Trees 4 Children Progress Report May 2013

Figure 1: Melia trees and vegetables in the Phase 2 Food Forest. The addition of manure and daily irrigation to grow vegetables clearly benefits the growth of the trees, while the partial shade and windbreak provided by the trees boosts the yield of vegetables, including kale, carrots, onions, cilantro, peppers, pumpkins, passion fruits, and papayas. The goal of scaling up the farms in the Sustainability Program is to increase the amount of T4C acres being managed as Food Forest.

Summary: In the past 6 months Trees 4 Children planted Phase 5 on schedule and completed the final replanting in Phase 3. The improved planting techniques show good results, particularly the trees planted just prior to the rains. T4C Team and I evaluated the timing and intercropping with the timber trees, made small improvements to the nursery to scale up the seedling production for sale, formalized a comprehensive annual work plan to guide monthly activities, and developed the Year 6 T4C budget. I also worked with the whole Sustainability Department to develop strategies for scaling up production from village consumption to commercial levels. Finally, I recommended ways to engage the families in sustainability through household conservation and production activities. We implemented examples of these with the recent UWSP-PRI Kenya Permaculture Course at Nyumbani Village in May-June 2013.

Growth and Survival Updates: I sampled tree survival and growth in Phases 3 and 4, results below.

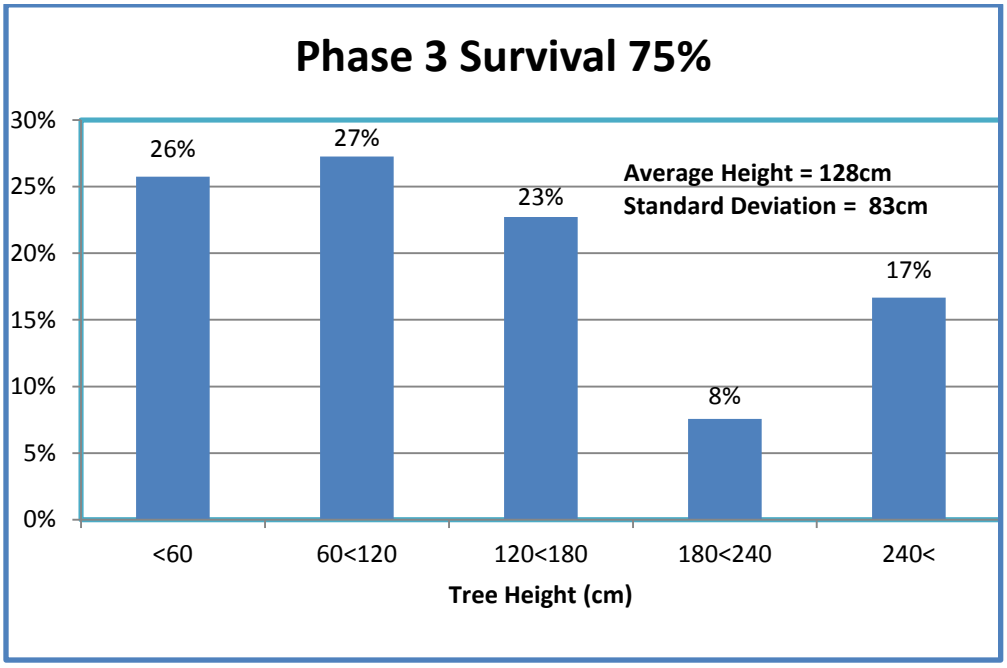

Figure 2: Wide variability in Phase 3 growth due to replanting. 50% of trees that survived from initial plantings are good size. The recently planted 50% of trees are growing well. Overall survival is only satisfactory, needs improvement.

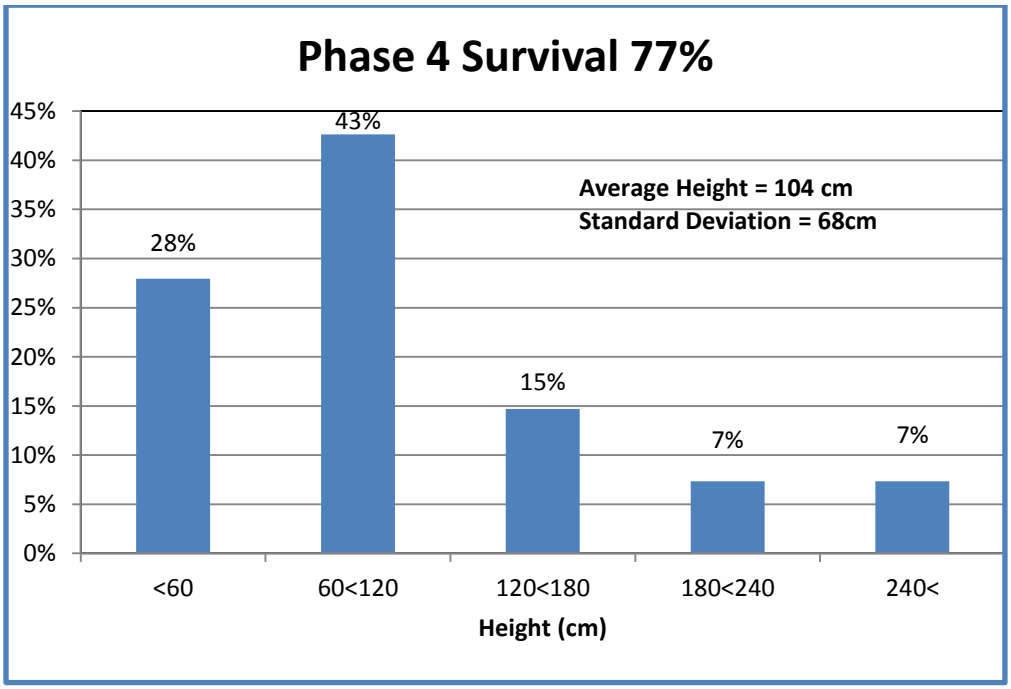

Figure 3: Rapid and uniform growth is Phase 4 due to improved establishment practices. 15% show exceptional growth. The smaller 30% are the most recently planted. Survival highest in trees planted prior to rains. Need to improve timing of planting.

Survival is similar in both phases, Phase 3 (75%) and Phase 4 (77%). We should be able to achieve survival above 80% with proper care. We have noticed in many phases, recently 4 and 5, that survival is higher in areas that are planted during the dry season just prior to the rains. We see slightly lower survival in places that are planted during the rainy season. We believe this is due to stress caused by the combination of transplant shock and excessive root moisture. Under such conditions we see more fungal problems in the field, the leading cause of seedling mortality. Generally we replant seedlings lost during the rains, but we will save labor and the cost of additional seedlings if we can shift our planting goals from ***during*** the rains to ***before*** the rains. All trees experience a bit of transplant shock when moved from the nursery to the field. We think the trees get through transplant shock better with less water, provided by irrigation during the dry season, and then the trees are ready to grow vigorously when the rains arrive. ***Our goal for the second half of Phase 5 will be to plant all trees prior to the rains and measure the resulting survival.*** We will also monitor the results in Phases 4 and 5 more closely to see if this factor remains important over time, or if the trees that were initially stunted make a recovery.

Excessive Pruning: I observed excessive pruning of trees to varying degrees in Phases 1-3. Over pruning will slow tree growth, especially if done during the growing season. We retrained the pruning team to prune trees up to a maximum of half (50%) tree height. This will leave half height of the tree with branches and canopy to encourage better growth, especially tree diameter. Our other rule we have is to wait to prune until the pruner cannot wrap their hand around the stem, equivalent to a diameter more than 4cm. Up until this point they should only prune trees to remove sucker sprouting from the base or branches that cause the tree to fork rather than a single stem. We also agreed to only prune trees during dry season after the trees drop their leaves and are in a dormant state. ***Year 6 goals are to prune only when trees have achieved sufficient size and only during the dormant, dry months of August and September.***

Leaf Disease and Insect Pests: We observed an outbreak of leaf hoppers present in nearly all phases. They are small yellow bodied flies with light blue wings. They transmit a leaf disease that spreads to other trees (including Melia and many others) as well as vegetable crops. It is unclear if the disease and insects started on the trees or the vegetables, but as generalizing disease/pest it quickly spread throughout both trees and crops. The problem was not isolated to the trees or just on Nyumbani land. They are all around the farms, community outside, and even in the broader region. The disease causes the leaves of the plants to yellow and fall off, particularly the top branches. It is not likely to kill the trees or cause long term harm, but the early loss of leaves in some cases will reduce this season's growth slightly. It may in severe cases cause the trees to re-sprout from below the affected branches, but this has not been observed in the Melia. The leaf hoppers were only present shortly after the rains in May. Their populations decreased rapidly with the onset of the dry season in June. ***Greater diversity of trees and vegetables is the best way to avoid these kinds of disease and pest outbreaks and spreading.***

Intercropping of Legume Ground Cover: In the past (2010-2011) we tried intercropping of sunflowers twice in Phase 2 with limited success. We concluded that this was because of the timing of the planting with the rains. The sunflowers were not planted early enough and they did not produce

seeds. (The Farm Foreman, Patrick, has since had three consecutive seasons growing sunflowers on a smaller scale in the farms where he can control the timing of planting better. The rains have also been better in recent years.) In 2012 we trialed Green Grams as a cover crop in Phases 3, 4, and 5 with much greater success. Green Grams are legumes that add nitrogen to the soil and require less rain than grains like maize and sunflower. When planted along the swales with the trees they provide a ground cover crop that adds fertility and provides a protein rich food harvest for the village. This provides an immediate return for the investment in weeding the trees and crop simultaneously. We agreed to increase intercropping and experiment with other promising crops. Pigeon Peas are another drought resistant legume that is grown locally, adds fertility, windbreak, and sun buffer to the soil and provide a nutritious food crop. Pigeon Peas require 2 rainy seasons to harvest, so planting once will provide a longer cover crop and larger harvest. ***Our goals for Year 6 are to plant Green Grams on all of Phases 4 and 5 during the Oct-Dec rains and then plant Pigeon Peas in Phases 4 and 5 during the March-April rains. We will plant Green Grams in Phase 6 during the March-April rains.***

Figure 4: Green Grams growing well on recently planted swales in Phase5.

Intercropping Trees: We have improved our planting scheme to mimic the layers and diversity in found in natural forests. This includes planting the canopy layer of fast growing timber trees, slower

growing but longer lived fruit and fuelwood trees, small shrubs for rapid and frequent harvesting, and legume ground covers. As previously described in other progress reports, we feel this will build greater ecological stability and resiliency into our forests because of the biodiversity, and also diversify the yields from each layer in the forest over space and time.

Our plating density for trees is 600 trees per acre. Of these trees our goal is to plant 75% Melia for fast growing timber. The remaining large trees will be a mixture of 10 other fast-growing and high-value trees:

Tree Species Planted	Function/Use
Melia Volkensii	Timber
Senna Siamea	Timber/Nitrogen Fixer
Leucaena Leucocephala	Fast Growing Timber/Nitrogen Fixer
Acacia Polycantha	Fuelwood/Charcoal/Nitrogen Fixer
Acacia Geraldii	Fuelwood/Charcoal/Nitrogen Fixer
Acacia Xanthafolia	Fuelwood/Charcoal/Nitrogen Fixer
Senna Spectabilis	Fuelwood/Charcoal/Nitrogen Fixer
White Sapota	Fruit
Java Plum	Fruit
Tamarind	Fruit
Guava	Fruit
Moringa Olifera	Vegetable/Medicine

In total this makes 12 species of trees, which does not include the existing native trees that we leave growing on the site. These will add at least another 6 species of trees and shrubs. We are also adding diversity with the legume cover crops.

Tree Nursery: We evaluated the propagation system and concluded that the propagators have no problems meeting our current production goals of 30,000 Melia and 50,000 intercropping trees (Moringa, Acacia, Senna, Leucaena, and fruits) as long as they have the supplies they need. Their propagation skills are excellent. Their main limitation is the availability of fruits and seeds. We had a problem with Melia fruit supply from December-April. They are also sometimes limited by the supply of other basic materials, like polybags, soil, sand, and water, or space in the propagation boxes or greenhouses.

We can address the fruit and seed limitation by improving the purchasing system. We get fruits and seeds from local farmers that collect them from the types and qualities of trees we want. In the case of Melia we are very particular that we get good genetic material from quality seed trees, i.e. those with straight stems, rapid growth, and produce many large fruits that in turn have more seeds. Seed collectors are paid per kilogram for the fruit or seeds they collect. Part of the problem, we learned from the seed collectors, is that they don't like the delay in payment from when they deliver the fruits and when they are paid. Typically they were paid after several weeks or at the end of the month. We had much better results recently when the Forestry Foreman took a cash advance from the accounts

department and paid the fruit collectors on the spot, or at least partial payment. This motivated them to collect more fruit. We now have a supply of several months' worth of fruits for the propagators to use. This system of payment on delivery should be continued so we have a consistent and growing supply of quality fruits. ***Our plan for Year 6 is to continue the cash advance method so we can pay fruit collectors on the spot. We also want to carefully monitor the amount of fruit we need to purchase to meet our production goals (kgs fruit/seedlings), which will help us plan how much fruit we need throughout the year.***

The limitation of basic supplies and greenhouse space is one that the Forestry Foreman and Nursery team can easily coordinate with the Sustainability Manager to supply when they are needed. We discussed making a regular schedule for delivery of supplies like potting soil so they never run out. They also need to plan ahead for when the germination boxes need repair or replacement so materials can be purchased and they can be built. Otherwise these materials are budgeted and can be provided.

Figure 5: T4C Propagators Francis and Catalina pounding Melia fruits to remove the nuts and prepare them for nutckracing.

We also worked on one minor detail in the commission based payment system to the propagators. The agreement with them was to supply them with all the raw inputs and they would supply all the labor.

The cost of the inputs is roughly 10ksh/seedling, including fruit, polybag, soil, water, nutcracker, greenhouse, and other supplies. The labor cost was agreed to be 10kshs/seedling, which includes the lengthy process of extracting the nuts from the fruits, seeds from the nuts, germinating the seeds, and then transplanting them into polybags. The issue that arose was that T4C had to start employing a full-time person to care for the seedlings from the time they were transplanted into the polybags until they were taken to the field. This created a large additional cost to the seedlings. ***The propagators agreed to decrease their commission from 10kshs to 9kshs/seedling and the additional 1kshs would pay for the caretaker. The Forestry Foreman agreed to make sure they are supplied with all other materials on a timelier basis.***

Our goal is to expand the nursery so it can meet the needs for planting at Nyumbani Village and supply 200,000 or more seedlings for sale to the outside community. This would generate short-term income for the T4C project, approximately 3-6,000,000kshs/year (15-30kshs/seedling). We need to gradually work towards this goal and expand the size of the nursery and propagation staff to meet it. ***Our Year 6 goals are to market the seedlings locally and regionally, particularly during peak planting seasons of March-April and Oct-December. We will educate farmers in the surrounding communities on the usefulness of planting high-value trees and proper tree planting and care methods. The Nursery team will help to recruit leaders from the surrounding communities and bring them to the village for trees training. The training will be free in exchange for a contribution of labor, such as weeding or mulching trees. We will also conduct forestry training to external groups for a fee.***

Trees 4 Children Annual Workplan:

January	February	March
Irrigate old 30 acres	Irrigate old 30 acres	Irrigate old 30 acres
Weeding long rains	Contours 20 acres	Irrigate 20 acres
Contours 20 acres	Hole prep 20 acres	Plant 20 acres
Hole prep 20 acres	Plant 20 acres	
April	**May**	**June**
Rains throughout!	Irrigate 20 acres	Irrigate 20 acres
Old 30 acres DONE	Weeding short rains	Mark contours new 30 acres
Intercropping plants		Harvest intercropping
Gapping		Heavy mulching
July	**August**	**September**
Irrigate 20 acres	Irrigate 20 acres	Irrigate 20 acres
Contour plowing 30 acres	Hole prep 30 acres	Irrigate 30 acres
Hole prep 30 acres	Planting 30 acres	Planting 30 acres

Clearing next phase	Clearing next phase	Clearing next phase
Heavy mulching	Pruning old phases	Pruning old phases

October	November	December
Irrigate 20 acres	Irrigate 20 acres	Rains throughout
Irrigate 30 acres	Irrigate 30 acres	20 acres irrigation DONE
Planting 30 acres DONE	Rains Come!	Gapping
Clearing next phase DONE		

TREES 4 CHILDREN YEAR 6 BUDGET (September 2013-August 2014)

Includes commencement of Phase 6, completion of Phase 5, and maintenance of Phases 1, 2, 3, and 4.

EXPENSE DESCRIPTION QUANTITY UNIT COST TOTAL	QUANTITY	UNIT COST	TOTAL
OBJECTIVE 1: Seedlings			
Propagate Melia Seedlings at Nyumbani	30,000	20	600,000
Propagate Intercropping Seedlings	50,000	10	500,000
Contract Labor for Propagation	100	200	20,000
TOTAL OBJECTIVE 1			1,120,000
OBJECTIVE 2: Land Preparation			
Contract Land Clearing	50	6,000	300,000
Tractor Plowing Ridges	50	8,000	400,000
Contract Labor for Land Preparation Phase 5	300	200	60,000
Contract Labor for Land Preparation Phase 6	600	200	120,000
TOTAL OBJECTIVE 2			880,000
OBJECTIVE 3: Irrigation			
Solar Pump Service and Repair	1	100,000	100,000
Shallow Well Service and Repair (FOC)	1	50,000	50,000
Gate Valves	36	1,500	54,000
Heavy Duty Hosepipe (1" x 50m)*	6	10,000	60,000
Fuel (for borehole genset and portable petrol genset)	1,500	120	180,000
Polytechnic Repair Tank Stands	5	5,000	25,000
Tank Stand Cement Foundation	5	5,000	25,000
Contract Labor for Irrigation Phase 3	900	200	180,000
Contract Labor for Irrigation Phase 5	1,200	200	240,000

Contract Labor for Irrigation Phase 6	1,500	200	300,000
TOTAL OBJECTIVE 3			1,214,000
OBJECTIVE 4: Woodlot Establishment			
Contract Labor for Digging Pits	30,000	20	600,000
Contract Labor for Humanure Application	400	200	80,000
Contract Labor for Planting Phase 5	400	200	80,000
Contract Labor for Planting Phase 6	800	200	160,000
Contract Labor for Mulching Phase 3	200	200	40,000
Contract Labor for Mulching Phase 5	400	200	80,000
Contract Labor for Mulching Phase 6	400	200	80,000
Contract Labor for Weeding Phase 3 (spot weeding once)	20,000	5	100,000
Contract Labor for Weeding Phase 4 (whole phase once)	60,000	5	300,000
Contract Labor for Weeding Phase 5 (whole phase twice)	120,000	5	600,000
Contract Labor for Weeding Phase 6 (half phase once)	30,000	5	150,000
TOTAL OBJECTIVE 4			2,270,000
OBJECTIVE 5: Management Personnel			
Forestry Foreman	1	21,000	252,000
Woodlot Attendants	6	10,000	720,000
Humanure Attendant	1	10,000	120,000
Security Guard	1	8,000	96,000
Contract Labor for Security all phases	300	200	60,000
Non-Anticipated Labor Needs	300	200	60,000
Motorbike**	1	90,000	90,000
Motorbike fuel	250	100	25,000
Marketing Tree Nursery and Trainings	1	100,000	100,000
TOTAL OBJECTIVE 5			1,523,000
TOTAL EXPENSES (KSHS)			7,007,000
10% Contingency Including Inflation (KSHS)			700,700
GRAND EXPENSE TOTAL (KSHS)			7,707,700
GRAND EXPENSE TOTAL USD (KSHS/84)			91,758
Notes:			
*** Hosepipes purchased in Yr 5 but not budgeted, thus budgeted in Yr 6 but not purchased again.**			
**** Motorbike purchased in Yr 5 but not budgeted, thus budgeted in Yr 6 but not purchased again.**			

Sustainability Scale-Up Recommended Steps for Marketing Team:

1. Business Planning to analyze the profit potential and prioritize investments
2. Market Analysis for products
3. Assessing and planning production levels for markets
4. Investments in production systems to scale up proven activities
5. Contracting with high-value markets to synchronize with production
6. Develop efficient packing, delivery, and sales system, communication between marketer and farm manager levels
7. Evaluation of successful business activities
8. Re-investing profits into Sustainability Department to reach desired scale

Products that need thorough business planning to analyze profitability and investment priority: (Nyumbani Village, Kitui is certified organic by Encert Limited, therefore all of the mentioned products from the Sustainability Department should be assumed to be organic and marketed in high-value, organic and sustainable markets, both domestic and international. They should also target markets that would pay a premium for the humanitarian mission of the village.)

1. Livestock:
    a. Bulls include buying, fatting, and resale of local bulls to market as high quality meat, Kenya Meat Commission, 50 or more bulls per year (currently 9)
    b. Goats include buying, fattening, reproducing, and selling goats to local and regional markets. Target could be 300 or more goats per year (currently 100)
    c. Chickens include Kinyeji and broiler birds for meat and eggs (currently 100)
    d. Rabbits for meat (currently 15)
2. Greenhouse Produce: (currently 5 greenhouses)
    a. Tomatoes, peppers, French beans, cucumbers, and herbs
3. Food Forest Fruits and Produce: (currently 7 acres)
    a. Pawpaw and passion fruit
    b. Beetroot, carrots, onions, eggplants
    c. French beans
    d. Watermelons, pumpkins
4. Value Added Produce:
    a. Honey
    b. Vegetable oils (sunflower, moringa)
    c. Moringa leaf powder
    d. Dried vegetables
5. Tree Seedlings for Drylands:
    a. Melia Volkensii for high value dryland timber
    b. Acacia species for building, fuelwood and charcoal
    c. Moringa for nutritious vegetable
    d. Multi-purpose, agroforestry species for fodder, fuelwood, soil fertility
6. Wood Products

a. Timber and poles for construction
b. Sustainable charcoal
c. Furniture, door and window frames

A degree of financial autonomy needs to be developed between the Sustainability Department and the accounting system to allow it to make timely purchases of inputs with cash, rather than having to make payments with checks and go through the often lengthy requisition and procurement process. Inputs such as low cost livestock, grains, and fruits are often available seasonally at low prices. To take advantage of these low input costs there needs to be cash funds available. For example, payment for livestock such as bulls can be 15,000-20,000kshs, which is more than is currently allowed for cash purchase, however, livestock dealers need to be paid in cash on delivery. They will not accept check payment after receipt. Similarly, fruit and tree seed collectors that supply the tree nursery are not willing to deliver products and wait to be paid at the end of the month. They require cash payment for timely delivery. It would be helpful to review the accounting procedure to allow the Sustainability Department to make more quick purchases using cash. There may be actual changes that are required to achieve this, such as having a separate accountant and accounting process for Sustainability, or it may simply require more timely communication and response.

Another area that needs assessment is water since it is the most limiting factor in production from the farms, forest, and livestock areas. With somewhat frequent problems with the water systems, including the tower borehole, Masinga water, and solar borehole and shallow wells, there could be competition between the Sustainability Department and the rest of the domestic use of water in the village. It would facilitate development of Sustainability to have a more secure and separate water source. The borehole currently being used by Trees4Children with the solar tracker could be more fully utilized if it was harnessed by a diesel generator. This could then be used only by Sustainability, shared between T4C and the farms. The solar system could be divided and used for future shallow well systems (12 panels = 6 new shallow well systems). The investment cost of a new diesel generator (and upkeep) needs to be weighed as part of the business planning and investment analysis. In the end it may be more prudent (although also more risky) to stay with the existing diesel pumping systems on the other boreholes for the time being.

Finally, the Sustainability Department needs to initiate the integration of the families and other departments into the production process. This will achieve several goals for the village, but from the Sustainability standpoint, they should aim to involve the families and surrounding community as much as possible to reduce the input costs for the business activities. For example, if every family brought 1kg of freshly cut livestock fodder to the dairy unit when the pick up their milk, this could be fed to the cows to decrease the cost of purchasing feed supplements and increase milk production and quality. With a population of 100 families and over 1,000, simple and seemingly trivial acts like this would produce a lot, in this case a ton of highly-nutritious livestock feed per day. And the fodder would be harvested from multipurpose trees that the families manage in their small shambas. When they cut it for daily milk it would also supply fuelwood when it is dry, and the tree would regrow. Creative initiatives that integrate Sustainability activities with the families' daily activities are very important for the village to achieve self-

sufficiency as well as a sense of ownership, ethic of conservation of resources, and more diverse life skills training for the children.

On the latter note, a diverse life skills or sustainability certificate represents a recognition system, rather than forcing the families to work in exchange for their resources. The recognition or reward system could be a certificate that the children get when they complete a curriculum of required skills, which would include planting the multipurpose fodder and fuelwood trees. Then it would be simple for them to deliver the cut fodder on a daily basis. Other ideas would be for each child to know how to raise chickens, rabbits, goats; grow organic vegetables; harvest and rainwater; recycle greywater; and make energy efficient jikos. Basically, this would be a re-framing of all the things currently being implemented by staff and laborers in the clusters in a way that the children would assume responsibility for them. Over time this will reduce overall costs to the village and link to Sustainability activities to reduce inputs for business activities. It will also develop more confident and capable children that will know how to live sustainably.

Figure 6: Nyumbani Children with their new mud rocket stove made by the Permaculture course.

UWSP-PRI Kenya Permaculture Course at Nyumbani Village: This May-June Dr. Holly Petrillo and I led a Permaculture Design Certificate Course (PDC) in collaboration with the Permaculture Research Institute of Kenya (PRI-K). We spent the first 7 days of the 3 week course at Nyumbani Village. The students included 14 UWSP students and 14 Kenyan students, plus additional community members or staff from each site we visited. Besides Nyumbani, we also spent time at Drylands Natural Resources Centre in Maiuni (Nicholas Syano's community project), Amrita Children's Home in Athi River, and Gibson's Coffee Co. in Kirinyaga. At each site we held Permaculture classes and implemented field projects with the host community. At Nyumbani Village our theme was working with the families to help them understand and implement Permaculture on a household level for conservation and increased production.

One of the main questions in the sustainability of the village to me is how to involve the families more in the conservation of resources (i.e. to reduce operational costs) and increase production with some of the production coming from the families. In my mind there are two paths the village could take. One path is to impose a centralized conservation strategy through resource rationing, such as how they currently receive their food supply. However, this does not seem like an empowering option and will always require staff supervision to be effective. The other path is to develop a conservation ethic among the population through innovative projects that reward conservation and inspire the children and grandparents to create their own methods that they could self-regulate. This path is clearly my preference and the goal of Permaculture. The main question towards this path is how to make conservation and productive resource use the children and grandparents ideas?

The families could easily reduce their consumption of several commonly used resources, like water, fuelwood, and non-biodegradable waste (plastics, powdered detergents). In the case of water in particular, a reduction in water use would directly save the village money by decreasing the amount of diesel fuel used to pump the water or by decrease the amount of fresh water purchased from the government water supply. If the families bore even a small fraction of the true cost of the resources they use, I am sure they would adopt simple conservation measures. However, currently there is no feedback loop to the families for resource use. ***The village must make a feedback policy: positive feedback loops that reward conservation and negative feedback loops that penalize waste. This will provide the pathway for families to become conservers and producers. At the present their only pathway is to be consumers. Education will be a large part, but cannot be the only part of this. There need to be real consequences and real rewards connected to families' actions.***

During our PDC at Nyumbani we implemented several small projects with the families. We built 12 improved cook stoves (rocket stoves). Nearly all the 100 families cook over an open fire made between three stones upon which their pot rests. The efficiency of such 3 stone stoves (jikos) is less than 10%, i.e. 90% of the heat from the fire wasted. The rocket stoves simply use mud to build a thick wall around the stones and up the sides of the pot. This greatly increases efficiency because the fire is smaller and directly under the pot. The concentrated fire with air inlets burns hotter, resulting in cleaner, more complete combustion with less smoke. The pot is insulated and requires less heat once boiling to simmer. In half a day a family can build several rocket stoves using mud from their compound to fit all their cooking pot sizes and cut their fuelwood consumption in half or more.

The families could also put the resources available to them to more productive use. Few families are fully utilizing the use of the half-acre shambas (farms), which collectively make 50 acres. A UWSP forestry intern at the village in 2008 calculated that it would take only 50 acres of densely planted woodlot to sustainably meet the village needs for fuelwood (that was without the use of improved, fuel efficient cook stoves). This would be a much more productive use of their shambas than the current marginal use for rain-fed crops. It would also decrease the work of the families exponentially if they had a fuelwood supply next to their houses, rather than needing to walk far to the T4C forests to collect sticks. The same trees grown for fuelwood could also be legumes that produce protein and mineral rich fodder for livestock. If the families each brought 2kgs of fodder to the livestock area to trade for their daily bottle of milk, it would create a positive feedback loop. The families would be growing their own fuelwood and feeding the dairy cows, thus reducing the amount of feed supplement (Dairy Meal) purchased by Sustainability. The fodder would actually increase the milk production that would be provided to the families. No longer would Sustainability be giving the families milk; the families would be producing ***THEIR OWN*** milk.

Figure 7: Double Rocket Stove with 2 Chimneys to direct smoke out of the kitchen. Made by the Permaculture students.

During the PDC we also built 12 banana circles in family houses. A banana circle is an integrated system of greywater filtration, composting solid waste, and fruit production. We dug small circular holes where the showers drain from the houses. A trench directs this greywater into the circle that is filled with compost materials, such as crop residues, grass and leaves, kitchen waste, ashes, chicken manure, waste paper, and sweepings from the compound. The compost acts as a filter to break down the soap and nutrients in the greywater. Then fruit and edible trees like bananas, papayas, and moringa are planted around the circle. The compost and greywater feed these water loving fruit trees. Sweet potato vines and other vegetables can also be planted around the edge of the circle. This turns potential health hazards like greywater and household waste into food production systems. Greywater gardens are very appropriate in drylands.

Figure 8: 2013 Permaculture Course with a Linear Food Forest they planted, a swale for rainwater harvesting with fruit, timber, and fuelwood trees.

We also planted food forests in 2 clusters around their washing stations. We planted avocados, mangos, bananas, papayas, and moringa for food trees; acacia, melia, and senna for windbreak, shade, fuelwood, and eventually timber; passion fruits as a climbing vine with fruit; and leucaena as a fodder, fuelwood

shrub. The washing stations are always saturated with greywater from clothes washing. The trees will grow rapidly and improve the families living environments and grow food and other products. We also planted a linear food forest in one family's half acre farm. This was similar to the washing stations, but was planted along two long swales, water harvesting ditches made on contour, that will passively collect runoff rainwater to irrigate the trees. Swales could also collect and distribute greywater from houses and their wash stations. The families do not need to use clean tap water to irrigate trees. The bathwater from each child could irrigate several trees, as could the clothes washing water. Care must be given to use biodegradable soaps that are plant safe. Most powdered detergents contain bleach and chemicals that are toxic to plants.

We hope these model systems will spread around the village. This will require a united effort between many departments: Administration to set the positive feedback policy, Sustainability to provide training and supplies, Homecare to motivate the families and follow up, Schools to reinforce the importance in their lessons and give the kids time to do home activities, and everyone to encourage.

Figure 9: Nyumbani Grandmother and her rabbits. Rabbits, chicken, and other small animals could be a strong part of a cooperative production scheme with positive feedback to the families and income to the village.