Final Report to the Ohio State University
Global Water Initiative
Forest Garden Component of the Singida Villages Project
Villages of Mughanga and Ghalunyangu
Singida Region, Tanzania
Submitted: May 15, 2020

SUMMARY
Ohio State University (OSU), through their Global Water Institute (GWI) began the Sustainable Village Water Systems Project (SVWSP) in Tanzania in late 2017. GWI works to improve sustainable water access and develop a workforce that can turn water and energy into economic prosperity. Through the SVWSP, GWI awarded Trees for the Future (TREES) a generous grant of $49,999 to implement forest garden demonstration sites and develop forest gardens with 60 farmers from the villages of Mughanga and Ghalunyangu. While other GWI partners established and organized water access points, TREES mobilized 60 farmers near water points to form 2 farmer groups. The establishment of Forest Gardens included providing training and extension services and seeds, planting materials and equipment for up to 30 Forest Gardens in each village. OSUs funding helped support 60 farming families – comprising 498 people - to improve their lives through planting trees and vegetables in sustainable farming systems. The project began in May, 2018 after three months of mobilization. As of March, 2020, the farmer participants have planted 168,305 trees on 60 acres of land. The project was so successful that in 2019, TREES registered and began working with 200 additional farmers in the villages.

PROJECT CONTEXT AND OBJECTIVES
The aim of this project was three fold: 1) create a sustainable farming model that can be used to increase incomes to pay for new potable water access. 2) Plant trees to ensure sustainable food systems and rechargeable groundwater tables near water access points. 3) Develop training and demonstration sites that encourage further training and adoption of the forest garden methodology. Singida is known as the sunflower region of Tanzania. Thousands of trees have been cut down across the region over the last decades to make charcoal for cooking and to make room for
monocropping of sunflowers and corn. The villages of Mughanga and Ghalunyangu, where OSU GWI’s projects are located, are only 60 miles from the Maswa Game Reserve which borders the famous Serengeti National Park. This sustainable agroforestry project is particularly important in this region because it begins to restore a buffer between conservation areas and agriculture production. In addition, farmers are growing everything they need, preventing further deforestation and mining of forest resources.

The impacts that agroforestry systems achieve are as follows:

- Creates ecosystem synergies allowing the intercropping system to produce higher yields
- Protects the fragile semi-arid ecosystem of semi-arid where soil conditions cannot support typical monoculture crops.
- Ensures large quantities of biomass for mulching and moisture retention.
- Increases farmer incomes and food security
- Prepares farmers for adaptation to climate change and resilience to rainfall variability, including drought and flooding: reducing the effects of climate-induced hydro meteorological events by transforming dryland into a sponge that can absorb and channel rainwater into the ground during heavy rain events and release green water during months of drought.
- Creates CO₂ sequestration-intensive farmland
- Improves soil fertility through intensive pruning, mulching, use of manure and the introduction of nitrogen-fixing (leguminous) cover crops.
- Assist farmers in adopting organic practices - no pesticides or chemical fertilizers.

**PROJECT BENEFICIARIES**

In May, 2019, following a three month mobilization and registration period, farmers in the OSU 1 Project began training in Forest Garden Design and Nursery Development. Next month, they will be completing the first year of the four year program. The figures below provide information on the number and demographic breakdown of Total project beneficiaries and the numbers that OSU GWI supported through your generous partnership.

<table>
<thead>
<tr>
<th>Project Total</th>
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<tbody>
<tr>
<td>Number of Farmers</td>
<td></td>
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<tr>
<td>Female 40% Male 69%</td>
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<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Families Beneficiaries</td>
<td></td>
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<tr>
<td>498</td>
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</table>
TREE PLANTING ACTIVITIES

TREES projects are planned and implemented following a seasonal calendar (See Season Planting and Harvesting Work Plan). In Tanzania the rainy season occurs between late November to January. Often there is a dry month in February and the rain continues into March and April. However, this second rain is highly variable. This year, the rains have continued and allowed for excellent continued tree growth.

Development of Two Demonstration gardens: Demonstration Sites were developed with the following Lead Farmers from each village

- Ally Rajabu Mahayu, Mughanga
- Sifaeli Nalopa Nsali, Ghalunyangu

Trainings: In preparation for a successful outplanting season, technicians spend months training farmers in groups on the following modules:

Year One trainings and activities done from May 2018 to April 2019
- Forest Garden Design
- Growing Agroforestry Seedlings
- Outplanting Agroforestry Seedlings
- Permagardening for the family

Year two Trainings from May 2019 to April 2020
- Review of the Forest Gardening
- Growing Fruit Tree Seedlings
- Planting Fruit Tree Seedlings
- Permagardening for the market
- Fruit tree grafting

Seeds and materials distributed to farmers

Agroforestry Seeds
1. Acacia policantha 200g/farmer
2. Gliricidia sepium 100g/farmer
3. Leucaena diversifolia 200g/farmer
4. Leucaena leucocephala 200g/farmer
5. Moringa Oleifera 500g/farmer

Fruit tree seeds/Seedlings
1. Papaya Hybrid seeds 1g/farmer
2. Passion seeds 50g/farmer
3. Guava seed 50g/farmer
4. Mango 5 seedlings/farmer
5. Avocado 5 seedling /farmer

**Vegetable seeds distributed**
1. Swiss chard 25g/farmer
2. Chinese cabbage 25g/farmer
3. Onions 25/farmer
4. Carrots 25g/farmer
5. Tomatoes 25g/farmer
6. Okra 25g/farmer

**Materials and equipment distributed**
1. Spades 1pc /farmer
2. Rakes 1pc /farmer
3. Watering cane 2pc/farmer
4. Wheelbarrow 1pc/farmer
5. Pruning shears 1pc/farmer
6. Polythene tubes 6kg/farmer

**Collaboration with BM Farm Africa**
- Collaboration in training of some modules like Permagarderning since they were very experienced in vegetables and fruits production
- Different meetings with farmers like mobilization meetings in Mughanga and Ghalunyangu during water project sensitization with farmer community
- Staff meeting in the office to discuss how to identify the best farmers and how to work with them

<table>
<thead>
<tr>
<th>Project</th>
<th>Project Total</th>
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<tbody>
<tr>
<td>Number of Trees Planted</td>
<td>168,305</td>
</tr>
<tr>
<td>Number of Training Conducted</td>
<td>32</td>
</tr>
<tr>
<td>Number of Acres Planted</td>
<td>60</td>
</tr>
<tr>
<td>Metric Tons of CO2 Sequestered over 20 years</td>
<td>8,678</td>
</tr>
</tbody>
</table>

See the table below highlighting the tree species and vegetables out-planted by 60 farmers between March 2018 and March 2020. The accompanying Seasonal Planting and Harvest Work plan provides visual details on the function of each tree species with the system.
<table>
<thead>
<tr>
<th>Tree Species</th>
<th>Numbers</th>
<th>Vegetable Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agroforestry trees</strong></td>
<td></td>
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<tr>
<td>Acacia polyacantha</td>
<td>26,865</td>
<td>Okra</td>
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<tr>
<td>Gliricidia sepium</td>
<td>11,406</td>
<td>Carrot</td>
</tr>
<tr>
<td>Leucaena leucocephala</td>
<td>9,320</td>
<td>Onion</td>
</tr>
<tr>
<td>Leucaena diversifolia</td>
<td>5,397</td>
<td>Tomatoes</td>
</tr>
<tr>
<td>Moringa oleifera</td>
<td>10,539</td>
<td>Pumpkin</td>
</tr>
<tr>
<td><strong>Fruit trees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papaya</td>
<td>456</td>
<td>Cassava</td>
</tr>
<tr>
<td>Passion</td>
<td>748</td>
<td>Beans</td>
</tr>
<tr>
<td>Guava</td>
<td>486</td>
<td>Chinese Cabbage</td>
</tr>
<tr>
<td>Avocado</td>
<td>300</td>
<td>Swiss Chard</td>
</tr>
<tr>
<td>Mango</td>
<td>300</td>
<td></td>
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<tr>
<td><strong>Timber trees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrocarpus Fraxinifolius</td>
<td>1,020</td>
<td></td>
</tr>
<tr>
<td>Grivellia robusta</td>
<td>265</td>
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</tbody>
</table>

AGROFORESTRY SYSTEM DESIGN AND COMPONENTS
TREES Forest Garden Approach is an adaptable methodology. Although we have recommended species and approaches that farmers learn during training, ultimately the farmer designs their own Forest Garden. During Forest Garden Design training, TREES technicians utilise a participatory process to engage with farmers to further adapt the design to align with farmer’s recommendations. This results in a design, crop selection, and placement that all farmers are committed to implementing because they have ownership over the design process. The basic building blocks of all forest gardens are outlined below.

Living Fence/Green Wall
Green Walls consist of three rows of agroforestry trees that surround the entire perimeter of the field. The purpose of the green wall is to protect the field from animals, wind and water erosion, stabilize soils, fix nitrogen in soils, provide organic matter for composting, and provide additional food crops and animal fodder. The two outer rows consist of a mixture of agroforestry trees indicated in the Planting and Harvesting Plan. Additional seedlings are grown in later years for
transplanting to fill in missing spaces of those that may not survive. The inner third layer of the green wall consists of a row of timber trees that support the structure of the outer layers and provide a long term investment and may be sustainably harvested in 30 plus years.

**Alley Cropping**

Alley cropping segments the field with nitrogen fixing and food crop trees. Alley cropping improves the soils, provides organic material for composting and mulching, captures and infiltrates rainfall, and also provides animal fodder and food.

**Fruit Trees**

Fast growing, quick producing fruit trees including *Papaya and Passion Fruit* were planted throughout the field. These trees will provide a valuable food source and income within the first three years. In addition, slower growing fruit trees including *Avocado and Mango* were planted in the field and will produce after the third year.

**Staple Crops**

In the alleys between trees, farmers have the choice of growing staple crops or expanding vegetable permaculture. Either way, these alleys provide a secure food source and income. Farmers plant a variety of crops in these alleys including: *Beans, Cassava, Maize, Sweet Potato, and other*. Some alleys may be split with various staple crops. In addition, some farmers may choose to plant horticulture crops in a portion of the alleys including tomatoes, watermelons and pumpkin.

**Market Garden**

The market garden provides a space for continuous horticulture production, including after the all trees are fully grown. Crops grown in this area are for home consumption and/or sale including: *Okra, Carrots, Onion, Chard, Okra, Tomato, and Pumpkin*. Market gardens produce during different seasons: including wet and dry season crops. Some of these crops will also be grown in the staples alleys during the first 3 years of production and some staple crops could be grown in this area post 5 years.

**Composting and Mulching:** Farmers develop one open pit compost pile within the first year and a second later in the project. The compost includes a mixture of available organic matter, manure (if available) and is continuously turned and kept at optimal moisture to ensure aerobic decomposition. Farmers are trained on compost development and can additionally harvest leaves, from trees in the green wall and alleys, to mix into the compost to add organic matter. In addition
these leaves make excellent mulching material for fruit trees.

**Aggregation and Processing:** With increased production of fruits and vegetables, there is an opportunity to aggregate the production of these smallholder farmers for processing or sale to a higher market.

**Value added products:** High protein animal feed can be made from species in the green wall. In addition, flowering trees will provide an ideal environment for beekeeping. These food and income generating activities can be introduced later in the project.

**Biodegradable seedling sacs:** With the expansion of agroforestry systems and the desire to have all elements of the value chain sustainable, TREETES made the commitment to using biodegradable tree seedlings sacs were used in all our projects in 2019. However, in Tanzania they were unavailable and importing across the border from Kenya proved to be infeasible. For 2020 we have now found a supplier in Tanzania and will be using 100% biodegradable tree sacs.
**MONITORING AND EVALUATION**

Monthly farmer visits conducted by technicians to observe progress and provide one-on-one mentoring and technical support. Technicians also record the number of trainings conducted and trees planted and report this information through an online Monthly Reporting Form integrated with Salesforce. Randomly selected samples of this data and the data collected below are backchecked by the Regional Coordinator, Country Director and Programs Director annually.

To track the impact of our projects, TREES has a robust GIS based mobile Monitoring and Evaluation system, TaroWorks, integrated with SalesForce. Through this system we register farmers at the beginning of the program and conduct two annual surveys:

**Registration:** This records the farmers name, GPS point of the field, photo of farmer and land, land size, baseline tree count and crops species. It also records gender and family demographics.

**Annual Technical Data Form TDF:** This annual survey is conducted for every forest garden and tracks the physicalities and production (size, marketable products, # of trees onsite, and household data. This annual survey is conducted in September, several months following tree planting, to observe and record actual trees in the field providing survival rate information. Therefore we currently only have the 2019 baseline TDF data for OSU 1 (see table below).

**Annual Sample Survey:** For this annual survey we use ArcGIS to determine a selection size that will result in a 95% confidence level and randomly select farmers in each country to do this more in-depth
survey which includes 75 questions in four areas:

- General demographics: family size, age, education levels, gender
- Food and security access: (USAID Household Access to Food Survey)
- Household dietary diversity (FAO survey) Questions regarding different types of foods eaten in the last 24 hours and directly correlated to food groups.
- Household resilience reflecting increase in income

The timing of these surveys is critical. They are taken during periods of highest stress in the year (before harvest) and measure important aspects of the realities of our participants’ day-to-day lives. For the communities in Tabora this is between January and February. We currently have baseline data on food security and dietary diversity for OSU 1. This data was taken prior to their first vegetable harvest. As you can see in the chart below, the food insecurity is quite high and dietary diversity very low. The numbers for food insecurity and dietary diversity in the chart are ‘index scores’. For more details on the process see info below.

**Household Food Insecurity Access Score:** In TREES journey to build more prosperous and resilient farming communities, one of the major impacts we aim for is increased food security for our participating farmers and their households. By improving people’s access to food, our work is eliminating hunger for thousands of families. The way in which we measure this impact is via the Sample Survey’s Household Food Insecurity Access Scale (HFIAS). This tool was developed by the United States Agency for International Development (USAID) and is a global standard for measurement of household food insecurity.

Each of the questions in the survey is asked with a recall period of four weeks (30 days). The respondent is first asked an occurrence question – that is, whether the condition in the question happened at all in the past four weeks. These are very difficult questions to ask and to hear the results for. A sample of some of the questions are listed below.

- Did you or any household member have to eat a limited variety of foods due to a lack of resources?
- Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
- Did you or any household member have to eat fewer meals in a day because there was not enough food?
- Was there ever no food to eat of any kind in your household because of a lack of resources to get food?
- Did you or any household member go a whole day and night without eating anything because there was not enough food?

Results of OSU 1’s HFIAS can be seen below.
HFIAS Results
Singida OSU Project HFIAS Results

<table>
<thead>
<tr>
<th>Household Food Insecurity Access Score</th>
<th>2019</th>
<th>2020</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (out of 27)</td>
<td>7.47</td>
<td>4.71</td>
<td>3.73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Food Insecurity Access Category</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Secure</td>
<td>0.00%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Mildly Food Insecure</td>
<td>0.00%</td>
<td>35.71%</td>
</tr>
<tr>
<td>Moderately Food Insecure</td>
<td>13.33%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Severely Food Insecure</td>
<td>86.67%</td>
<td>7.14%</td>
</tr>
</tbody>
</table>

Household Dietary Diversity Score (HDDS): A second metric used to measure the food security of households also relates to the nutritional qualities of meals is dietary diversity. Dietary diversity is defined as the number of different foods or food groups eaten over a reference time period. Based on research conducted by the Food and Agriculture Organization (FAO), when combined with access, the diversity of a diet can provide an adequate measure of food security.

The TREES Household Dietary Diversity Score (HDDS) survey is adapted from USAID’s Household Dietary Diversity Score. Many of TREES’ sampling and analysis procedures were kept from the USAID survey, but TREES adapted the questions to include local foods commonly eaten in the areas where programs are implemented.

To better reflect a quality diet, the number of different food groups consumed is calculated, rather than the number of different foods consumed. This is a more meaningful indicator than knowing that households consume four different foods, which might all be cereals. The following set of 12 food groups is used to calculate the HDDS:

- a. Cereals
- b. Root and tubers
- c. Vegetables
- d. Fruits
- e. Meat, poultry, offal (organs)
- f. Eggs
- g. Fish and seafood
- h. Pulses/legumes/nuts
- i. Milk and milk products
- j. Oil/fats
- k. Sugar/honey
- l. Miscellaneous

Data for the HDDS indicator is collected by asking the respondent a series of yes or no questions regarding the food they have consumed using the previous 24 hours as a reference period (24-hour recall). Longer reference periods result in less accurate information due to imperfect recall. Results of OSU 1’s HDDS survey can be seen below. See page 19 of our 2019 Impact Report to see increase in access to different food groups across all of our projects.
Singida OSU - HDDS Results

<table>
<thead>
<tr>
<th>Household Dietary Diversity Score</th>
<th>2019</th>
<th>2020</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (out of 12)</td>
<td>6.40</td>
<td>9.07</td>
<td>9.20</td>
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</table>

<table>
<thead>
<tr>
<th>Household Dietary Diversity Category</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Dietary Diversity</td>
<td>27.07%</td>
<td>51.11%</td>
</tr>
<tr>
<td>Moderate Dietary Diversity</td>
<td>71.27%</td>
<td>48.33%</td>
</tr>
<tr>
<td>Low Dietary Diversity</td>
<td>1.66%</td>
<td>0.56%</td>
</tr>
</tbody>
</table>

CHALLENGES

**Water:** The primary challenge is water access. Drought, few water sources, and water sources often far from farmers premises and forest gardens caused some trees to die and made it difficult to produce vegetables. When the project started it was assumed that the farmers would create gardens near the water access points and be able to utilize the newly developed water sources. However, even potable groundwater is scarce and proved difficult to tap. Once the wells were established it was determined that the water recharge would only be sufficient for potable use and that farmers could not use it for agriculture production. To ensure sustainable irrigation water all future projects should include training and materials for developing rain water harvesting systems with farmers. However, despite this challenge farmers are seeing increased food security, dietary diversity and incomes to pay for household potable water.

**Drone:** Gathering drone imagery and infrared photos on a portion of the farmers land, was originally a component of this project. This imagery can assist us in the calculating Above Ground Biomass and Leaf Area Index. In September, 2018 Baseline data was taken. However, when we returned in September, 2019 to collect year 1 data, the drone was confiscated at the airport due to a new policy requiring a special permit. We were able to recover the drone upon departure. and obtain a permit for use in 2020. It appears due to COVID-19 we may not be able to collect data for 2020 as well. Follow up drone footage and the accompanying calculations will be provided to OSU as soon as it is obtained.

**FARMER STORY**

**Name:** Samwel Joseph Mlula

**Farmer Group:** Mkombozi

**Village:** Mughanga

**Project name:** OSU-Water Project
How Samwel Joseph Mlula Optimized his Farm and Inspired the community through Forest Garden Approach

Mr. Samwel is a farmer living in Mughanga with his family. He is among many other farmers who have been doing subsistence farming for generations. Prior to starting the project, his land was depleted due to mono cropping, overgrazing and unsustainable farming practices.

In May 2018, when Trees for the future and other partners collaborating in GWI SVWP, started the project in Mughanga, Mr. Samwel was among the earliest members to join the Forest Garden project. He worked hard, attended all of the training workshops, and established his nursery. After only two years of hard work, Samwel is now enjoying very big changes on his farm including improved soil health, increased crop harvesting, increased income from his forest garden by selling maize, cassava, papaya and many other vegetables, improved nutritious food and the health of his family, increased food security and many other environmental conservation benefits.

Due to the excellent appearance of the Forest Garden and its produce, the community around him has been inspired to join the project and Samwel is training his community to start the forest garden with their own resources. The following are among the few individuals who received training from Mr. Samwel:

1. Felista Tangi, School Director St. Therese Secondary School from Mwanza region who was very inspired and requested training from Samwel during the holiday. After the holiday, when she was back to Mwanza, she managed to start the Forest Garden in her School. She also hired one farmer from Mkombozi Group to train her students and supervise the school nursery.
2. Mpambaa Dispensary Committee got the training from Samwel and some passion seedlings and are requesting to join the forest garden project.
3. Faraja Sima is among the farmers from the same village who is very inspired by the forest garden approach and he started finding the resources to start the forest garden on his own.

TREES registered 200 additional participants to the two villages to join the program in 2019. These additional farmers are being funded by two of TREES Brandy Partners: Eminence Organic Skin Care Products and Nature.house.

ADDITIONAL DOCUMENTS AND COMMUNICATION MATERIALS

Forest Gardens around the World.

8 women making strides in African Ag

HIV Patients Finding Support and Prosperity in Their Farmer Groups

More Projects than Ever Before

Forest Gardens around the World

Seven Ways Forest Gardens Promote Independence
Teaching a Man to Fish

Soil Regeneration

2019 Impact Report

COVID-19 Response

TREES Documentary

ONE SHOT: Trees as our Last Chance for Survival, by TREES Executive Director, John Leary

MAP OF SINGIDA REGIONAL PROJECTS IN TANZANIA
<table>
<thead>
<tr>
<th>Nursery Establishment</th>
<th>Function in the System</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tbody>
<tr>
<td>Transplanting</td>
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<td>Direct seeding</td>
<td>Live Fence</td>
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<tr>
<td></td>
<td>Alley Crop</td>
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<td></td>
<td>Fixes Nitrogen in soil</td>
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<tr>
<td></td>
<td>Fruit Trees</td>
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<td></td>
<td>Perma-Garden</td>
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</table>

**AGROFORESTRY TREES**

- *Leucaena leucocephala* X X X X
- *Moringa olifera* X X
- *Acacia polyacantha* X
- *Leucaena diversifolia* X X
- *Gliricidia sepium* X X X

**TIMBER TREES**

- *Acrocarpus Flaxinifolius* X
- *Grevillea robusta* X

**FRUIT TREES**

- *Passion Fruit* X X
- *Papaya* X X
- *Mango* X X
- *Avocado* X X

**Staple CROPS**

- *Beans* X X X
- *Cassava* X X
- *Maize* X X
- *Sweet Potato* X X

**MARKET GARDEN**

- *Okra* X X
- *Carrots* X X
- *Onion* X X
- *Swiss Chard* X X
- *Sunflower* X X X
- *Tomato* X X X
- *Pumpkin* X X X

*1 Harvest year-round (peak times indicated)
*2 Harvest year-round
*3 Year-round because of multiple varities
*4 These fruits are grafted in the nursery in August and take 3 years to mature
*5 Produce Fruit in the first year