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The impact of income on nutrition: A case study of Northern Mozambique

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Cover Page Footnote

Hunter Swanigan is a 2019 honors program graduate with a major in Agricultural Business and a minor in International Economic Development. Lawton Lanier Nalley, is a professor in the Department of Agricultural Economics and Agribusiness.

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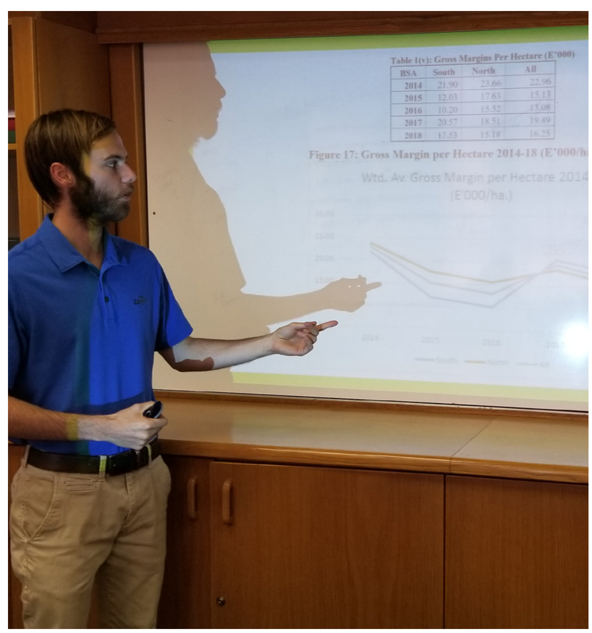
Meet the Student-Author

Hunter Swanigan

I am from Jefferson City, Missouri, and graduated from Jefferson City High School in 2016. I was not exactly sure what I wanted to do next. I decided to attend the University of Arkansas to expand my horizons. After my sophomore year, I studied abroad in Mozambique, which exposed me to international development, and influenced me to pursue a career in this direction. The next summer, I worked in Eswatini (formerly Swaziland) for the Eswatini Cane Growers Association through an internship program with the University of Arkansas. While in Fayetteville, I was a member of the Agricultural Business Club, the National Society of Leadership and Success, and the Honors College. I also took three semesters of Swahili. I graduated Summa Cum Laude in December of 2019, majoring in Agricultural Business and minoring in International Economic Development. I was also the Agricultural Business Club Outstanding Sophomore in 2017.

I would like to thank Dr. Nalley for showing me the world of international development by helping start both the Mozambique and Eswatini programs. He went above my highest expectations for an advisor for both what I could do after graduating and with working on my thesis. I thank all of my committee members, Drs. Jennie Popp, Amy Farmer, and Lanier Nalley for always answering any questions and being willing to help me throughout my time at the University of Arkansas. I also thank the Honors College, Dale Bumpers College, and the Study Abroad office for funds that allowed me to travel to Mozambique.



Hunter presenting his work during his internship in Eswatini at the Eswatini Cane Growers Association during the Summer of 2019.

Research at a Glance

- Many people in low-income countries suffer from malnutrition for a variety of reasons, with financial costs being a large barrier.
- Prices for food available in Mozambique during the dry season were collected and compared against 3 different income levels to determine what percent of the population could meet their nutritional needs with their limited income.
- Thirty-six percent of individuals in Mozambique could not meet their nutritional needs with what was available. Individuals who grew food at home could meet their needs, as their annual food budget was drastically reduced. Supplementation of calcium through the government or a non-governmental organization could decrease the annual food budget needed to meet nutritional recommendations.

The impact of income on nutrition: A case study of Northern Mozambique

Hunter Swanigan and Lawton Lanier Nalley*†

Abstract

In 2017, Mozambique ranked as one of the least developed countries in the world by measures of health, education, and income. With a minimal annual income, purchasing adequate food to meet recommended levels of nutrients for a healthy diet is difficult, leaving 40% of the country undernourished. This study analyzed what foods are available during the dry months (hungry season) of May through October in the Nampula province of Mozambique to determine if it is possible to meet recommended levels of nutrients from purchasing and growing food. Three different levels of income were used to determine what percentage of the country could purchase the recommended levels of nutrients: per capita income, government minimum wage, and the minimum wage at a private firm. Based on these income groups, 36% of the country would not be able to meet their needs from only buying food from the market at any time of the year. Those who grow their own food made meeting their nutrient needs more feasible, as they did not spend as much of their income (8% to 17%) on food. Different models were constructed to analyze the effect of the supplementation of specific vitamins and minerals that are continuously difficult to obtain. The most significant supplementation was of calcium, reducing the theoretical percentage of annual income spent on food from 325% to 65%. Based on these results, non-governmental organizations (NGO) or the Mozambican government should focus on a wide-scale supplementation program focusing on calcium to ensure proper nutrition.

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Introduction

Mozambique has been one of the most impoverished countries in the world since gaining independence from the Portuguese in 1975 (CIA, 2018). Although the government of Mozambique continues to work to improve the country's economic wellbeing, as of 2017, Mozambique ranked 222nd out of 229 countries in the world with a gross domestic product (GDP) per capita of $1,300 (CIA, 2018). The Human Development Index, which measures human development based on health, education, and standard of living, scored Mozambique a value of 0.418 in 2016, ranking the country 181st out of 188 countries in the world (UNDP, 2016). A 2015 estimate found that 46.1% of the country's population was under its own poverty line (CIA, 2018).

With Mozambique's standard of living, it can be very difficult to meet the recommended dietary allowance (RDA) for essential nutrients, which is defined as "average daily level of intake sufficient to meet the nutrient requirements of nearly all (97% to 98%) healthy people" (National Institutes of Health, 2018). The per capita consumption of fruits and vegetables has been cut in half since the 1960s and is the lowest in the region, and per capita consumption of animal protein and healthy fats from nuts and oils was also low, even relative to its region (Lourdes et al., 2011).

With the lack of a diverse diet and fruits and vegetables, undernutrition, which is defined as "deficient bodily nutrition due to inadequate food intake or faulty assimilation," is widespread across Mozambique with 43% of the children in Mozambique suffering from moderate to severe growth stunting, which is mainly caused by lack of proper nutrients at a young age (UNICEF, 2013). Micronutrient deficiencies such as vitamin A, iodine, and iron are the most widespread across the country, which again can be traced to lack of a healthy, diverse diet (FAO, 2010). In total, roughly 40% of the population of Mozambique was classified as undernourished from 2005 to 2007 (FAO, 2010). The purpose of this study was to investigate if an individual in Northern Mozambique can attain a portfolio of foods by either purchasing food at the market or growing food at home in the dry (hungry) season that will meet their nutritional needs with different income levels. Lastly, we will identify specific food items that could effectively 'fill in the gaps' of any nutrient deficiencies which are prohibitively expensive or simply not available to purchase or grow. These results will provide policymakers and non-governmental organizations (NGO) with useful data on what macro and micronutrients are limited in the dry season and the correlation with income and the ability to consume a holistically healthy diet.

Materials and Methods

Data were collected from Nampula (the city) in the summer of 2018. After data on the cost of available food was collected while in the country, previously published data by The World Bank (2018) and Hansen (2016) of Mozambique's income levels and average household size were used. Linear programming was used to build possible "meal templates" that met a households' daily dietary reference intake (DRI), derived from the National Institutes of Health, and its respective cost. The World Bank's per capita GDP estimate for Mozambique was used as an "average" income ($426.22; Income #1). The government minimum wage ($771.71 per year; Income #2), as well as the minimum wage at a private company ($895.46 per year; Income #3), were used as alternative yearly incomes. Data on household size was gathered from research in 2016 and was set at 6.6 people/household (Hansen, 2016). Since nutritional requirements vary based on age and gender, different levels were used to simulate a typical household of 6.6 people. The DRI for a male and female in the age range of 19 to 30 years, a male and female in the age range of 14 to 18 years, and a male and female in the age range 4 to 8 years were used. Lastly, DRI for a female aged 4 to 8 years multiplied by 0.6 was used to build a household total of 6.6 people. Data on food items available during the dry season were collected in various markets in Nampula during June of 2018. A local translator was used to ask vendors their prices for respective items in order to get the most accurate price for an individual living in the area (Table 1). Data were sourced from a study conducted in the same area in 2015 of food items that were commonly grown in home gardens (Hansen, 2016). Three food items were grown at home that were not available to purchase at the market (cassava leaves, bean leaves, and sweet potato leaves). Prices for these items were calculated by multiplying the price of a similar food item, cabbage, by 1/8. This was done because the food items grown at home would have a small price if available at the market. All prices were converted from Mozambique metical's to U.S. dollars at the rate of $1 = 60.84 meticals. The first goal of this study was to determine if a well-balanced meal is attainable, given each level of yearly income. The price of obtaining a DRI sufficient meal for a 6.6 person household daily was calculated and multiplied by 365 and then compared to each of the three income scenarios to see if each respective income was sufficient to at least provide healthy meals for the entire household for a year. From these results, we identified certain crops/food that could be added to the area that would remove nutrient deficiencies in hopes of improving the area's overall nutrition profile in a cost-effective manner.

Three different models were used to represent different scenarios in which individuals may find themselves in Mozambique (Table 2). Model A, representing the Urban Consumer, had no constraints on food available; all food items could be consumed that were found in markets around Nampula. In this model, it is assumed that the individual purchased all their food from the market, and none is grown at home, representing the average urban Nampula consumer. This model would represent the 36% of the Mozambican population that lives in urban areas and does not grow food at home (CIA, 2018). Model B, representing the Rural Consumer, has no food constraints, but it is assumed that supplemental food is grown at home. The different prices/serving of food items used in this model were found by subtracting the percentage of households growing the food from 100% and multiplying this value by the market price. For example, 20% of households surveyed grew bananas (Table 1), which have a market price of $0.08/serving. As such, rural consumers had a cost of $0.08*(1-0.2) = $0.06/serving. Data for the percentage of households growing certain food items came from a survey of 60 families in the Nampula region in the summer of 2015 (Hansen, 2016). Model C is similar to Urban Consumer in the fact that no food is grown at home; all nutrition is bought. That being said, model C considered seasonality by removing all fruits available on the market from the model, given their obvious seasonality, and represents the Seasonal Urban Consumer, which highlights what is more likely

Table 1. Price per serving of foods available in Nampula Mozambique, summer 2018.

Food Item	Serving	U.S.$/Serving	% of Homes Growing Food[a]
2% milk	1 liter	1.56	0.00
Apple	1 kg	2.63	0.00
Banana	1 medium	0.08	20.00
Bean	1 kg	0.41	41.70
Bean leaves	900 g	0.07	86.70
Cabbage	1 head	0.58	0.00
Cassava root	1.6 kg	0.33	66.70
Cassava leaves	900 g	0.07	93.30
Chicken	1 whole bird (1.3 kg)	3.70	31.70
Cucumber	1 kg	0.90	0.00
Eggs	1 egg	0.16	8.30
Fish	1 kg	1.89	0.00
Green bell pepper	1 small	0.08	0.00
Large roll	1 roll	0.08	0.00
Lettuce head	1 head	2.78	0.00
Limes	1 kg	0.33	50.00
Maize flour	1 kg	0.41	15.00
Milo drink	400 g	4.93	0.00
Oil (rapeseed)	1 liter	1.23	0.00
Orange	1 large orange	0.07	15.00
Peanut butter	400 g	2.78	0.00
Peanuts	200 g	2.63	66.70
Pineapple	1 small	0.14	13.30
Potatoes	1 kg	0.82	0.00
Pumpkin	1 kg	3.93	0.00
Rice	1 kg	0.66	20.00
Spaghetti	1 pack	1.07	0.00
Sweet potato	1 kg	3.60	48.30
Sweet potato leaves	900 g	0.07	76.70
Tomato	1 kg	1.31	30.00
White onion	1 kg	1.97	0.00

[a] Data retrieved from Hansen (2016).

available to purchase during the dry (hungry) season.

Three different income levels were used for each of the model scenarios (Urban Consumer, Rural Consumer, and Seasonal Urban Consumer) described above. The lowest annual income (Income #1) was attained from The World Bank (World Bank, 2018) and defined as the per capita income of the entire country. The next income level (Income #2) is the government minimum wage for the country for 2018. Lastly, the minimum wage at a private company in 2018 (Income #3) was used, which was the highest of the 3 incomes. Finally, the feasibility of each model was found by comparing the annual cost for a household given the constraints of each model to the three different income levels.

Results and Discussion

In the Urban Consumer model, the final cost per household (of 6.6 people) to obtain a diet that meets DRI of nutrients was estimated to be $2,852.09 annually. As shown in Table 3, the results from the Urban Consumer model consist of a diet that is made up of foods including milk, beans, fish, oil, and oranges.

The binding constraints in the Urban Consumer model include carbohydrates, vitamin C, vitamin D, calcium, iron, and calories. Food items high in vitamin C that are available in the area include cassava and bean leaves (which are only grown at home so are not included in the Urban Consumer or Seasonal Urban Consumer models), cabbage, cassava root, limes, potatoes, and Milo drink mix. The only foods which contain vitamin D are fish, Milo drink mix, eggs, and milk, which are all relatively expensive foods. Food items high in calcium include Milo drink mix, bean and cassava leaves, milk, beans, and cabbage. Foods high in iron include Milo drink mix, beans, and cassava leaves.

In the Rural Consumer model, the final annual cost to provide a nutritious diet for a household is $70.30 (Table 3), which is attainable for all three income groups analyzed in this study. The reduction in cost is associated with food grown at home supplementing market-bought food. This diet consists entirely of cassava leaves and fish (Table 3), as this is the least expensive way to meet DRI. This low price is because cassava leaves are grown at home and thus cost very little to attain.

Like the Urban Consumer model, the binding constraints for the Rural Consumer were vitamin D and calories. As stated earlier, foods high in vitamin D include fish, Milo drink mix, eggs, and milk. This model is affordable, requiring 8% to 17% of annual income, and covers most micronutrients.

Lastly, the Seasonal Urban Consumer model has the highest final cost at $2,913.91 annually (Table 3). This is due to the constraint of seasonality in foods, removing fruits from the market, thus removing low-cost sources of key vitamins and minerals. The Seasonal Urban Consumer model consists of milk, beans, cabbage, and fish (Table 3). The binding constraints are carbohydrates, vitamin C, and vitamin D.

The Seasonal Urban Consumer model is very similar to the Urban Consumer model; however, the Seasonal Urban Consumer does not have the binding constraints of calcium, iron, or calories that are present for the Urban Consumer. Because there are no fruits available in the Seasonal Urban Consumer model, it consists of more milk and beans than the Urban Consumer model, which addresses the constraints of calcium and iron. The Seasonal Urban Consumer model also introduces cabbage to meet micronutrients usually met by fruits.

In order to reduce the final cost of food for the year, the binding constraints were modeled as being supplemented (either through a NGO or a targeted government program), making it unnecessary to purchase these vitamins/minerals. Since vitamin D was binding in each model, it was removed from the models and reestimated to see how the optimal meal plan would change, both with regard to the food items and the associated final cost. This did not change the final price significantly, only changing the percentage of income spent on food by 1% in all three models. The most significant change came from supplementing

Table 2. Description and objectives of models (A, B, and C) used to represent different food and nutrition scenarios in which individuals may find themselves in Mozambique.

Model A Urban Consumer	Model B Rural Consumer	Model C Seasonal Urban Consumer
All food bought at the market	Food bought at the market and grown	All food bought at the market, no fruits
Minimize: total fat, saturated fat, sodium, cholesterol, carbohydrates	Minimize: total fat, saturated fat, sodium, cholesterol, carbohydrates	Minimize: total fat, saturated fat, sodium, cholesterol, carbohydrates
Maximize: fiber, protein, vitamin A, vitamin B12, vitamin C, vitamin D, iron, calcium, potassium, calories	Maximize: fiber, protein, vitamin A, vitamin B12, vitamin C, vitamin D, iron, calcium, potassium, calories	Maximize: fiber, protein, vitamin A, vitamin B12, vitamin C, vitamin D, iron, calcium, potassium, calories

calcium. This changed four scenarios (Urban Consumer, Income #2, Urban Consumer, Income #3, Seasonal Urban Consumer, Income #2, Seasonal Urban Consumer, Income #3) from not being feasible to being feasible, with the largest cost change (although still not feasible) in Seasonal Urban Consumer, Income #1, reducing the percentage of income spent on food from 682% to 140%. The differences in diet when calcium is supplemented is less milk and leafy greens are consumed, and more oil, cassava root, and maize flour are consumed. Milo, which is widely available across Africa, is a powdered drink mix that is high in protein, vitamin B12, vitamin C, vitamin D, iron, and calcium. It is shelf-stable, and dense in calories and nutrients, making it ideal for transportation. A government subsidy or cost reduction by the company that produces Milo for those at risk of undernutrition, mainly children and pregnant women, would be beneficial. Another similar option would be subsidizing fortified ready-to-eat cereals and/

Table 3. The number of servings of each food item in the Urban, Rural, and Seasonal Urban Consumer models (A, B, C, respectively) and final annual price per household (HH).

Food Item	Model A Serving	Model B Serving	Model C Serving
2% milk	0.64		1.35
Apple			
Banana			
Bean	0.34		0.94
Bean leaves			
Cabbage			0.26
Cassava root			
Cassava leaves		9.65	
Chicken			
Cucumber			
Eggs			
Fish	0.1	0.1	0.1
Green bell pepper			
Large roll			
Lettuce head			
Limes			
Maize flour			
Milo drink			
Oil (rapeseed)	0.08		
Orange	19.34		
Peanut butter			
Peanuts			
Pineapple			
Potatoes			
Pumpkin			
Rice			
Spaghetti			
Sweet potato			
Sweet potato leaves			
Tomato			
White onion			
	Model A	**Model B**	**Model C**
Final Annual Price/HH	$2,852.09	$70.30	$2,913.91

or bread, both of which are already eaten in urban areas. More relevant to rural areas would be the introduction and/or increase in production of crops that are high in calcium, such as spinach, kale, collard greens, and similar dark leafy greens.

Conclusions

Households growing their own food were able to meet their DRI in a much more cost-effective manner than those that did not. The largest reduction in the annual cost per household came from supplementation of calcium, which changed the feasibility of four scenarios from being not possible to being possible to meet their DRI with their annual income. Further research into identifying food items that are high in calcium that could be produced in the country in an economically efficient manner, especially for those living in urban areas, would have the largest impact on those living in Mozambique.

Acknowledgments

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