

## Stanza 10

*Ditthin ca anupagamma silava dassanena sampanno  
Kamesu vineyya gedham na hi jatu gabbeseyyam puna-r-eti*

He that traffics not with views (*ditthin ca anupagamma*) is virtuous (*silava*) with perfected (*sampanno*) seeing (*dassanena*), purged (*vineyya*) of greed (*gedham*) of sense-desires (*kamesu*), he will surely come no more to any womb (*na hi jatu gabbeseyyam puna-r-eti*).

Traditionally Sri Lankan Farmers observed loving kindness to all living forms in the farm environ as rituals. At all steps in farming for example

- prevent any harm to any life form dwelling in the area in burning pruned material and shrubs slashed during clearing jungle for Chena cultivation (page 2. Chena cultivation)
- *Andaharaya* (loud recital of specific poems to encourage and guide buffaloes and cattle pulling the plough in the field and those who thresh harvested paddy on then threshing floor), poems are all describing how valuable and lovable the working animal, compare to be similar to his family members, expressed loving kindness and appreciate the contribution given by him, in ploughing
- Sharing the production with others/animals, a form of response to some pest especially birds that helps maintaining the ecosystem, to remind the farmer that birds are useful and even some insects and do not mind sharing the production with a view that it will not starve farmer and his family but a gift for the other animals in the ecosystem.

All strategies are designed to preserve loving kindness. In a case of serious pest problem: Farmer is provided with encouragement “*pirith water spray*” to meet the stress without harming the basic concept of non killing.



## Timely Cultivation

In the Folk-lore there are several expressions, "*Kal yal bala wapuranna*". Sow in time having considered the season, "*Wap mulata isinna*" meaning sow during early Wap. Wap is the name given to lunar month commencing late September to end of October. This varies from calendar year to year. In the year 2005 Wap began on 15th of October and in 2006 on 4<sup>th</sup> of October. In Southern Sri Lanka traditionally sowing is done before 17th October and is called "Koneta pera wapuranna". This is strictly on the position of earth in relation to sun. The common belief "thel ganna pera, Yala wapuranna" express that one should sow seeds in mid April–final day of Sinhala new year celebrations.

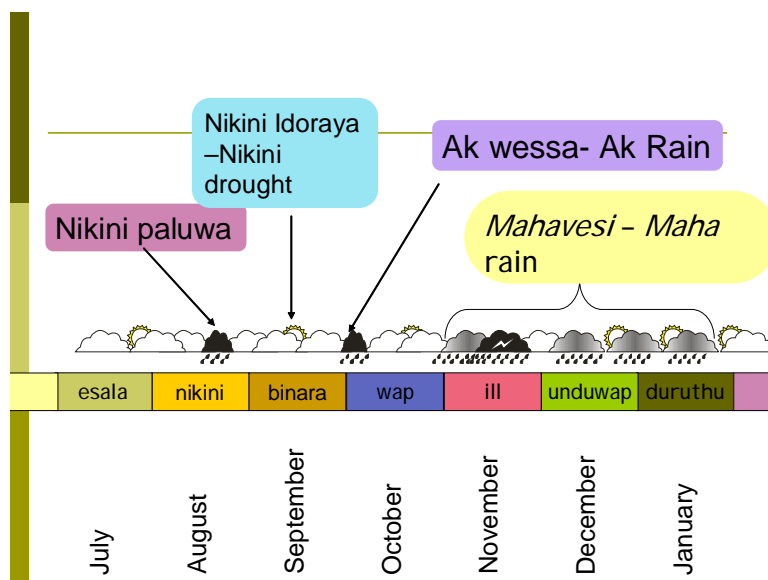


Fig. 24. Timely cultivation and rainfall pattern in Sri Lanka.

Prior to Akwessa (Ak-rain) is a drought lasting four to about 5 weeks, it is referred to as nikini drought. This drought period begins after a convectional rains called "Nikini Paluwa" or "Wal-eta wessa", (wal eta= weed seeds, wessa= rain). This falls after the full moon day of lunar month named Nikini, around end of July. Data for past 20 years show that there is no change of convectional rains in quantity or spread wise or occurrence except the days of rains which vary from a few days to a week or too. The dates of lunar month vary from calendar year to year and the dates of rain from full moon day also vary. It means there is an uncertainty. For rice it does not matter if the NE monsoon rains does not fail. Once in about 10 years according to rainfall data, NE monsoon rains fails. NE monsoon in 2003-04 is one such season. In such a year crop failures are unavoidable, however in the ancient practices adopted was to avoid such losses.

Ancient people had the ability to forecast weather pattern well ahead of the beginning of the season. They have followed an integrated method of weather forecasting. The main components of the integrations are;

**(A)Astrology:**

From astrology it can be predicted (a) whether the year concerned has a good rainfall or scanty. (b) Astrology could predict the exact dates of rainfall. In Sri Lanka, days suitable for planting yams and roots are selected according to bio dynamic calendar. Watching new moon before and after Sinhala and Hindu New year is an established practice. What our ancient people had been watching was to see which side of the moon is heavier, if the side on the land side is heavier; they called it a good season for farming. If the heavier side is towards ocean they called it a good for fishing, it means there is less rains, probably they may have made use of the difference of slight refraction effect created by the atmosphere to predict weather, and make decisions on farming.

Besides weather prediction there is another aspect of astrology that is finding a suitable or auspicious time for commencing work of the cropping season, sowing or planting, and other farm operations e.g. building and occupying watch hut etc. Day, *Karana* and *Hora* seems to be more important than other conditions such as *Yoga*. Day wise Saturday belied to be good for greens, Tuesday for yams and Monday and Friday generally followed by Wednesday and Thursday as good days. By *Karana* what is explained is the position of the moon in relation to earth and Sun. First *Karana* starts six degrees before the centers of sun, moon and earth is in a straight line. Each *Karana* is 12° of space. Time taken by moon to travel through 12° varies because moon revolves round the earth in an ellipse. It can be argued that due to changes of its own position with respect to sun and earth in orbit, moon influences the growth pattern of plants. The case studies done shows that, predicted results are true especially for protection from wild animals, elephants etc. There are seven *Karanas*. The fifth or the "dive" or leopard *Karana* believed to give high yields and good crop protection. *Hora* wise for planting "*Chandra*", or its "*panchama hora*" or "*shookma hora*" supposed to bring high yields.

The period in lunar months where the rain occurs could be predicted by astrology; the intensity and spread of rain by flowering habits of certain trees, the exact time in weeks by natural sounds of birds and some other animals.

By timely cultivation, in addition to vigorous crop growth, protection from pests, diseases and wild animals, as well as an increase in yield too can be expected. Cold nights and low temperature at critical stage of rice crop increases the grain weight. International Rice Research Institute in Philippine reported that, increase in temperature during critical phase of the rice crop, (approximately from 10 days before flowering and 20 days after flowering), if the temperature rises by one degree centigrade, the yield could drop as much as 16%. Low temperature in the night would lower the rate of respiration of the crop thus conserving food synthesized by photosynthesis during the day resulting in high yield.

Sri Lanka being slightly north of equator, the coldest days falls from early January to mid February. If the rice crop can be harvested from about 10th to 25th February or during early lunar month *Navam* yields are higher as the critical phase falls during the coldest days.

In Yala or SW monsoon season when rice is sown in the middle of April, rice plant flowers during mid June, for Sri Lanka during this period, days are one hour longer than the night. This condition allows longer active photosynthesis and hence a high yield. Due to rains and other factors average temperature during this period is also slightly lower than that of May and August. This too is helpful to increase the yield.

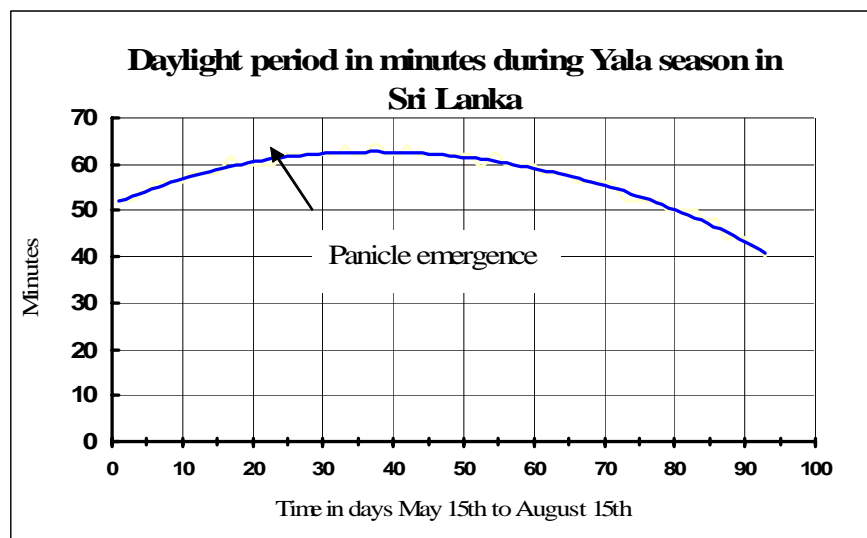


Fig. 25. Daylight period in minutes during Yala season in Sri Lanka

There is a drought period at the end of each monsoon rains. During this period organic matter especially the leaf litter etc. and animal wastes accumulates due to shortage of water. The decomposition begins with the onset of convectional rains followed by monsoon rains. The decomposition process releases plant nutrients in easily available form. When the crop is in the field at this time the crops grow vigorously. Lightning fixes some atmospheric nitrogen The fixed atmospheric nitrogen also comes down with the early rains,

Due to unfavorable climatic conditions and shortage of food, insect population is low at the beginning of the season. With crops and other vegetation growing multiplication of pests take place and reach destructive levels in February, March NE monsoon season (*maha*) and August and September in SW monsoon season (*yala*) When the crops are sown early by this time the crop is ready for harvest thus avoiding the damage by pests.

### A case study.

*Huruluwewa* irrigation scheme can be considered as one that suffers most from water shortage, from inception in 1953 for the 50 years till 2003. Out of 100 cultivation seasons, the farmers could cultivate only 27 seasons. This shows the availability of water. However the condition was slightly improved by providing water through the *Mahaveli* river diversion scheme. As there was not much of an impact because, the water received from Mahaweli was not sufficient and the shortage continued. As a remedial measure an attempt was made to introduce Nawa Kakulama method of rice cultivation. The timely cultivation was emphasized in the awareness seminars conducted before the season. The intention of conducting seminars was to educate the farmers and the officers of farmer organization. The governmental officers too participated in these seminars.

Cultivation meeting prior to commencement of season's work is held with the participation of Governmental officers and officers of farmer organizations to decide the schedule of operations, main concern being deciding the date of opening the sluice, last date of sowing and irrigation schedule. Normally cultivation is not allowed unless there is sufficient water in the reservoir. In the season 2003/04 when meeting was held reservoir had only 14 feet of water. This amount is just sufficient for the first month for preparatory tillage. Under this condition cultivation is not begun. But a few officers of farmer organization insisted that they should go for "*Pera maha*" that is timely cultivation. Farmers also agreed that they will not claim damages or put the blame on officers if the crop fails due to shortage of water. As a result, at the above meeting it was decided that sowing must be completed on or before 15th November. On previous years, when totally depended on irrigation water, it was normally 15th of December. When the farmers commenced work, some rains came down and the preparatory tillage was done with rains and saved the water in the reservoir. Unfortunately the NE monsoon rains failed. With limited water available only wetting of the fields was done to save the crop from dieing till the NE rain falls. Though expected no rains came. On 8th of January a *Bodhi-pooja* (offerings to deities associated with the Bodhi (*Ficus religiosa*) tree) was done and prayed for rains. It rained whole day the 9th January. The crop could be maintained till 22nd of January without irrigation and with little water in the reservoir entire crop was saved. Under normal circumstances this season would never have cultivated. Firstly there was not enough water in the reservoir therefore they would wait till reservoir is filled sufficiently to maintain the crop and once sufficient water is there cultivation would have begun. But there was no rain hence the cultivation would have abandoned.

Taking this opportunity a well designed survey was done. The comparison was done with the block Eppawala of Mahaweli H area, where conditions were very similar.

Rain fall	Maha 2002-3	1503.4 mm
	Maha 2003-4	375.4 mm
Total extent	Huruluwewa	10,400.ac
	Eppawale	3000.ad

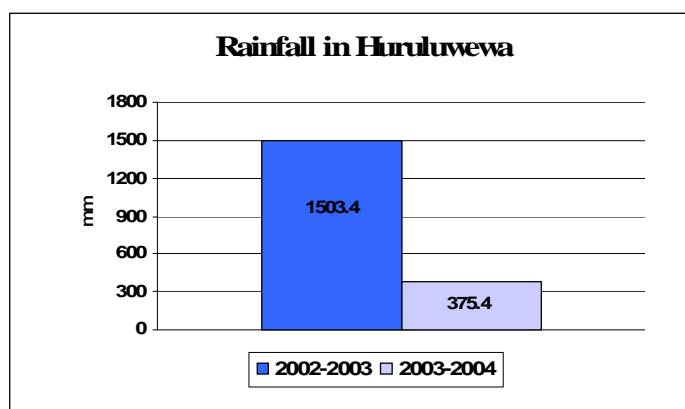


Fig 26: Rainfall in Huruluwewa

200 farmers from each location were interviewed. According to the survey yields are as follows.

		<b>Eppawala</b>	<b>Huruluwewa</b>
2002-03	Last day of sowing	15 Dec.	15th Dec.
2003-04	Last date of sowing	15 Dec.	5th Nov.
Yield			
2003-04		70-49 bush	92-59 bush

This shows that yield drop in Eppawala is significantly low and can be attributed to the postponement of the date of sowing. According to department of agriculture figures, the yield was much higher than the previous year where rainfall was good.

270 acres of land in reservations had also been cultivated in addition to 10,460 ac. Except for a few (Liyaddas) fields of some farmers who sow late, entire extent of Huruluwewa had been harvested. This too is an exception. There is always a difference in extent sown and harvested. This season in Huruluwewa the difference was very narrow or almost nil, there by the total yield of the Huruluwewa scheme during this season ought to be better.

Considering all these facts and figures, it can be concluded that Huruluwewa got the highest ever yield during this season and also the highest income. The prices of paddy had been above the guaranteed price because of low national production. It can be estimated that over Rs. 340 million had been earned by Huruluwewa farmers because of timely cultivation. If they waited for rains as previous years there would not have been any income. The season would have been an abandoned season, due to not sufficient water in the reservoirs and failure of NE monsoon. It should gratefully be mentioned that irrigation engineer and his staff for their efforts to distribute little water in the entire scheme. The farmers too had co-operated by not agitating for more water for their respective channels and fields.

Chapter on Timely Cultivation is a contribution by Mr. G.K.Upawansa at ECO, Nawalapitiya.

## Addendum

- Nekatha: Auspicious time: Astrologers recommend for specific gain.
- *Nekathes* recommended for farming: *Berane, Ada, Sitha, Sa, Anura, Uthrapal, Uthrasala, Uthraputupa*—Best for land preparation.
- *Thithis*: Lunar month is divided into 30 periods called *thithis*. 15 i.e. 00°00 to 180°00 on the rising moon and 15 with waning moon 180°00 to 00°00
- All *thithis* of odd numbers except *nawawaka* which is (96-108 and 84-72) are considered *Riktha*, *Diyawaka* and *dasawaka* even numbers are considered good for land preparation.

Taurus, Scorpio & Virgo are the best lagnas and Tuesday (*Kuja*) as the best day.

- Lunar month (29d, 12h & 44 min) approximately 27 days is divided into 7 periods called *Karana* which last 21h and 45 min.
- Seven *Karanas*—Namely *Divi* (Leopard), *Sinha* (Lion), *Ooru* (Wild boar), *Gaja* (Elephant), *Pakshi* (Bird), *Mesha* (Goat),

*Virishaba* (bull). Any crop planted during a particular *Karana* would have growth attributes similar to the animal that it belongs.

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*Sukhino va khemino hontu, Sabbe satta bhavantu sukhitatta*

*- Let all creatures be joyful  
or let them be safe  
or let their hearts rejoice -*

\* \* \*

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