

# Sustainable Horticultural Crop Production in Tanzania

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## **I. INTRODUCTION**

The United Republic of Tanzania is best known for its amazing natural features and wildlife. It is home to Africa's only glacier-topped volcano, Mt. Kilimanjaro, which is 5,895 meters/19,340 ft high; the world's second largest fresh water lake, Lake Victoria; the world's second deepest fresh water lake, Lake Tanganyika; and the Ngorongoro Crater and Serengeti plains, where it is easy to find lions, elephants, zebras, rhinos, and giraffes. Tanzania is also ideally situated just below the equator, south of Kenya, and has 1,424 meters of shoreline along the Indian Ocean, which include three islands, see Figure 1, (US CIA 2009). The country is about twice the size of California, with topography of tropical coastal plains, dry plateaus, and temperate highlands. The coast sees average rainfalls over 1000 mm/40 inches, while the plateau receives just 250 mm/10 inches, (US CIA 2009).

Natural resources found in Tanzania include hydropower, tin, iron ore, phosphates, coal, gold, natural gas, nickel, diamonds, and other gemstones. Industries have developed around these resources and also include mining of salt and soda ash, producing cement, refining oil, making shoes and apparel, and producing sugar, beer, cigarettes, wood products, and sisal twine, (US CIA 2009).



Fig. 1 – Map of the country, Tanzania (U.S. Department of State 2009, [www.state.gov/p/af/ci/tz](http://www.state.gov/p/af/ci/tz))

The land is covered by brush, trees, and grasslands that are difficult to clear for production. The majority of Tanzanian agriculture is in the hands of small farmers who cultivate less than 2 hectares each. Very few farmers use animals or machinery for their work. Cultivation is done by hand and employs 80% of the labor force. Part of the reason for not utilizing animals for cultivation is because over half of Tanzania is infested with the tsetse fly, which transmits a fatal infection to animals and humans (Encyclopedia Britannica 2009).

It is estimated that nearly 1,840 sq km are irrigated in Tanzania. This is quite small compared to the amount of land with potential for irrigation. Most irrigation is for rice and sugar cane, but

Its most important resource, though, is agriculture—making up 48% of the country's gross domestic product and 85% of their exports. All of it produced on 4-7% of the land, 1% of which is in permanent crops—crops that are not replanted each year such as coffee, tea, cashews, and sisal, (New Agriculturist 2003, US CIA 2009). Much of the rest of the land is unfit for agriculture because it is lacking nutrients, is too sandy along the coasts, or is too dry or too wet.

some farmers are growing maize, vegetables and cut flowers. Poor planning of some irrigation canals has led to dramatic decreases in crop yields because of salt accumulation from substandard drainage. It was reported in the *East African* that one farmer's yields fell from 40 bags of rice produced on one hectare in 1974, down to just seven bags produced on the same hectare today (*The East African* 2009; United Nations 2009).

All of these issues, along with poor roads and infrastructure, lack of capital, diseases like malaria, human immunodeficiency virus (HIV), and yellow fever, plus 32% of the population without access to safe drinking water have all contributed to the slow progression of the Tanzanian economy. The country is in the bottom 10% of the world's poorest nations, (United Nations 2009). Yet, it is one of the most politically stable African countries, which makes it a promising candidate for development investment, including a horticulture industry.

## **II. DEFINING SUSTAINABILITY**

The United Republic of Tanzania does not have specific guidelines for defining what is sustainable or a 'green' practice that I could find. The term is used commonly throughout literature produced in the country by the government, non-governmental agencies, and by for-profit business. The word seems like it is part of common vocabulary and perhaps its meaning is taken for granted. The following examples of how the term 'sustainability' is being used by the public and private sectors illustrates the word's meaning in Tanzania.

The Earth Summit held in Rio de Janeiro in 1992, produced a set of guidelines for sustainable development called Agenda 21. Tanzania then set up a National Plan for Agenda 21 within the government's Division of Environment. The Earth Summit's Agenda 21 called on local communities to bring about the change needed to support the growing populations that will

need to rely on fewer energy inputs, (Jacobi et al. 2009). After the Earth Summit in 1992, the government of Tanzania revised its Agricultural Policy to include environmental awareness education and research into earth-friendly technology and sustainable agricultural practices, (United Nations 2009). Unfortunately, these terms were not defined.

Dar es Salaam, the capital city, has a thriving urban and peri-urban agriculture/horticulture culture that is feeding families, schools, hotels, and restaurants. Peri-urban agriculture is practiced on the outskirts of a city where there may be more open space. Throughout publications on the subject, the term ‘sustainable’ is used, but without a formal definition being given. Sustainable is used in relation to urban agriculture/horticulture to describe practices that provide an income and employment to poor populations, supplies fresh food, increased nutrition, food security, energy conservation through limited inputs, little-to-no transportation costs, fewer storage costs, and improvement of micro-climates and air quality (Bruinsma and Dubbeling 1998).

Another influence on Tanzania’s interpretation of sustainability comes from the Tanzania Horticultural Association (TAHA), which is a member organization that promotes the industry. The TAHA mission is “...to promote the Horticulture sector in Tanzania to become more profitable, sustainable, and participate more effectively in the development of the country” (Tanzania Horticultural Association 2009). Their vision “...is to create a vibrant, prosperous and sustainable horticultural production in Tanzania,” representing 14 exporters and 45 growers (Tanzania Horticultural Association 2009). Unfortunately, TAHA does not define sustainability.

Two Tanzanian flower growers are participating in the Milieu Project Sierteelt from the Netherlands ([www.mymps.nl/?id=50](http://www.mymps.nl/?id=50)). The organization promotes the growing of flowers without the use of chemicals and certifies growers. This certificate can also apply towards a

certificate from Fair Flowers Fair Plants, supported by the European community. This organization defines sustainability as “cultivated flowers and plants grown in a way that respects people and the environment,” (Fair Flowers Fair Plants 2009).

### **III. HISTORICAL PRACTICES**

Tanzania does not have a long history of horticultural practices and an even shorter history of greenhouse production—the first commercial one being built in 1992 (Hatibu et al. 2000). The island of Zanzibar is an exception, as it has been one of the world’s largest producers of cloves since the 1850s. This was made possible by cultivation of the plantations by slaves. Other spices were introduced and thrived, like cumin, ginger, nutmeg, pepper, cinnamon, and cardamom. Zanzibar quickly came to be known as ‘The Spice Island’ (ZanzibarNet 2009).

The mainland, which has very different growing conditions, has only more recently begun to develop a horticulture industry. According to the TAHA, the horticulture industry started in the 1950s, with perishable horticultural exports beginning in the 1970s. Trade reports from 1966-1968, though, show that Tanzania was exporting vegetables during the 1960s (Wurster and Jensen 1969).

Trade reports from 1966, 1967, and 1968, show a long list of fruits and vegetables being exported. The cash crop for Tanzania at that time was cashews, which were worth 5,082,265£ in 1968. Nuts accounted for 70% of their exports. Seeds, bulbs, and cut flowers were grouped into one category that was worth 25,498£ in 1966. Tanzania’s total value of horticultural exports in 1968 was 7,202,834£ (Wurster and Jensen 1969).

Other than cashews, Tanzania was considered slow to develop a horticulture industry because of a lack of demand within east Africa and the great distance to other markets in Europe.

There was also a lack of information on marketing products, cost analysis of new technologies and chemical fertilizers, processing capabilities of fresh crops, information on how to grow new crops that Europeans preferred, access to suitable varieties, and storage and transportation issues (Wurster and Jensen 1969). A lack of investment capital has also held the horticulture industry back.

One such example is that of the first cut-flower farm, Tanzania Flowers Limited. They began cultivating carnations (*Dianthus caryophyllus*), euphorbia, and bishop's weed (*Ammi majus*) in fields in 1987, because they did not have the funds to build a greenhouse. They did expand in 1992 to build a 6000 sq. m. greenhouse—the first commercial greenhouse in Tanzania—in which they grew roses. By 2003, they had increased their greenhouses to 36,000 sq. m. (Msogoya and Maerere 2006).

#### **IV. CURRENT PRODUCTION STATISTICS**

Horticulture is the fastest growing industry in Tanzania, according to the Tanzania Horticultural Association, with export growth at 8% each year. Today, major cash crops in order of importance are sugar, cotton, cashews, tobacco, tea, coffee, sisal, and pyrethrum. Sunflowers, groundnuts, simsim, and soya are grown for oil (Tanzania Horticultural Association 2009). As for horticultural exports, cut flowers make up the bulk of profits. During the 2005/2006 financial year, Tanzania exported 1,706.48 metric tonnes of fruits and vegetables, and 4,792.40 metric tonnes of flowers (Guardian 2007).

The horticultural sector earns nearly \$130 million each year and provides jobs to 30,000 – 50,000 people. Fifty varieties of roses are grown, along with cutting flowers like gerbera, aster,

lisianthus, gypsophilla, million star, hypercium, papyrus, tuberose, fern and chrysanthemums. Herbs and border plants are also grown.

Unfortunately, the horticulture industry is affected by neighboring political problems. As much as 65% of all Tanzanian cut-flowers leave Africa through the Kenyan airport in Nairobi. The political strife there in 2008 caused the cancellation of many flights, causing a loss of roses worth nearly 185,000 USD in just one month (Nkwame 2008; Ihucha 2008). More recently, the industry has shown its susceptibility to changing global markets. Prices for Tanzanian flowers in the European auctions have fallen by half since October of 2008 (Reuters 2009).

The current global economic crisis will surely not hold down the horticulture market permanently. In late 2008, the U.S. government helped fund programs to develop more reliable ways to export horticultural products. One of these programs, the Tanzanian Airfreight Project, secured a weekly, dedicated cargo flight just for Tanzanian horticultural crops that began in January 2009 (Embassy of the United States 2008; East African Business Week 2009). The assurance of a reliable, weekly cargo flight is expected to bring investors and improve the sustainability of the industry.

## **V. CURRENT PRODUCTION PRACTICES**

In 2003, T.J. Msogoya and A.P. Maerere (2006) conducted a survey of eight cut-flower growers to assess the performance of this young industry. At that time, there were 13 companies growing cut-flowers and cuttings. Most of the cut-flower industry is located in northern Tanzania, nearest the equator, where the rainfall averages 1000-1200 mm (39-47 in) and temperatures range from 17-30° C (63-86° F). Yields per hectare are greater here compared to other parts of the world because flowers can be grown year-round (Msogoya and Maerere 2006).

According to the survey, land under cultivation increased steadily through the 1990s and into the 2000s. In 1995, 31 ha were dedicated for growing roses. By 2003, roses were being grown on 259 ha. Rose yields also increased from 113 million stems to 908 million stems over the same time period. Chrysanthemum cultivation among those surveyed increased from 1 ha in 1997 to 9 ha in 2003. Shoot tip yield rose from 19 million in 1997 to 145 million in 2003.

The cost of operating a greenhouse in Tanzania is less expensive than in temperate parts of the world—the Tanzanian growers interviewed use less advanced technologies in their greenhouses. Glazing materials are plastic products, usually a polyethylene cover over wooden support beams. Being so near the equator, the greenhouses do not require heat or light sources, the only exception being in chrysanthemum production.

Although a greenhouse costs less in Tanzania, it does take up 50% of the initial investment capital to construct one (Fig. 2). The purchase of land for the operation is 18% of costs. Initial rose cuttings for starting production take up 12% of investment capital. Growers import new varieties and then generally propagate their own stock afterwards. The rest of the investment costs are taken up by purchasing machinery, cold storage rooms, and other equipment.

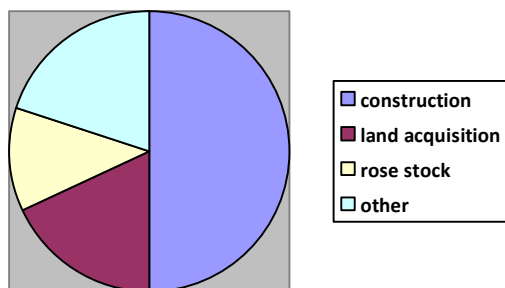


Fig. 2 – Initial investment costs for greenhouses built in Tanzania (Hatibu et al. 2000).

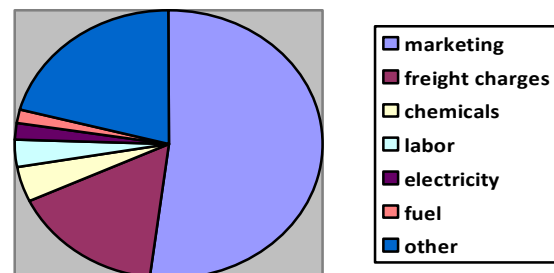


Fig. 3 – Operating costs for greenhouses built in Tanzania (Hatibu et al. 2000).



Marketing is the biggest operational expense for Tanzanian growers, accounting for 52% of the crop production costs (Fig. 3). Freight charges consume 16% of the budget. Chemicals for fertilization, and pest and disease management during cultivation and post-harvest are 4.2% of the operational expenses. The use of chemicals seems heavy because of the necessity for blemish-free flowers. Fertilizers, fumigants, fungicides, and insecticides are used. During post-harvest handling, sterilants, nematocides, foliar feeds, acaricides, and wetting agents are used (Hatibu et al. 2000). There are many problems with the chemicals used in cut-flower production. One such problem is that a lot of common chemicals used in the industry world-wide are not registered for use in Tanzania. It costs 5,000 USD to have a chemical tested. Another problem is the negative impact chemicals and fertilizers have on water supplies, the ecosystem, and human health.

Labor is considered cheap in Tanzania compared to more developed countries, taking up just 3.4% of the budget when labor could be 20-30% of the expenses in other countries. Electricity expenses are very low compared to other parts of the world—just 1.9%. Fuel costs average 1.6% of the expenditures. Drip irrigation is the most used method for irrigating greenhouses, but their expense was not included (Hatibu et al. 2000).

Other less significant expenses include supplies like growing media. Growers use both soil and soilless growing media, the most common soilless medium being coconut peat and an unknown volcanic product (Msogoya and Maerere 2006). It is unconfirmed as to where the coconut peat and volcanic product is supplied from, but they are most likely local given the close proximity to both sources. Since coconut peat is a renewable resource, it can be considered a sustainable growing medium.



Fig. 4 – Kiliflora’s two cut flower farms near the northern city of Arusha, Tanzania: Loliondo Farm (left) and Nduruma Farm (right) (Kiliflora 2009, [www.kiliflora.com](http://www.kiliflora.com)).

There are two growers in Tanzania that exemplify many sustainable business and environmental practices—Kiliflora and Mount Meru Flowers. Kiliflora participated in the Milieu Project Sierteelt from The Netherlands, which certifies producers of cut flowers who implement sustainable practices. Kiliflora was also certified by Fair Flowers Fair Plants, a European organization, for following strict guidelines when it comes to wages, freedom to form unions, health safeguards, and non-use of toxic chemicals and pesticides.

Kiliflora has two farms on which they grow roses destined for The Netherlands—Loliondo Farm and Nduruma Farm in the northern city of Arusha (Fig. 4). They collect the water drained from the greenhouses into a retaining pond and recycle it as irrigation for soil houses. They also treat their wastewater by passing it through a series of wetland ponds to filter it. Organic fertilizers and pesticides are used and they focus on recycling waste. As part of their socially sustainable practices, they have demonstration tree nurseries for educating the local community on the topic of deforestation, which of a major concern in Tanzania as nearly 90% of their energy use comes from wood. Kiliflora focuses on native tree species. Additionally, they have many

community development projects from building schools to distribution of mosquito nets (Kiliflora 2009). All of these points can be accepted as sustainable practices.

Mount Meru Flowers is perhaps the most state-of-the-art rose grower in Tanzania. According to their website, they use greenhouses manufactured by Richel, which are 7.5 m (24.6 ft) high at the ridge and 5.0 m (16.4 ft) high at the gutter. From the image in Figure 5, we can see the greenhouses are connected at the gutters and the ridge opens completely for passive venting. They grow their roses in polypropylene bags on galvanized steel troughs. The system is manufactured in Israel by Mapal Plastics, who claim their trough system provides better control over temperature, humidity, aeration, sterilization, and make it easier to transplant (Mapal



Plastics 2009). Mount Meru Flowers also has built a water reservoir to collect the rainwater that comes off the greenhouses (Fig. 6).

Fig. 5 – Mount Meru Flowers greenhouse, Arusha, Tanzania. (Mount Meru Flowers 2009, [www.mount-meru-flowers.com](http://www.mount-meru-flowers.com))



Fig. 6 – Mount Meru Flowers, showing their rainwater collection reservoir. (Mount Meru Flowers 2009, [www.mount-meru-flowers.com](http://www.mount-meru-flowers.com)).

Another company from Israel called Netafim designed the irrigation and water collection system. They have signed the United Nations CEO Water Mandate, which seeks to assist companies developing sustainable practices and policies around water use (Netafim 2009; UN Global Compact 2009). All the greenhouse conditions, like temperature, humidity, and outside wind speeds, are monitored by computers developed by Priva Intergro from The Netherlands. The computers open or close the vents accordingly and adjust fertilizer rates that are applied through the drip irrigation system—called fertigation.

## **VI. RANKED STRATEGIES**

Figure 7 ranks the historical and current production practices of the horticulture industry. The current production rankings focus on the cut flower industry because they are the only ones using greenhouses in Tanzania, to the knowledge of this author. I began the rankings with the growing of cloves and other spices in the mid-to-late 1800s. All the labor was that of slaves taken from the mainland, so this practice was very unsustainable, and Tanzania is no longer a leader in production of cloves (ZanzibarNet 2009).

The horticulture industry was said to begin in the 1950s (TAHA 2009). Seventy percent of the exports at that time were cashews grown in the open, but I did not rank the practice because very little information is available about the production practices then (Wurster and Jensen 1969). The horticulture industry began growing cut flowers in 1987 in open fields. This method of growing means the flowers are more susceptible to environmental damage and cannot be grown year-round. Tanzanian flowers would have been less competitive on the European market because they could not have been as high of quality as ones grown in greenhouses. High amounts

of chemicals would have been applied, and being exposed to rains, there would have been more chances of pollution run-off and contamination of surrounding areas and waterways. From a business and environmental perspective, growing cut flowers this way is only moderately sustainable.

In 1992, the first greenhouse was constructed (Msogoya and Maerere 2006). It is unknown to this author what the greenhouse was constructed of. Moving production from the field to the greenhouse, they could grow year-round and have more competitive flowers on the market because they would not have damages associated with outdoor weather conditions. During this time period there wasn't a dedicated cargo flight to take Tanzanian horticulture products to European markets and refrigerated trucks were expensive to obtain. The flowers had to be trucked long distances to Kenya to be loaded onto a plane. This business model was not sustainable and so this time period received a ranking of 6.

Current production practices show that at least two of the cut flower growers are using state-of-the-art production facilities. The details of these practices were discussed in section V. The greenhouses are all covered with plastic because it is cheaper, so there is a high reliance on fossil fuels. Roses are grown in polypropylene bags because the growing conditions are easier to control (Mapal Plastics 2009). They are using highly automated systems, though, which results in energy and water conservation. Most greenhouses do not require artificial lighting, heating, or active cooling. The growers do have large cooling storage rooms for post harvest, though, so these require high energy inputs. There is now a weekly cargo flight specifically for Tanzanian horticulture products leaving from a closer airport than the one previously used in Kenya. The growers have also become models of good social practices for treating employees, their families,

and the community they operate in. Overall, the business side of things has improved its sustainability ranking to 7.

Fig. 7 – Timeline of horticulture production in Tanzania and the pros and cons to production practices. Sustainable rankings are on a scale of 0 = not sustainable, and 10 = very sustainable.

<b>Time Period</b>	<b>Pros</b>	<b>Cons</b>	<b>Sustainable Ranking</b>
Mid- late- 1800s	World’s leading producer of cloves	Produced using slave labor	0
1950s	Beginning of the horticulture industry; mostly cashews	Unknown production practices	NA
1987	First cut flower farm established—exclusively field grown; fewer energy inputs, less reliance on fossil fuels	Susceptible to environmental damage, exposure to rain may lead to more pollution runoff	5
1992	First greenhouse built, unknown structure type; more control of environmental conditions, less damage to flowers, continued growing capability year round	Higher reliance on fossil fuels; no dedicated cargo flights to European markets; few refrigerated trucks	6
2003 – current	13 commercial cut flower growers; no need for heating; use passive cooling systems; use of integrated pest management; safe use of pesticides, numerous good social practices	High reliance on plastics to cover greenhouse structures and grow roses; high amount of chemicals applied, though some are organic; greenhouses are not actively cooled but growers have large cooler rooms	7

As evidenced in section V, Tanzania is working to develop a sustainable business model for the horticulture industry. They are hitting on many key points addressed in Agenda 21 that have to do with social and economic issues and natural resource management. Figure 8 looks at some of the social, business, and specific production practices and whether or not they are sustainable. Some of the growers offer many benefits to their employees that enable them to work, such as free lunches and sometimes free breakfasts, child care, extended maternity and grieving leaves, health care, money for their children’s education, free uniforms, and routine

medical exams, (Kiliflora 2009; Msogoya and Maerere 2006). Benefits like these help to create a sustainable and productive business by caring for the wellbeing of its employees. It also promotes an improved community by educating the children and providing opportunity for employment to the parents.

Tanzanian growers are also taking many steps to follow the environmental aspects of Agenda 21. They are practicing water conservation by diverting discharge water into retaining ponds for natural filtering before it goes back into the watershed (Kiliflora 2009). Some growers are collecting rainwater from the greenhouse roofs (Mount Meru Flowers 2009). Kiliflora has a dedicated space for a community tree nursery. They provide education to the community on how to manage their own tree nurseries, and the Kiliflora trees get planted in the surrounding area.

Some of the business practices are not sustainable, though, and should be addressed. The one of biggest concern that I found is that Tanzania does not have a diversified export market. One-hundred percent of their chrysanthemum cuttings are sold to The Netherlands and 90% of the rose cuttings. The other 10% are sent to Germany, Sweden, Norway, and England (Msogoya and Maerere 2006). If anything negative were to happen to the trade relationship between The Netherlands and Tanzania, the horticulture industry would be devastated.

The heavy use of chemicals in floriculture is also an environmental and health concern. Some growers are using organic products and require their workers to take many safety precautions, like wearing full safety suits with masks, rotating through a shifting schedule of who sprays each week, and requiring blood samples every three months to monitor their exposure levels (Kiliflora 2009). But there is always a risk of exposure, and Msogoya and Maerere (2006) discovered that workers who handle the flowers in the cutting and packaging departments often do not wear protective gear.

Another unsustainable business practice is the long hours required by most growers. One grower interviewed by Hatibu et. al. had 12-hour workdays, five required 10-hour days, and most had 9-hour days. Kiliflora, known for so many sustainable business and environmental practices, required 6-day work weeks (Hatibu et al. 2000).

Cargo flights from Kenya to European markets have proven to be an unsustainable resource, as illustrated previously. The horticulture industry lost a lot of revenue because of Kenya's political problems and their preference to allow Kenyan products on the cargo planes first. The Tanzania Horticultural Association and the U.S. Embassy have taken steps to fix this problem by gaining a dedicated cargo plane for only Tanzanian horticulture products and the plane leaves from the Kilimanjaro airport in Tanzania (Embassy of the United States 2008; East African Business Week 2009). The Tanzanian horticulture industry is still very young and working through a lot of their problems. Successes like this one shows that the country does have the potential to create a sustainable industry as it continues to grow.

Cut flowers make up the bulk of horticultural exports in Tanzania. During the 2005/2006 financial year, they exported 1,706.48 metric tonnes of fruits and vegetables, and exported 4,792.40 metric tonnes of flowers (Guardian 2007). Cut flowers are the most profitable area to begin research into more sustainable growing methods. Roses account for over 75% of the flowers grown for export in Tanzania, with chrysanthemums in second place (Private Agricultural Sector Support 2009). As stated previously, 100% of the chrysanthemum cuttings are sold to The Netherlands and 90% of the rose cuttings. The other 10% are sold to European markets (Msogoya and Maerere 2006). These two flowers would make good candidates for research on plants that are already being grown. In one publication on investment potential in the floriculture industry, chrysanthemums and tropical orchids (*Dendrobium*, *Phalaenopsis*, and



*Oncidium*), were named as the most highly demanded flowers in Europe (Private Agricultural Sector Support 2009). It is logical to consider researching growing methods of orchids since the market connections are already established.

Fig. 8 – The different social, environmental, and business/industry practices implemented in Tanzania and whether or not they are sustainable.

<b>Social practice</b>	<b>Sustainable</b>	<b>Not sustainable</b>
Free lunch	X	
Child care	X	
Maternity leave	X	
Grieving leave	X	
Health care	X	
Paying education expenses of employees' children	X	
Free uniforms	X	
Long work hours and weeks		X
<b>Environmental practice</b>	<b>Sustainable</b>	<b>Not sustainable</b>
Natural filtration of waste water	X	
Rainwater collection	X	
Donating trees to community	X	
Teaching community classes on tree nurseries	X	
Integrated pest management	X	
Roses grown in polypropylene bags		X
Heavy application of chemicals		X
Some businesses are using organic chemicals	X	
Use of protective gear when spraying chemicals	X	
No protective gear for workers who handle flowers after spraying		X
Use of plastic to cover greenhouses		X
No reliance on active heating and cooling systems	X	
Automated monitoring and controlling systems	X	
<b>Business/industry practice</b>	<b>Sustainable</b>	<b>Not sustainable</b>
Most exports go to one country		X
Dedicated cargo flight for Tanzanian horticulture products	X	
Reliance of few species of flowers		X
Association dedicated to promoting	X	

Tanzania horticulture		
Expensive and long process of registering new chemicals		X

## VII. SUSTAINABLE DEVELOPMENT STRATEGY

As evidenced in Table? 8, there are many socially and environmentally responsible practices that will help make the industry sustainable, while there are many business practices that need to be changed. One big challenge to sustainability is that glass glazing materials are very expensive. Until there are new products that do not use fossil fuels on the market, there is not much that can be done. Most growers are using permanent structures covered with a polycarbonate, so they will last longer than plastics used on high tunnels and low tunnels. *Rosa*, the most cultivated flower, is being grown in polypropylene bags for more control over the growing conditions and ease of transplanting. If another, more sustainable, growing method could be identified, then it would be better for the environment and hopefully better financially.

Indeed, I think the two main companies I was able to find extensive information on are actually leaders in sustainable environmental and socially responsible business practices. The operations are owned by Dutch companies, who have more resources than local companies. They are trying to use organic chemicals, but, on this point, they cannot always use the newest developed organic or least harmful chemical because the registration process for new chemicals is very expensive and time-consuming. I discussed this challenge in the previous section. It would be helpful to the industry if the government established a different process. More in-country research could be started to look at new organic chemicals. More research should also be done in ways to produce flowers without the use of so many chemicals. Rewards to this research may lead to money saving production practices since chemicals are generally expensive, and the

health and environmental consequences of using them are also expensive. Many growers are using integrated pest management strategies, which is very good.

Currently, the horticulture industry is suffering in the global economic downturn. Flowers are particularly hard hit because they are more of a luxury item than vegetables and fruits. Vegetable prices have dropped 25-30%, while flower prices have dropped 40-50% (Juma 2009). As mentioned previously, almost all the flower exports are delivered to The Netherlands and only a limited number of different species are grown. Overall, flowers bring more to the Tanzanian economy than do vegetables, so my proposal is to do further research into making the floriculture industry more sustainable by diversifying the species grown and entering more markets in Europe or in other parts of the world. The rewards of diversifying are a more stable industry with consistent profits and I think they could be cost effective because the profits are high for cut flowers. One of the challenges in entering new markets is overcoming the new requirements in labels, codes, and legislation of other countries (Machira 2009).

Energy inputs, other than for transportation, are not an issue, and labor is inexpensive and abundant. All the flower farms are in one region in northern Tanzania, so I propose more research should be done into the profitability of establishing farms in other regions of the country, particularly those with similar growing conditions as northern Tanzania. The regions along the coast would probably require active cooling systems in the warmer months. But, the Iringa region and Mbeya region, in the center and south of the country, would be ideal places to grow because they have access to airports in Mbeya and Dar es Salaam (*cf.* Figure 1), as well as similar growing conditions (Private Agricultural Sector Support 2009). Entering new regions would bring rewards of improving the economic conditions in other areas of the country and perhaps being better suited to growing different species of flowers. As mentioned in section V, it

is less expensive to buy land and construct a greenhouse in Tanzania than in other parts of the world. I think it would be cost-effective to establish farms in other regions of the country.

Critical gaps in understanding include not having ever grown flowers commercially in other regions of the country. It cannot be known for sure what will grow there successfully. The laborers most likely do not have a horticulture background and will have to be educated in all phases of the production process. At the other end of the chain, there is a gap in understanding of the legislation, labels, codes, and requirements that other countries place on their imported products. Gaining access to other markets in the world may result in having different production requirements and may be more expensive.

In order for some of this research to happen, there needs to be someone to provide the investment capital. Land will have to be acquired, greenhouses built, workers trained, plant material purchased, and money to sustain the research. Unfortunately, this type of investment is out of reach for most Tanzanians since the country ranks as one of the poorest nations in the world (United Nations 2009).

Compiling the information above with the species for research in the previous section, I have come up with the following list of research questions:

- Can *Rosa* and *Dendranthema* be grown profitably using most of the current, sustainable production practices implemented by Kiliflora and Mount Meru Flowers, in the regions of Iringa and Mbeya?
- Are there sustainable growing methods for *Rosa* that are cost-effective and competitive to growing in plastic bags?

- Can *Dendrobium*, *Phalaenopsis*, and *Oncidium* be grown profitably in the regions of Iringa and Mbeya? What are the growing requirements for these species and can they be grown sustainably?
- Is there market potential for Tanzanian cut flowers in other European countries, or possibly other countries such as the United States, Canada, or Japan? What are the requirements for exporting cut flowers into those countries?

The reasons for choosing these species have been justified in section VI, along with some of the advantages and disadvantages. One big disadvantage to the test growing experiments is the enormous set-up costs and the ability to obtain plant material to start with. But, if it turns out that Tanzania is perfect for growing orchids and can expand their production of roses, then they will be able to gain a larger share of the market.

### **VIII. PROPOSED DESIGN OF SUSTAINABLE PRODUCTION FACILITY**

For the experiments and research, I propose using the Richel greenhouse used by Mount Meru Flower company. The greenhouses are connected at the gutters, which are 5.0 m high, and the ridge is 7.5 m high. They are designed for passive cooling by having all the houses connect and each roof can open completely. For the purpose of this experiment, the greenhouses will be sectioned off or separate structures will be used to test different growing conditions without interfering with neighboring tests. The irrigation and water collection system used by Mount Meru Flowers is state-of-the-art and will be used in the experimental production facility. The system was designed by Netafim, who has signed a sustainability mandate from the UN. (Refer to section V.) The monitoring system will also be the same as what is used at Mount Meru Flowers—Priva Intergro. There will be at least four different sustainable growing methods used

to test against the plastic bag method used at Mount Meru Flowers. A fifth greenhouse on site will use the plastic bags from Mapal Plastics as the control group.

The duration of the experiment will last two years. Sufficient time should be devoted to these experiments so any problems in the system can be worked through, staff can be adequately trained, and hopefully test markets in new countries can be contacted. For trouble-shooting, a consultant from Mount Meru Flowers or Kiliflora, professors from the agricultural department at the University, or government extension officers should be hired or contacted.

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