

CAPSTONE PROJECT REPORT  
INTERNATIONAL AGRICULTURAL DEVELOPMENT  
MASTER'S OF SCIENCE  
UNIVERSITY OF CALIFORNIA, DAVIS

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## INTRODUCTION

On June 14<sup>th</sup>, 2016 I began a six month fellowship in Kenya working on a value addition project for a non-profit organization called Development in Gardening focusing on two horticultural crops, *Moringa oleifera* and *Hibiscus sabdariffa* (also known as roselle). Development in Gardening (DIG) uses farmer field schools, a technique created by the Food and Agriculture Organization of the United Nations, to promote crop diversification as a means of preventing household malnutrition among smallholder farmers in East and West Africa. DIG's farmer field schools are best established in Kenya, where they were looking to expand their programs to include horticultural crops with high market value and identified moringa and roselle for their nutritional properties and perceived marketability. As a fellow through the Research and Innovations Fellowship for Agriculture, I was tasked with analyzing the market potential for moringa and roselle and assisting in creating pilot programs to introduce these crops to farmers in DIG's network. Initially, my goals were to meet with industry leaders to identify market linkages and to interview regional farmers on best production practices for these crops. However, I arrived in Kenya to find the pilot program was well underway by DIG's Kenyan staff, who assumed I was there to provide agronomic advice on hibiscus production halfway through the season.

Despite the miscommunication, I continued to pursue my original objectives by meeting with national and international moringa and roselle companies while also assisting DIG staff with weekly farmer trainings. The most notable company I contacted was called Botanical Treasures, and was introduced to me by Dr. Carrie Waterman, a post-doc nutritionist from the University of California, Davis. Botanical Treasures sells packaged moringa and hibiscus products internationally, and offered to purchase roselle from DIG's farmer groups in bulk. However, DIG's farmers refused to sell their roselle to Botanical Treasures in hopes of receiving a better price by packaging and selling their roselle as a group. To determine the feasibility of these market options, I created a cost-benefit analysis of roselle production and packaging by collecting data through DIG's network, which confirmed the farmers' intuition that selling in bulk would have negative returns at their scale and yield. Unfortunately, the group also underestimated the costs associated with packaging and marketing their roselle locally, and decided not to continue producing roselle in subsequent seasons. Ultimately, roselle production proved to be infeasible at the scale of most of DIG's farmers unless a significant investment was made to improve soil fertility and crop health, which was outlined in the cost-benefit analysis. If this analysis had been conducted before the pilot program, DIG would have had more success in selecting appropriate farmer groups.

In addition to the roselle cost-benefit analysis, I created a moringa business plan for DIG's implementation partner, the Lwala Community Clinic. The business plan outlines the amount of bulk moringa the clinic would have to sell to Botanical Treasures in order to provide a unit of moringa powder to a malnourished patient. Similar to the roselle cost-benefit analysis, the data used for this analysis was collected at DIG's model farm.

The rest of this report consists of the roselle cost-benefit analysis, a one-page synopsis of the cost-benefit analysis, and the moringa business plan as they were presented to DIG and the Lwala Community Clinic. These reports were intended to be used locally, and are reported in Kenyan Shillings. As a simple conversion, 100 Kenyan Shillings is approximately equivalent to \$1 USD.



# ROSELLE VALUE-ADDITION

## Cost-Benefit Analysis

An analysis of value-added roselle production systems based on farmer groups  
near Rongo, Kenya.

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## ROSELLE VALUE-ADDITION

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## Introduction

This analysis was created as a part of Development in Gardening's (DIG) Roselle Value-Addition pilot project in Rongo, Kenya to understand the potential for roselle production systems to improve the lives of smallholder farmers in Kenya's highlands. Roselle (*Hibiscus sabdariffa*) is a plant native to West Africa typically grown to make tea, herbal infusions, jam, and other products from its bright-red sepals. Rich in iron, and Vitamins A and C, roselle tea was identified by DIG for its potential to address anemia within its farmer communities. DIG has two major goals through its Roselle Value-Addition pilot: 1) to increase household income by teaching their producer groups to grow roselle, make value-added products, and enter into local and national markets, and 2) to improve household nutrition by encouraging home consumption of roselle tea among producers.

The major goal of this analysis is to understand the production practices and scale of production required for DIG to successfully meet its goal of improving household incomes. A cost-benefit analysis was conducted to determine the profitability and gross margins across a range of production scales and yields, and variety of value-added products. Data for this analysis was collected at DIG's model farm plot located at the Lwala Community Clinic, and the Kuna and Waware community groups associated with the pilot program. The analysis suggests a threshold of both production scale and yield that need to be surpassed for farmers to benefit from the value-addition project. Although the analysis relies on small sample sizes and inaccurate tools of measurement to collect data, DIG can use these thresholds as general guidelines for planning future projects involving roselle production and value-addition.

## Cost-Benefit Analysis

In DIG's Roselle Value-Addition pilot, a farmer group from a rural center called Kuna near the city of Rongo was selected to grow roselle, learn value-added processing, and find local and national markets for their products. Using production information from the Kuna group, as well as from DIG's model farm at the Lwala Community Alliance, this cost-benefit analysis determines the feasibility of roselle value-addition across several production scales.

Members of the Kuna group managed roselle production in the same fashion as traditional maize systems. Depending on the size of the field and available household resources, some members ploughed their fields using hoes, while others used oxen and simple moldboard ploughs. Weeding occurred on a similar schedule to that of maize, with 2-3 major weeding events occurring per season. After the roselle bloomed, the entire flowers were harvested and the sepals were removed from the boll to be dried.

This analysis gives farmers three options for selling their roselle, two of which were identified by a major roselle tea company in Kenya called Botanical Treasures. Within Botanical Treasure's procurement model, farmers work in groups by region to consolidate and dry roselle. The majority of farmers in the production group sell "wet" roselle, which include sepals unseparated from the bolls, to a central aggregator for 20Ksh per kilogram. The aggregator then removes and dries the sepals before selling them to Botanical Treasures for 300Ksh per kilogram. As an additional option, Botanical Treasures purchases dried roselle in bulk directly from farmers at a price of 300Ksh per kilogram. As an alternative to bulk sales, farmers are given the option of drying and packaging roselle individually, then selling the

roselle through local markets. This is the option the Kuna group decided to pursue. These bags can include a group label to bring brand awareness, or can be sold without the label to save on additional packaging costs. The prices for packaged roselle used in this analysis come directly from the Kuna group, who were selling labeled packages for 30Ksh and unlabeled packages for 50Ksh. The drastic price difference is a result of how farmers viewed the packages. Despite the average package weight being nearly equal, the branded package looked smaller, and so Kuna farmers decided to sell it for 30Ksh less.

In addition to the Kuna group, data for this analysis was collected through another DIG farmer group in a city called Waware, and through DIG's model farm at the Lwala Community Alliance. Some aspects of production and packaging were not able to be measured, as discussed further in the challenges and assumptions section below. Despite these limitations, this analysis will provide a general outline of the production scales and yields required for farmers to profit from roselle, and can be used to plan future roselle value-addition projects.

## Methodology

To determine the feasibility of roselle production and value-addition at the household level, this analysis compares the total costs and revenues of the production system to calculate its gross profit and gross margin. Gross profit is calculated by subtracting all the costs of producing value-added roselle products from the expected revenues. Gross margin is a measure of efficiency within the production system, expressed as a percentage, and is calculated by dividing the gross profit by total revenue. Between two production systems with equal costs, the system that creates more profit will have a higher gross margin. For this analysis, gross margin was used as a marker of feasibility for a specific scenario, regardless of the size of gross profit. To see the both the gross profit and gross margins across all scenarios, please refer to Appendix B.

To calculate the gross profit and gross margins of roselle production systems, the total costs of producing value-added roselle products had to be measured. These costs include the tools and inputs required for cultivation, planting, weeding, harvesting and creating value-added products, and the labor required across all aspects of the production system. Since the author arrived during the middle of the production season, no direct measurements on the amount of labor required for ploughing, planting and weeding were taken. However, roselle production in Kuna closely follows the production practices of maize, for which labor requirements have been published in a land use study conducted in Kakamega.<sup>1</sup> The labor for cultivating, planting and weeding roselle was inferred from that study.

Labor required for harvesting, remove the sepals, and packaging roselle was measured by the author using the stop watch feature on an iPhone and multiplying the given time by the number of laborers involved, as seen in the table below (the complete table is found in Appendix A). The average time required for harvesting one kilogram of roselle was calculated by taking the average time it took to harvest one kilogram from the Kuna group and the upper and lower DIG plots. Similar methods were used to obtain the average time required to remove and package dried sepals per kilogram of dried roselle. To measure field size, a pace count was conducted around the perimeter of the field and

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<sup>1</sup> Nambo, E. 2010. "Trends in land use and agricultural intensification in Kakamega, Western Kenya" (Doctoral dissertation). Retrieved from the Rheinischen-Friedrich-Wilhelms-Universität zu Bonn.



converted to meters. Wet weight yield, which includes the boll and sepals, was measured using a hanging scale, while dry weight was weighed using a table scale.

Location	Date	Size of Field (m <sup>2</sup> )	Harvest (hrs/kg)	Wet Weight (kg)	Yield, wet weight (kg/m <sup>2</sup> )	Dry Weight (kg)	Calyx Removal (hrs/kg)	Package Time (hrs/kg)	Package (#/kg)
DIG, upper garden	27-Jul	18.070	0.128	10.90	0.603		0.553		
Kuna	9-Aug	391.320	0.138	60.00	0.153			2.605	59.000
DIG, lower garden	16-Aug	91.090		10.40	0.114	0.560	0.745	3.959	71.274
DIG, lower garden	29-Aug	28.690	0.174	3.83	0.133	0.221	0.458		
Waware	11-Oct	63.710		24.73	0.388	1.380			
<b>Averages:</b>		<b>118.576</b>	<b>0.146</b>	<b>21.28</b>	<b>0.278</b>	<b>0.391</b>	<b>0.585</b>	<b>3.282</b>	<b>65.137</b>

**Table 1:** Measurements of labor, yield and field size taken from roselle plots in Kuna, Waware, and the DIG model farm at the Lwala Community Alliance. The DIG lower garden was split into two sections with variable yield.

Determining agricultural wages and scale of production within the analysis proved to be a challenge. A variety of wage rates were reported between DIG staff, a farmer working in nearby Kitere, and the Land Use Analysis by Nambiro (2010).<sup>1</sup> DIG pays agricultural workers 200Ksh to work an average of 5 hours on the model farm at the Lwala Community Clinic, which is an average wage of 40Ksh per hour. However, a farmer in Kitere who hires agricultural workers to work on a large scale sugar cane plot (estimated at 6,000m<sup>2</sup>, or about 1.5 acres) pays workers 100Ksh for 5 hours of labor, at a rate of 20Ksh per hour. It may be possible that smallholder farmers value their labor for producing value-added roselle products at less than 20Ksh per hour. This could occur if paid labor is scarce within the community, or if household members prefer to work on their own enterprises over higher-wage work elsewhere.

Similar to the wage rate, roselle yield was also found to vary widely, with the lowest and highest wet yields occurring in the upper and lower plots of DIG's model garden at the Lwala Community Clinic. These yields were .114kg/m<sup>2</sup> and .603kg/m<sup>2</sup>, respectively. In an attempt to circumvent the complexities of identifying an exact wage rate and an average expected roselle yield within DIG's target communities, this analysis is broken down into nine scenarios based on three potential wage rates and three harvest yields. Wage rates begin at a low of 10Ksh per hour, based on the assumption that households rate their labor lower than the market value, and increases to 20Ksh and 40Ksh per hour, based on the rates provided within the community. Roselle yield begins with the lowest recorded, .114kg/m<sup>2</sup>, and increases to .388 kg/m<sup>2</sup> recorded from a field in Waware, then to the highest recorded yield of .608kg/m<sup>2</sup>. It should be noted that higher yields in Kenya are possible – Karkin, a roselle company based in Kisumu, achieves an estimated average yield of 1.080kg/m<sup>2</sup> using industrial organic practices. However, since .608kg/m<sup>2</sup> is the highest recorded using DIG production techniques, this was used as a potential upper average for DIG projects.

Furthermore, farmers within DIG's network grow at vastly different scales. Some farmers in the Kuna group grow over a thousand square meters of roselle, where others grow only several hundred. Since this analysis is intended to find thresholds where roselle production is feasible, it splits each scenario into four potential scales of production: 100m<sup>2</sup>, 500m<sup>2</sup>, 1,000m<sup>2</sup> and 4,000m<sup>2</sup>, the last of which is approximately one acre. Finally, the analysis splits each scenario and production scale into the possible

<sup>1</sup> Nambiro, E. 2010. "Trends in land use and agricultural intensification in Kakamega, Western Kenya" (Doctoral dissertation). Retrieved from the Rheinischen-Friedrich-Wilhelms-Universität zu Bonn.

methods of selling roselle mentioned above: 1) in bulk as “wet” sepals, 2) in bulk as dried sepals, 3) packaged without a label, and 4) packaged with a label.

As the total yield for production systems rises, it is expected that additional capital will be needed for drying and packaging roselle beyond the household tarps and blankets that are typically used. To account for this with the Kuna group, DIG built an open-air drying rack capable of drying 8kg of wet roselle over 20 hours, at a cost of 10,300Ksh (approximately \$100 USD). Larger production systems that package roselle will also benefit from an Impulse Sealer, which seals polypropylene bags more efficiently than the typical method using candles. The Impulse Sealer costs 2,800Ksh (approximately \$28 USD). Both the Impulse Sealer and open air drying rack are added to any scenarios where yields are 100kg or greater.

### Challenges and Assumptions

Beyond determining an appropriate wage rate and average yield, there are several major challenges and assumptions that limit the results of this analysis. Foremost is the accuracy and completeness of measurements used. Ideally, this analysis would have measured the yield and labor requirements for value-added products for the harvest of every plot, however the personal schedules of farmers did not always allow measurements to be taken. In addition, because of small sample sizes and limited access to accurate measurement instruments, the compiled averages used in this analysis have a high degree of error. The hanging scale used, for example, was the only tool available to measure the wet weight of roselle in the field, but it often gave contradictory results in subsequent measurements of the same harvests. Due to these limitations, this cost-benefit analysis is a generalization of the potential costs and revenues a farmer can expect from selling value-added roselle products.

Another major challenge was to determine the labor cost involved in marketing packaged roselle. Although not an insignificant cost, this was left out of the analysis because of the difficulties in producing an accurate measure. It can be expected for farmers to initially invest time in introducing their products to local markets, especially since there is a dearth of roselle products in rural Kenya. From this point, there are two possible outcomes: the local community will enjoy the products and the farmer will strive to meet local demand, or the local demand will become saturated and the farmer will have to search for additional markets. Since this is omitted from the analysis, it is important to keep in mind that packaging and marketing roselle at the local level includes potentially large, unaccounted costs.

Several major assumptions were also used in this analysis that may skew the results. First, the analysis assumes farmers will sell all of their product, which is actually a best-case scenario in some instances. As mentioned above, farmers selling package roselle locally might exceed demand for their products and be forced to sell outside their preferred markets or consume the roselle at home. In this scenario, farmers are incentivized to grow less if they are unable to find a new market for their product. This is less of a problem for roselle sold in bulk to large companies such as Botanical Treasures, who are able to tap into national and international markets. To ensure farmers have sufficient markets for their products, scenarios in which both bulk sales and package sales are feasible are ideal for future projects.

Second, the analysis assumes the production practices at each scale to remain the same, using hand cultivation methods. In reality, this is not the case – as scale increases, households generally move from hand cultivation to more efficient oxen ploughs. Since that efficiency is overlooked in this analysis, the gross margins of larger production systems is potentially larger than predicted. However, it is not certain



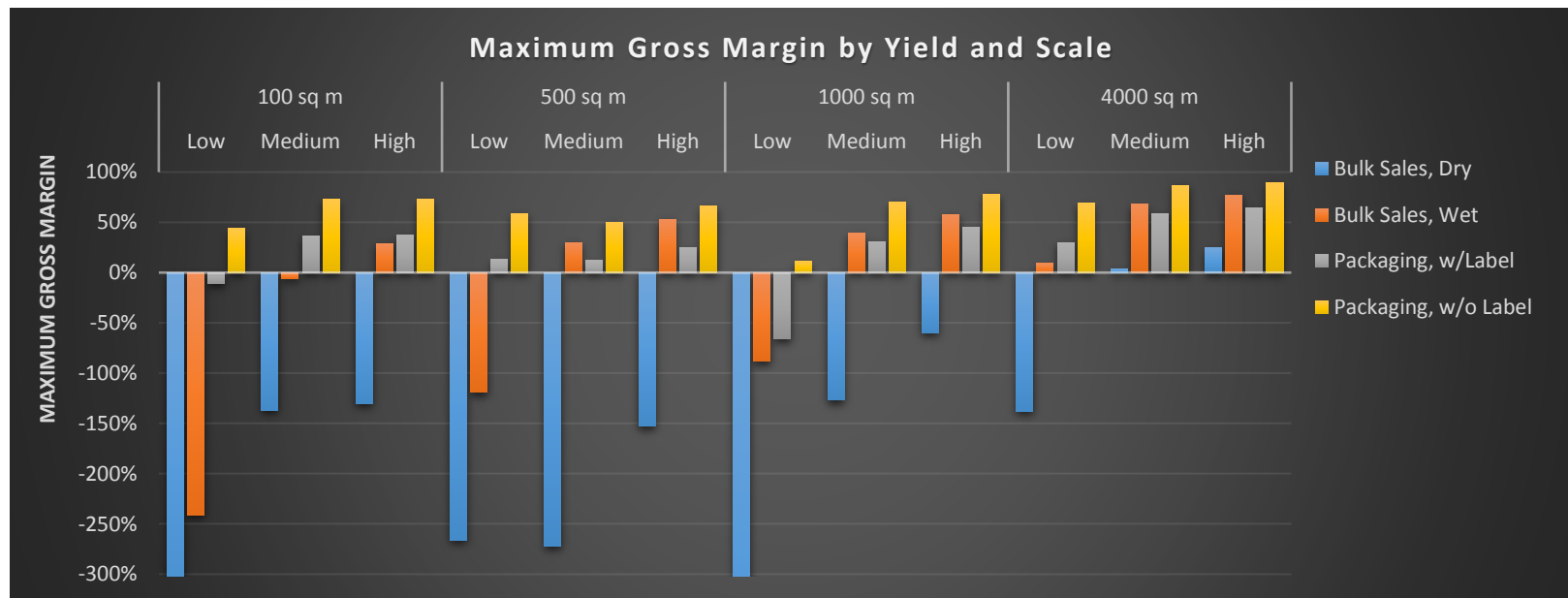
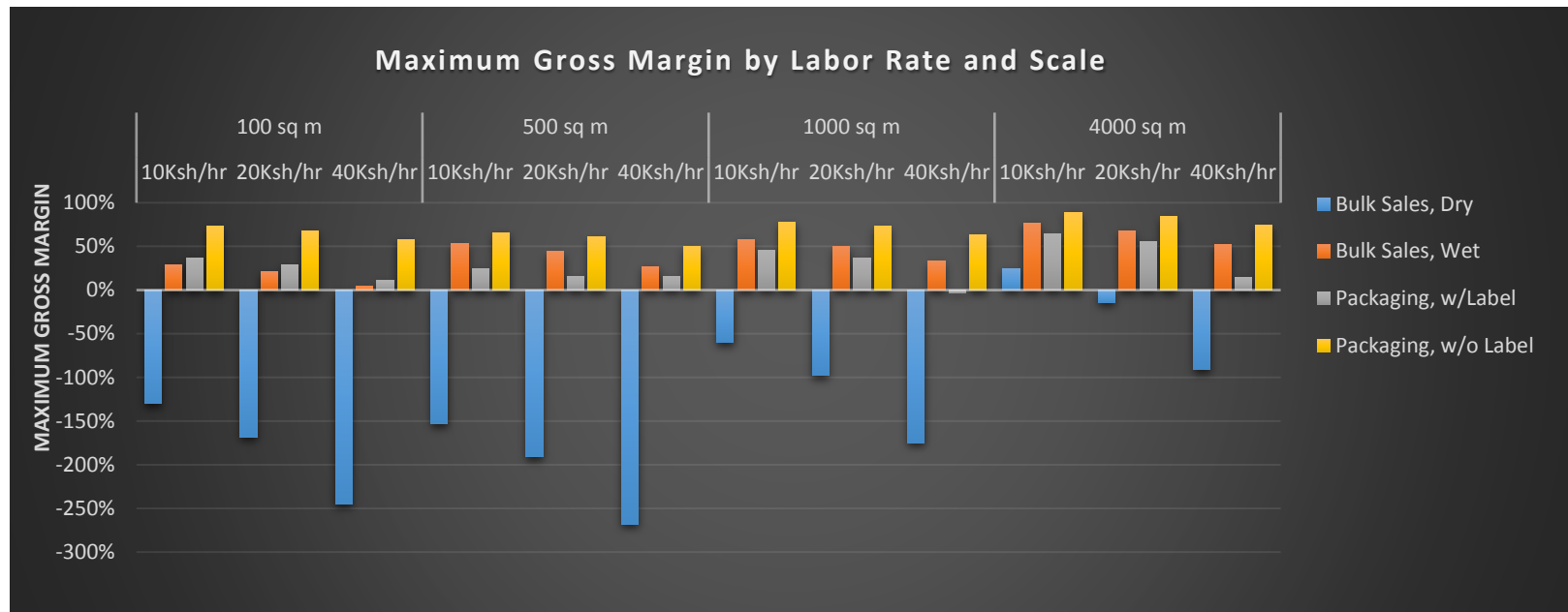
at what scale households move toward this form of production, or if there are other factors beyond scale that limit or promote the use of oxen ploughs, so it is assumed that all households use the same production methods.

Lastly, the analysis assumes household cattle can produce enough manure to maintain all levels of yield in the analysis. The majority of farmers in the Kuna group only source manure from their own cattle for their fields, but it is unlikely that all households can maintain soil fertility with their cattle across all yields and production scales. This is an additional unknown cost that is not accounted for in this analysis.

## Results and Discussion

The results of the cost-benefit analysis show clear scenarios where producing value-added roselle products is feasible for smallholder farmers. Figures 1 and 2 below demonstrate best-case scenarios across four roselle products based on scale of production, labor rate and yield. Figure 1 presents the maximum projected gross margin for each product across four scales and three labor rates, assuming yield will average  $.601\text{kg/m}^2$ . Figure 2 presents the maximum gross margin for each product across the same levels of scale, but includes three levels of yield and assumes the wage rate to be 10Ksh/hr. As can be seen in both figures, packaging roselle without a label is consistently feasible across all scales, wage rates, and yields. Packaging roselle with a label is also feasible in many cases, but, along with selling wet roselle in bulk, is much more sensitive to roselle yield than to agricultural wage, and even has a strongly negative gross margin in two cases. The most severe case can be seen in the  $1,000\text{m}^2$  scale of Figure 2. At that scale, even the lowest yield scenario produces over 100kg of wet roselle, forcing the production system to adopt drying racks and an Impulse Sealer for packaging. Despite the high yield, the production system does not produce enough packaged roselle to offset the new production costs, at least for the first production season. After the investment is paid off, the gross margin is expected to be positive in future seasons. This effect can also be seen in labeled, packaged products in Figure 2 at the  $500\text{m}^2$  scale, where yields of  $.388\text{kg/m}^2$  cause the production system to purchase a drying rack. The additional costs of a drying rack does not seem to have an effect at the  $1,000\text{m}^2$  scale and higher, with yields averaging  $.388\text{kg/m}^2$ .

As mentioned above, selling wet roselle in bulk is strongly influenced by yield across all production scales. Figure 2 shows that selling wet roselle is not feasible at the lowest yield scenarios for systems producing  $100\text{m}^2$ ,  $500\text{m}^2$ , and  $1,000\text{m}^2$  of roselle, and has a small positive gross margin of 9% in the  $4,000\text{m}^2$  scale. The gross margin for wet roselle is even negative with medium yields at the  $100\text{m}^2$ . In contrast, Figure 1 shows bulk wet roselle is feasible across every scale and wage level, indicating yield has a larger effect on gross margins than wage.

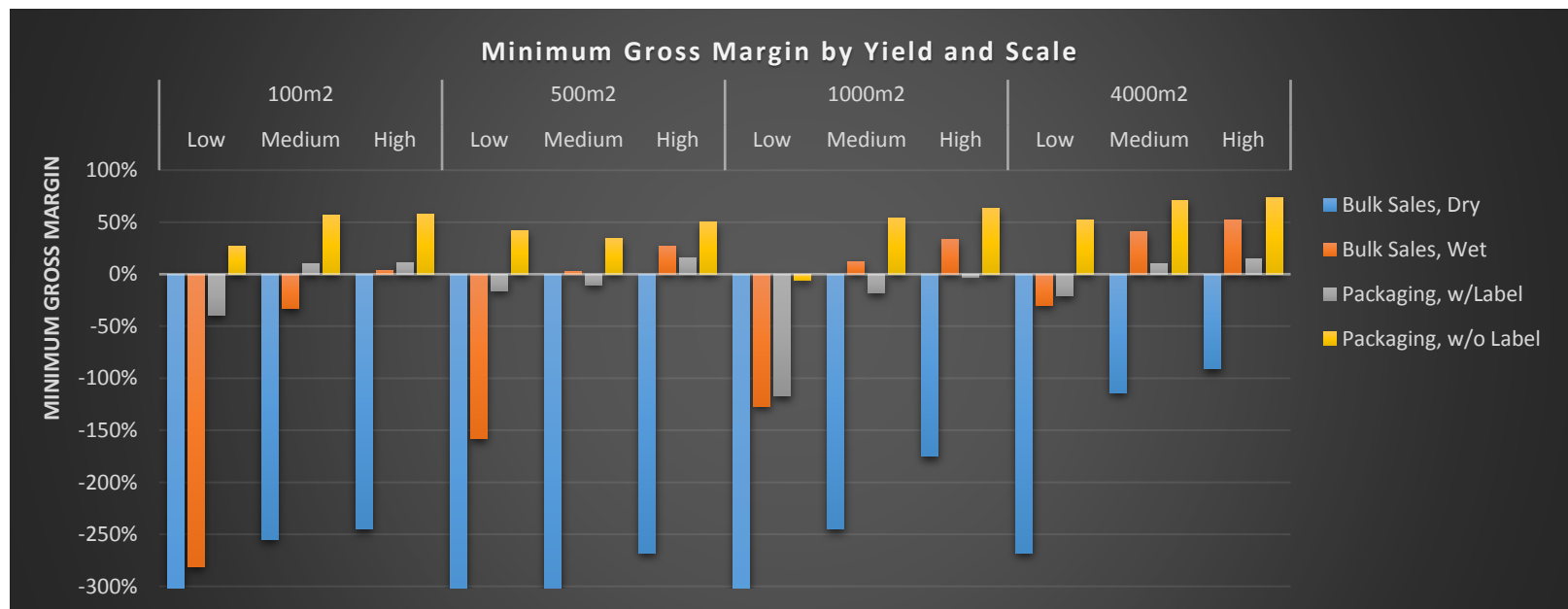
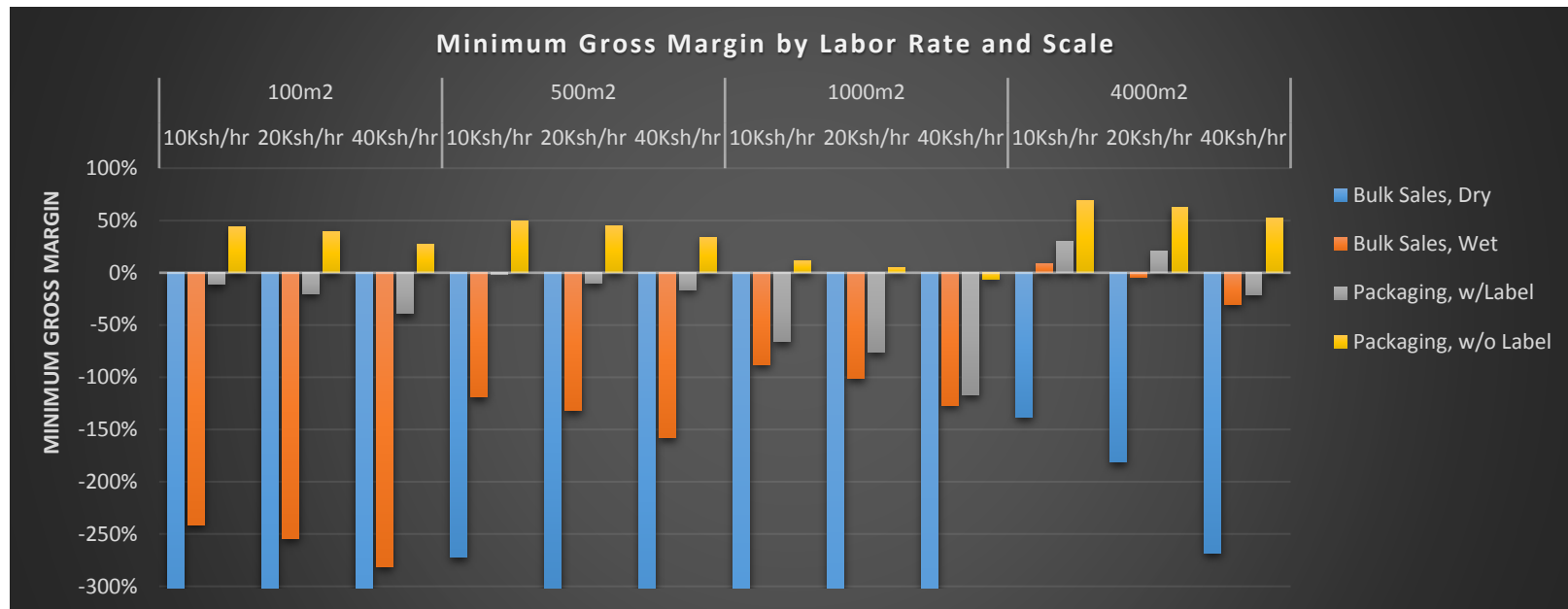


**Figures 1 and 2:** Best case scenarios are shown for the gross margins of each roselle product. Figure 1 displays projected gross margins based on scale and wage rate, assuming yield will be at least .601kg/m<sup>2</sup>. Figure 2 displays similar projections of gross margins for scale and yield, assuming the wage rate remains at 10Ksh/hr.

Keep in mind that each of the figures above show best-case scenarios for at least one variable – yield in Figure 1 and labor rate in Figure 2. Figures 3 and 4 below show the worst-case scenarios, with Figure 3 assuming an average yield of .114kg/m<sup>2</sup> for the majority of cases, and Figure 4 assuming the wage rate will be 40Ksh/hr. Once again, yield is shown to be a more important determinant of feasibility than wage. In Figure 3, every product has a negative gross margin from scales of 1,000m<sup>2</sup> and below except for packaging without a label. As with the best-case scenarios, the gross margin actually drops at the 1,000m<sup>2</sup> scale as yield surpasses 100kg and the system cannot make up for the additional costs of a drying rack and Impulse Sealer. Despite these extra costs, bulk wet sales, and both labeled and unlabeled packaged roselle are still feasible at high yields across nearly all scales, as seen in Figure 4. Overall, unlabeled roselle is by far the most feasible value-added option across all scales, yields and wage rates.

Based on these results, there is little wonder why the Kuna farmer group decided to package their roselle and sell locally rather than sell in bulk to Botanical Treasures. There are several potential downfalls to this option that should be kept in mind. First, there is more risk to selling roselle locally since the market for roselle products is immature. Farmers can be expected to spend far more time marketing their products in this scenario, and since the additional labor cost of marketing is not included in this analysis, true gross margins for selling packaged roselle is smaller than predicted. Second, there is no guarantee that local demand for roselle will be greater than the amount produced. Farmers may find the local markets saturate quickly, leaving them to consume their products within the household or find markets elsewhere. In this case, farmers will be incentivized to grow less roselle in subsequent seasons – or to grow none at all. Lastly, if farmers struggle to sell their product locally, they may be forced to reduce the price per package of roselle. In this case, the gross margins for unlabeled packages could be closer to that of labeled packages than predicted. Still, gross margins for unlabeled packages can always be expected to be higher than labeled packages due to the additional cost of labels. On the other hand, Botanical Treasures can provide a more stable market for farmers able to sell in bulk because they reach national and international markets, and farmers will not have to invest additional time in marketing their products. Ideally, farmers would have the option to sell both in bulk to Botanical Treasures and in packages to the local community to ensure complete sales of their harvest.

A final, but important, limitation to note is this analysis does not consider the best possible land use system for smallholder farmers, but only the feasibility of roselle production systems. Despite having positive gross margins for roselle, a production system might achieve higher gross margins and gross profits from growing another crop. Since maize and sugarcane are major staple crops in the Rongo area, it would be ideal to collect data on local yield and production methods to compare their gross margins with roselle. Alternatively, the predictions of gross profit and gross margins for roselle could be presented to farmer groups so they can compare roselle production systems to their current or historical maize systems and determine feasibility.



**Figures 3 and 4:** Worst-case scenarios are shown by using the minimum gross margin across all roselle products. Figure 3 shows worst-case scenarios by labor rate and scale, which in most cases assumes yield will average .114kg/m<sup>2</sup> the lowest possible in this analysis. Likewise, Figure 4 shows worst-case scenarios by yield and scale, assuming the wage rate will be 40Ksh/hr.

## Kuna Group Case Study

The results of the cost-benefit analysis can be used to predict the gross margins of members within the Kuna group. The group started growing roselle through in the 2016 long-rains season (April – June). By approximation, all individual plots are less than 1,000m<sup>2</sup>, with the majority ranging from 100m<sup>2</sup> to 500m<sup>2</sup>. Yield was not measured across plots, but roselle stand appeared similar to that of the Kuna demonstration garden, which yielded 138kg/m<sup>2</sup>. This is just above the lowest metric of the cost-benefit analysis. Based on group discussions and their willingness to engage in labor-intensive value-addition, the group would likely value their labor between 10Ksh/hr and 20Ksh/hr. The group has widely decided to package roselle without labels at 50Ksh per package.

Based on these variables, members of the Kuna group fall within the scenarios presented in Figure 3. With low yield, plot sizes smaller than 1,000m<sup>2</sup>, and medium to low wage rates, the only feasible option is to sell roselle in unlabeled packages for 50Ksh per package. As a whole, the group was provided labels free of charge from DIG. Once the labels run out, it would not be feasible for individuals to purchase their own labels to spread Kuna's brand under current yield and scale. By increasing yield to .388, which was seen in the Waware group, both bulk wet sales and packaging with a label would be feasible at scales of 500m<sup>2</sup> and above. This would greatly expand options within the group, allowing farmers to switch between bulk sales and packages based on the demand in local markets.

In a recent assessment of fields planted by Kuna group members, several recently planted fields have poor germination and varied plant spacing, and are unlikely to produce yields even at the lowest level used in this analysis. In addition, several fields in the long-rains also failed to produce. Initially, the reasons for poor yield and growth were thought to be caused by pests and fungal disease. After consulting with Botanical Treasures, it seems a lack of soil fertility and planting late in the rainy season may have a greater effect on plant growth, as roselle is more susceptible to disease when stressed. The picture at right is an example of a poor roselle stand in a recently cultivated plot from the Kuna group. The roselle remains in dense patches throughout the field, possibly from poor planting technique. The plants are also stunted for their age, and unlikely to produce a substantial yield. Some plots in the Kuna group are faring much better, with estimated yields around those measured in Waware. With the appropriate application of fertilizers, proper plant timing with the rains, and more emphasis on planting technique it is likely that crop failures can be avoided.



Picture 1: Roselle field from Kuna Group. Taken Oct. 27<sup>th</sup>.

## Conclusion

By far, the most important variable in determining the feasibility of value-added roselle projects is yield. Even with a high wage rate, all roselle products were feasible across even the smallest scales, except for selling dried roselle in bulk. Dried bulk roselle is possibly feasible for intermediary businesses, which purchase wet roselle from surrounding farmers before drying and selling the roselle to Botanical Treasures. Based on current yields, the only feasible option for Kuna group members is to sell unlabeled, packaged roselle to local communities. Being limited to this option has significant risks, as local demand for roselle is not guaranteed and labor spent on marketing could erode gross margins and gross profits. The opportunity to sell roselle through multiple avenues limits risk for growers, but yields need to reach at least an average of  $.388\text{kg/m}^2$  for bulk sales to be feasible across most scales. Ensuring farmers have access to sufficient fertilizers and are able to plant with the onset of the rains is key to achieving higher yields in future roselle value-addition projects.



## Appendix A: Data Collected from DIG Farmer Groups

All data were collected from the harvests of the 2016 long-rains from DIG's Kuna and Waware farmer groups, and DIG's model farm located at the Lwala Community Alliance.

Location	Date	Wet Weight (kg)	Harvest (hrs)	Harvest (hrs/kg)	Size of Field (m2)	Yield, wet weight (kg/m2)	Calyx Removal (hrs)	Calyx Removal (hrs/kg)	Dry Weight (kg)
DIG, upper garden	27-Jul	10.90	1.39	0.128	18.070	0.603	6.030	0.553	
DIG, lower garden	16-Aug	10.40			91.090	0.114	7.750	0.745	0.560
Kuna	9-Aug	60.00	8.25	0.138	391.320	0.153			
DIG, lower garden	29-Aug	3.83	0.67	0.174	28.690	0.133	1.750	0.458	0.221
Waware	11-Oct	24.73			63.710	0.388			1.380
<b>Averages:</b>		<b>21.28</b>	<b>3.44</b>	<b>0.146</b>	<b>118.576</b>	<b>0.278</b>	<b>5.177</b>	<b>0.585</b>	<b>0.391</b>

Location	Weight of pre-packaged roselle (kg)	Packaged Time (hrs)	Package Time (hrs/kg)	Package (#)	Package (#/kg)	Include Labels?	Package Weight (kg/pck)
DIG, upper garden							
DIG, lower garden	0.463	1.833	3.959	33	71.274	no	0.014
Kuna	2.000	5.210	2.605	118	59.000	yes	0.016
DIG, lower garden	0.221						
Waware	1.380			91		no	
<b>Averages:</b>	<b>0.895</b>	<b>3.522</b>	<b>3.282</b>	<b>76</b>	<b>65.137</b>		<b>0.015</b>

## Appendix B: Gross Margins and Gross Profits of Production Scenarios

	S1 - Low Yield, Low Labor			
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	-551.38	-1,356.88	-2,013.77	844.92
Gross Margin	-2.41	-1.19	-0.88	0.09
Bulk sales, Dry	-873.52	-2,967.61	-13,001.21	-12,306.86
Gross Margin	-3.92	-2.66	-5.83	-1.38
Packaging, w/o Label	912.04	6,059.19	2,306.88	57,310.51
Gross Margin	0.44	0.59	0.11	0.69
Packaging, w/Label	-133.46	780.69	-8,275.62	14,980.51
Gross Margin	-0.11	0.13	-0.66	0.30

	S2 - Medium Yield, Low Labor			
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	-43.63	1,181.86	3,063.72	21,154.88
Gross Margin	-0.06	0.30	0.39	0.68
Bulk sales, Dry	-1,038.87	-10,310.35	-9,654.69	1,079.23
Gross Margin	-1.37	-2.72	-1.27	0.04
Packaging, w/o Label	5,111.40	17,646.00	49,053.01	244,443.54
Gross Margin	0.73	0.50	0.70	0.87
Packaging, w/Label	1,515.90	-331.50	13,098.01	100,547.04
Gross Margin	0.36	-0.02	0.31	0.59

	S3 - High Yield, Low Labor			
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	355.07	3,175.34	7,050.69	37,102.76
Gross Margin	0.29	0.53	0.58	0.77
Bulk sales, Dry	-1,526.09	-8,996.46	-7,026.92	11,590.32
Gross Margin	-1.30	-1.53	-0.60	0.25
Packaging, w/o Label	8,025.59	36,016.47	85,793.95	391,407.28
Gross Margin	0.73	0.66	0.78	0.89
Packaging, w/Label	2,441.09	8,068.47	29,897.95	167,746.78
Gross Margin	0.37	0.25	0.45	0.64

	S4 - Low Yield, Medium Labor			
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	-581.10	-1,505.50	-2,311.00	-343.98
Gross Margin	-2.54	-1.32	-1.01	-0.04
Bulk sales, Dry	-970.07	-3,450.35	-13,966.70	-16,168.80
Gross Margin	-4.35	-3.09	-6.26	-1.81
Packaging, w/o Label	794.58	5,471.88	1,132.26	52,612.03
Gross Margin	0.39	0.53	0.05	0.63
Packaging, w/Label	-250.92	193.38	-9,450.24	10,282.03
Gross Margin	-0.20	0.03	-0.76	0.21

	S5 - Medium Yield, Medium Labor			
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	-113.47	832.63	2,365.27	18,361.07
Gross Margin	-0.15	0.21	0.30	0.59
Bulk sales, Dry	-1,335.88	-11,795.38	-12,624.77	-10,801.07
Gross Margin	-1.76	-3.11	-1.67	-0.36
Packaging, w/o Label	4,743.30	15,805.51	45,372.02	229,719.58
Gross Margin	0.67	0.45	0.64	0.81
Packaging, w/Label	1,147.80	-2,171.99	9,417.02	85,823.08
Gross Margin	0.27	-0.10	0.22	0.51

	S6 - High Yield, Medium Labor			
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	253.72	2,668.59	6,037.18	33,048.74
Gross Margin	0.21	0.44	0.50	0.68
Bulk sales, Dry	-1,980.51	-11,268.53	-11,571.05	-6,586.20
Gross Margin	-1.68	-1.91	-0.98	-0.14
Packaging, w/o Label	7,460.69	33,191.95	80,144.89	368,811.07
Gross Margin	0.68	0.61	0.73	0.84
Packaging, w/Label	1,876.19	5,243.95	24,248.89	145,150.57
Gross Margin	0.29	0.16	0.37	0.55

S7 - Low Yield, High Labor				
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	-640.54	-1,802.72	-2,905.45	-2,721.79
Gross Margin	-2.81	-1.58	-1.27	-0.30
Bulk sales, Dry	-1,163.17	-4,415.84	-15,897.67	-23,892.70
Gross Margin	-5.22	-3.96	-7.13	-2.68
Packaging, w/o Label	559.65	4,297.26	-1,216.99	43,215.06
Gross Margin	0.27	0.42	-0.06	0.52
Packaging, w/Label	-485.85	-981.24	-14,549.49	-10,364.94
Gross Margin	-0.39	-0.16	-1.17	-0.21

S8 - Medium Yield, High Labor				
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	-253.16	134.18	968.36	12,773.45
Gross Margin	-0.33	0.03	0.12	0.41
Bulk sales, Dry	-1,929.89	-14,765.46	-18,564.92	-34,561.69
Gross Margin	-2.55	-3.90	-2.45	-1.14
Packaging, w/o Label	4,007.10	12,124.52	38,010.04	200,271.65
Gross Margin	0.57	0.34	0.54	0.71
Packaging, w/Label	411.60	2,458.02	-7,444.96	17,625.15
Gross Margin	0.10	0.12	-0.18	0.10

S9 - High Yield, High Labor				
	Minimal Production	Small Production	Medium Production	Large Production
<b>Profit - Hibiscus, Ksh</b>				
Bulk sales, wet	51.02	1,655.09	4,010.17	24,940.69
Gross Margin	0.04	0.27	0.33	0.52
Bulk sales, Dry	-2,889.33	-15,812.66	-20,659.31	-42,939.25
Gross Margin	-2.45	-2.68	-1.75	-0.91
Packaging, w/o Label	6,330.88	27,542.89	68,846.78	323,618.64
Gross Margin	0.58	0.50	0.63	0.74
Packaging, w/Label	746.38	5,155.89	-2,049.22	39,708.14
Gross Margin	0.11	0.16	-0.03	0.15



## Roselle Value-Addition Recommendations

The roselle cost-benefit analysis for DIG's value-addition pilot determined that farmers currently producing roselle in DIG's farmer groups are limited to selling unlabeled, packaged roselle to local communities. However, the cost-benefit analysis did not measure the labor required to market roselle products to local communities. This additional cost could erode the profits of small-scale, low-yield systems and make them unfeasible. The cost-benefit analysis also assumed farmers could sell all of their products, which is not guaranteed within the relatively small markets found in rural communities. If demand for roselle is quickly satisfied, farmers will be left with unsold products and choose not to grow roselle in the future. These risks are avoided across all scales if yields average .388 kg/m<sup>2</sup> or higher, making unlabeled, packaged roselle and bulk sales of wet roselle feasible. Based on these results, the following recommendations are made for DIG's future roselle value-addition projects:

**1) Compare the gross margins of maize systems to those found in this analysis.** While many scenarios in the analysis were feasible, maize cropping systems may still provide higher gross margins across the scales farmers are growing. A comparison of gross margins across maize and roselle systems will further determine feasibility for DIG's farmers.

**2) Create an additional soil management program for roselle value-addition groups to ensure higher yields.** Farmers within the Kuna group are currently limited to selling their roselle in unlabeled packages. Raising yield through a soil management program will provide more marketing options for farmers. The soil management program should ensure that farmers have access to enough manure or chemical fertilizers to meet the demands of roselle production. An analysis of the nitrogen demands of roselle, local soil texture and fertility, and the nutrient composition of locally available organic and inorganic fertilizers should be conducted to determine the amounts of fertilizers required to increase and maintain yield. The soil management program could be an addition to the current seed input support program.

**3) Establish a bulk-sales model within new groups that allows farmers to sell wet roselle in bulk to a central processor.** Botanical Treasure's supply chain relies on groups of farmers who sell bulk, wet roselle to a central farmer, who then dries the roselle and sells it directly to the company. A similar supply chain could be created by DIG to provide additional market opportunities for farmers who are unable to sell all of their roselle through the local market. This market opportunity will become attractive to farmers who experience high yields, but are unable or unwilling to spend the labor in removing the sepals from and drying their harvests.

## Moringa Business Plans: Options for Producing and Distributing Moringa Powder

*Moringa oleifera* is known for its protein-dense, nutritious leaves, which can be made into a powder and added to staple foods as a nutritional supplement. This business plan looks into the costs of making moringa powder and options for providing free powder to malnourished patients identified through local clinics.

Solar Dryer Production Capabilities							
Solar Dryer Cost	Wet Capacity	Dry Weight	Powder Weight	Dry Time	Wet Capacity	Dry Weight	Powder Weight
11,000ksh	2.0kg	.30kg	0.24kg	4 hrs.	4 kg/day	.60 kg/day	.48kg/day

**Table 1: Production capability of the Lwala Community Clinic solar dryer.**

All production plans estimate costs through measurements taken from a solar dryer built at the Lwala Community Clinic, as seen in Table 1. This dryer is capable of producing .60kg of dried moringa leaves each day, which amounts to .48kg of moringa powder. This solar dryer could easily be built larger to increase production capabilities. The cost of solar dryers are not reflected in the overall costs associated with production options shown in Tables 2, 3 and 4.

Costs, On-site						
Harvest and Drying	Labor Rate	Milling (5kg batch)	Total Cost, wet	Total Cost, dried	Purchasing Price: BT	Total Cost, powder
1.75hrs/kg	20Ksh/hr	150Ksh	35Ksh/kg	315Ksh/kg	250Ksh/kg	500Ksh/kg

**Table 2: Costs of producing dried and powdered moringa from Lwala Community Clinic's plot**

The most basic production model involves selling dried moringa leaves in bulk to Botanical Treasures, a Kenyan-based company that sells tea products. Selling in bulk reduces marketing costs, which can be significant and are not included in the production costs for packaged moringa powder shown below. However, labor costs associated with producing dried moringa on-site at 315Ksh/kg are greater than revenues gained from selling to Botanical Treasures at 250Ksh/kg, as seen in Table 2, making this model infeasible if moringa is only grown on-site.

Costs, Off-site Purchases				
Solar Dryer Cost	Purchasing Cost, wet	Drying Cost	Purchasing Price, BT	Profit, BT
11,000ksh	20Ksh/kg	175Ksh/kg	250Ksh/kg	75Ksh/kg

**Table 3: Costs of purchasing wet moringa from the community and drying it.**

Another option for bulk sales is to purchase moringa from the community. Assuming farmers will want to sell "wet" moringa leaves at 20Ksh/kg, the costs associated with off-site purchases are only 175Ksh/kg, creating a profit between 70 – 75Ksh/kg depending on labor costs. Through this system, a clinic could provide 1kg of dried moringa powder for every 2.75kg of moringa leaves sold in bulk.



Packaged Sales Options							
Plastic Jar, 100g	Total Cost, Jars	Revenue, Jars	Total Revenues, Jars	Package, 50g	Total Cost, Plastic Package	Revenue, Packages	Profit, Packages
25Ksh/jar	750Ksh/kg	150Ksh/jar	1,500Ksh/kg	5Ksh/package	600Ksh/kg	50Ksh/package	400Ksh/kg

**Table 4: Sale options through packaging moringa powder in plastic jars and polypropylene bags**

Two other production options include packaging moringa powder and selling it to the local community. Packaging options include in 100g labeled, plastic jars, which cost about 25Ksh per jar, or in 50g unlabeled, polypropylene bags, which cost 5Ksh per bag. As seen in Table 4, the 100g jars sell for 150Ksh each, and the 50g packages sell for 50Ksh each. At these rates, one 100g jar could be distributed to malnourished households for free for every one jar sold, and two 50g packages can be distributed for free for every three packages sold. It is important to note that the costs shown in Table 4 do not include labor associated with marketing. If local markets become saturated quickly, the additional costs of marketing outside the community may significantly reduce profits. The price of each package option is also important – although the one-to-one ratio of the 100g jars may seem like a better option for distributing free powder, the higher price of the 100g jars may impede local sales and actually allow less powder to be distributed to malnourished households.

There are benefits to both selling in bulk and at the local level. Large production networks that have consistent access to wet moringa will benefit most from the stable market provided through bulk sales. Medium to small production systems may benefit more from the local sales of packaged moringa powder, which allows for a greater ratio of moringa powder to be distributed to households in need than bulk sales. The benefits of each system should be weighed according to the capacity of the production system to determine the best course of action.

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