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Zanzibar Central Medical Stores Network and Transportation Optimization Analysis

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Abstract
The Zanzibar Central Medical Store (CMS) is transitioning from a resupply system; products are being rationed and pushed out to health facilities, using an integrated logistics management system (ZILS) for reporting and distribution—facilities place orders and are resupplied products, accordingly. It is envisioned that the ZILS will empower the CMS to improve its mandate to supply good quality medicines, medical supplies, and equipment at affordable prices, which approved government and nongovernment healthcare facilities make available. As of January 2014, ZILS has been fully implemented in all facilities of Unguja and Pemba islands. The Network and Transportation Optimization Analysis complements the ZILS implementation by examining the parallel supply chains managed by CMS; they are being integrated under the new system to facilitate a smooth operation transition, including an understanding of the funding requirements. The goals of this analysis are to build supply chain network optimization models that identify cost-saving measures for warehousing, sourcing, inventory management, distribution, and route planning for the integrated supply under CMS. Specifically, this analysis examines the optimal location for a Pemba warehouse and how distribution routes can be optimized to reduce the operational costs associated with storing and delivering products to all health facilities on the islands.

Cover photo: During a route optimization pilot exercise in October, 2013, essential medicines are transported to health facilities on a remote island in Tanzania's Zanzibar Archipelago. Dr. Andrew William, Warehouse and Distribution Advisor, JSI/Tanzania.

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Acronyms

CMS	Central Medical Store
km	kilometer
MOH	Ministry of Health
PHCU	primary healthcare facility
TZS	Tanzania shillings
ZILS	Zanzibar Integrated Logistics Management System

Acknowledgments

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Zanzibar Central Medical Stores Network and Transportation Optimization Analysis

Purpose

To assess Zanzibar's distribution network using LLamasoft's network and route optimization tools—Supply Chain Guru and Transportation Guru—and to recommend the location of future warehouses and a corresponding optimal distribution network structure and delivery routes.

Background

Zanzibar Central Medical Stores (CMS) is transitioning to an integrated logistics management system (ZILS) for reporting and distribution; this will empower the CMS to improve its' mandate to supply good quality medicines, medical supplies, and equipment, at affordable prices; they will be available through approved government and non-government healthcare facilities. As of May 2013, the ZILS had been installed in two-thirds of the facilities on the Zanzibar islands, with the roll out to the final one-third completed by December 2013. This study complements the ZILS implementation by examining the parallel supply chains, which CMS manages, and are being integrated under the new system.

The goals for this analysis were to build supply chain network optimization models that identify cost-saving measures for warehousing, sourcing, inventory management, and distribution and route planning for the integrated supply, under the CMS.

Objectives

Network Strategy:

- What is the best place to warehouse CMS products on Pemba Island; what are the comparative costs of the various sourcing scenarios?

Transportation Strategy:

- How do the currently envisioned ZILS distribution routes compare with optimized routes?
- How will increases in the quantity/volume of products distributed affect the ability of the CMS to deliver shipments on time?

Inventory Strategy:

- How do the various network structures and delivery frequencies impact inventory considerations for the CMS Zanzibar?

Methodology

An analysis of this type requires a substantial amount of institutional data; and, if local knowledge is missing, the institutional data should be leveraged to make assumptions. Following is a high-level summary of the data collected, including sources, where applicable.

Data Collection

- Facility list with geocodes obtained from CMS Zanzibar staff.
- Facility shipment products and quantities obtained from CMS Zanzibar Pharma team.
  - The CMS staff also provided additional information on the ZILS and KIT networks.
- CMS staff shared transportation fleet information; the transportation team provided help with the operational assumptions.
- Road network data obtained from Microsoft's Bing mapping engine, with oversight, data vetting, and additional road-related assumptions confirmed by local CMS Zanzibar staff.
- CMS Zanzibar provided transportation and labor cost data and assumptions.

After collecting this data and confirming the operational realities and related assumptions, the team built several supply chain network models that would be analyzed in and with Supply Chain Guru—LLamasoft's network design software package. The purpose of these models is explained below.

Network model

This model helps analyze Objective 1, described previously. Because this analysis focused exclusively on Pemba Island, only these facilities were included. In additional to facility information, the standard order sizes of each health facility, warehousing and transportation costs, and service distance information was also included to obtain a full picture of how network structural changes would impact cost and service indicators.

Transportation model

Develop test scenarios; compare baseline or current systems with proposed changes, test robustness of optimized models, and *sensitivity analysis*, to cope with exogenous and endogenous change.

In addition to analytical models, the project enlisted the help and experience of local CMS Zanzibar staff to understand the unique challenges and opportunities on the islands of Unguja and Pemba. This contribution and collaboration will be extremely important for the successful piloting of new activities and, as a result, all the strategic changes made by the CMS.

Project team

The network optimization team for this activity comprised two short-term technical assistance providers, two USAID | DELIVER PROJECT/Dar es Salaam–based technical advisors, and three trainees/participants from the CMS and Ministry of Health (MOH) Zanzibar.

Onsite work

During May 13–16, the first four days, were dedicated to the in-brief meetings and training of the identified CMS/MOH staff on both Supply Chain Guru Network Optimization and Transportation Guru software platforms—they were used in the subsequent analysis. Tutorial models were used on the first day to familiarize the team with the software, approach, and data requirements. The remaining time was used exclusively to build and analyze models for and with Zanzibar CMS. Andrew William, in collaboration with CMS preliminary data collection, previously coordinated this preparation; it allowed for data cleaning and gaps filling for the remainder of the first week—May 17 and 18. The network and transportation models and test scenarios were built on May 20–22; the stakeholder and client out brief was held on Thursday, May 24, where the results from the preliminary analysis were shared. Feedback received during the out brief was used to design alternative scenarios of interest and to fine-tune the final analyses, which address the client needs, as closely as possible. Throughout this process, the project team has worked directly with CMS Zanzibar staff to collect and understand the data, as well as to understand the accuracy and feasibility of the results.

Analysis and Results

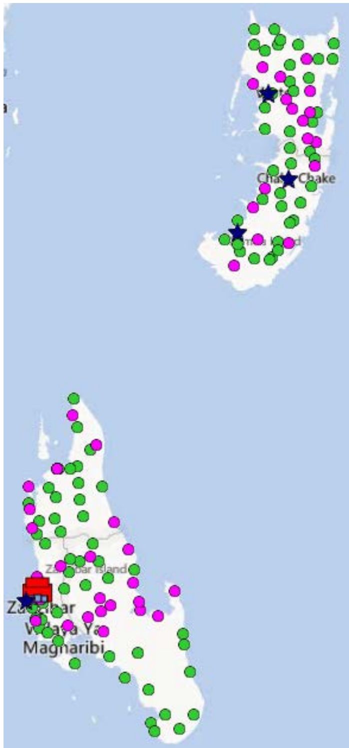
Network Overview

As seen in figure 1, the CMS Zanzibar network encompasses 145-plus health facilities on the islands of Unguja and Pemba in Zanzibar.

- 98 (green) ZILS health facilities are supplied via replenishment orders they place once a quarter
- 44 (pink) KIT health facilities are supplied by pre-planned, quarterly push deliveries of kitted products; all these facilities are expected to be transitioned to the ZILS system by the end of 2013
- 4 BULK (blue) hospital locations, which receive replenishment deliveries once a month.

Currently, CMS operates one (red) stocking facility in Zanzibar City on Unguja Island, and it uses a small warehouse in the northernmost district hospital facility, Wete, on Pemba.

Figure 1. Zanzibar CMS Current Network, May 2013



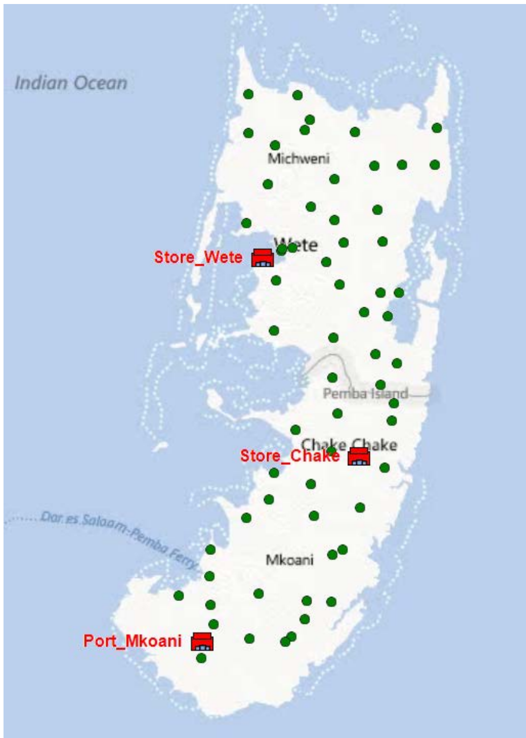
Network Strategy

What is the best place to warehouse CMS product on Pemba Island; what are the comparative costs of each sourcing scenario?

Currently, products delivered to facilities on Pemba travel a circuitous path from the mainland Tanzania to the CMS warehouse on Unguja; then, on to a ferry that delivers them to the port at Mkoani, on the southwestern part of the island. From the port, products that can be unloaded from the boat are loaded on to the one delivery vehicle on Pemba, and delivered to their designated health facility on the same day. All other products are taken by the delivery vehicle, on the same day, up to Wete, on the northern half of the island, where it is put into safe storage at the hospital. Deliveries to health facilities are then carried out once a day from Wete until all products have been distributed.

In figure 2, the three potential warehouse locations on Pemba represent the three hospitals on the island—Mkoani in the south, Chake Chake in the central region, and the currently utilized Wete store in the north. To analyze the differences between each potential stocking location, the team built a network model, and scenarios were run to compare costs, route loads and sequences, as well as total delivery time and distance requirements.

Figure 2. Pemba Facilities



As shown in figures 3, 4, and 5, the output of these models and scenarios were actual delivery route plans for each potential future network.

Figure 3. Screenshot from Supply Chain Guru of Route #4 with Potential Mkoani Store

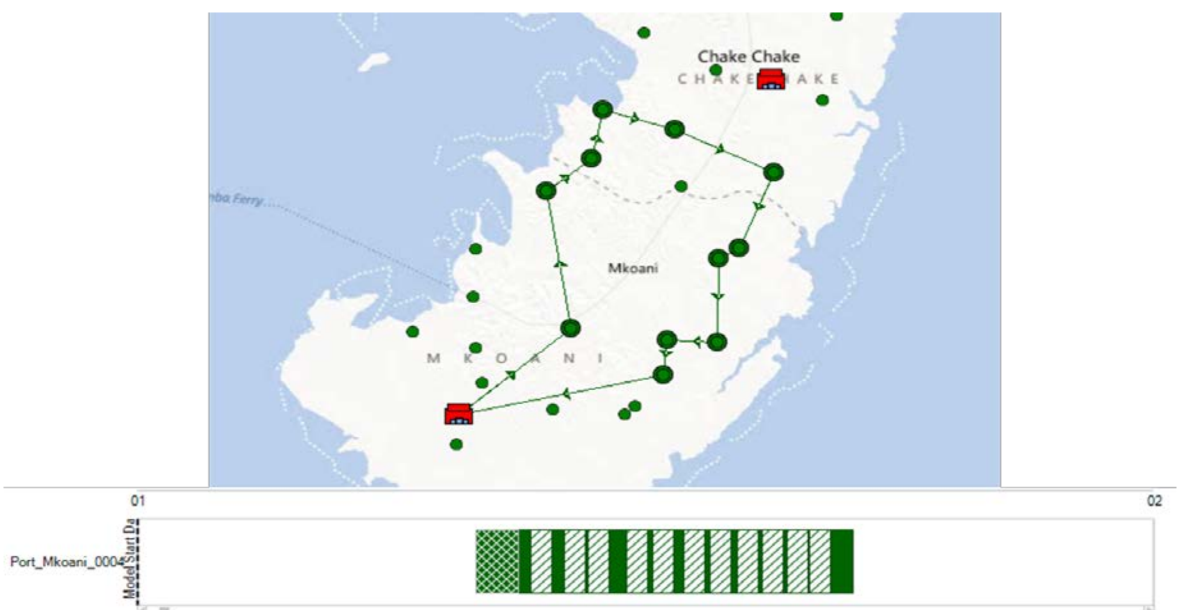


Figure 4. Screenshot from Supply Chain Guru of Route #6 with Potential Chake Chake Store

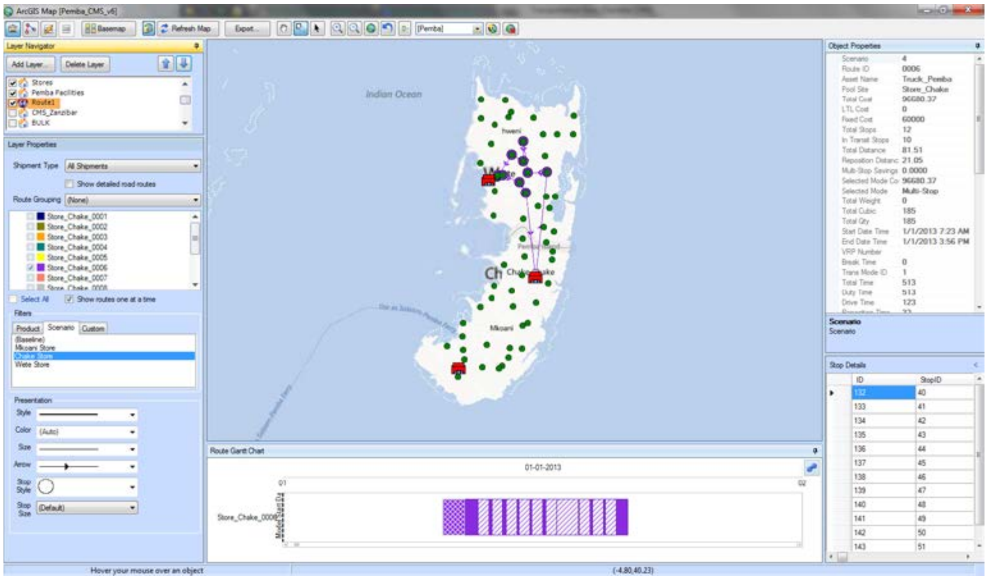
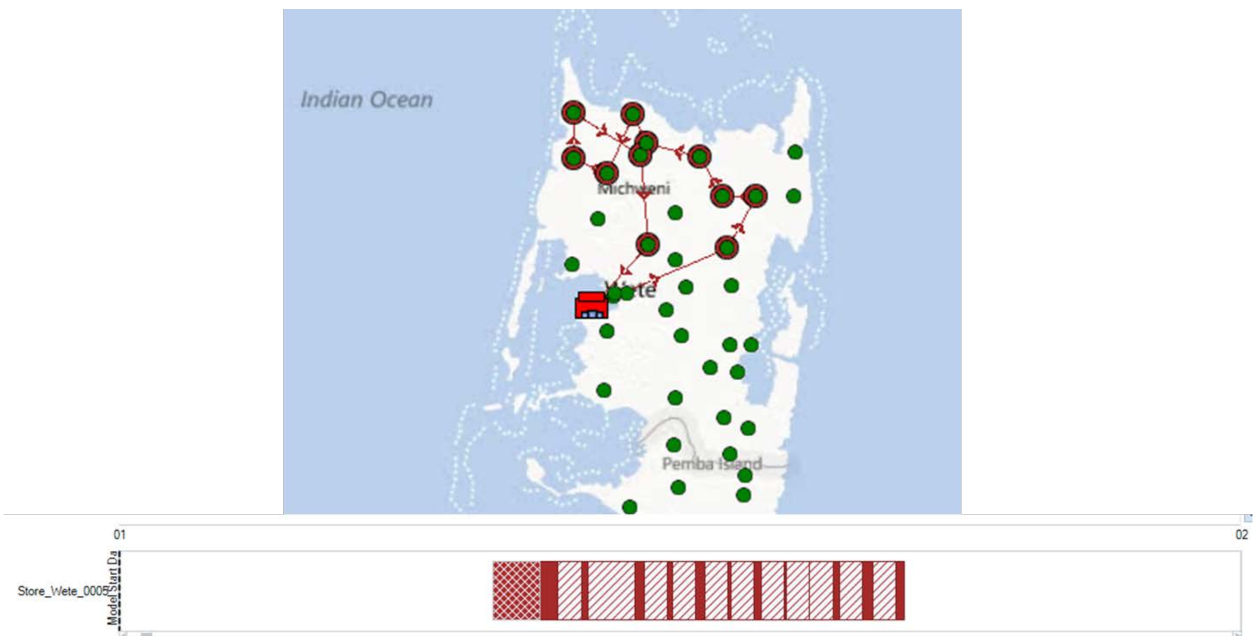


Figure 5. Screenshot from Supply Chain Guru of Route #9 with Potential Wete Store



In each of the route delivery maps, a Gantt chart at the bottom depicts the individual time components—loading and unloading times, drive times, and return trip times—that make up the route. Based on this information, including the detailed route outputs, we can compare the relative benefits of each scenario.

Figure 6 compares the total *Last Mile* route distance (kilometers [km])—or the distance to deliver all shipments, to all facilities, using each of the three potential stocking locations. The model outputs are quite similar, ranging from 11 routes required when distributing from Wete or Chake, to 12 routes required when distributing out of Mkoani. Mkoani requires an additional route because of the longer delivery distances—and thus, times—to reach facilities in the northern half of the island. The small differential in the number of required routes does not strongly influence the ultimate decision, because one delivery vehicle should be able to complete all routes in a three-month period, regardless of routes origin.

While it is important to note that fleet capacity is not a limiting factor, it is even more important to look closer at the service and cost implications of the stocking location decision. Based on this information, the Chake Chake scenario begins to look like the best choice from a network design perspective. Figure 6 highlights the intuitive conclusion that a stocking point in the middle of the island would minimize the total distances required to make all deliveries. This distance savings of >10 percent, compared to Wete; and >50 percent compared to Mkoani, which not only means shorter routes overall, but also less fuel, less wear and tear on the delivery vehicles, and less time on the road for the delivery staff. All these considerations result in substantial expected costs savings for a Chake Chake–based Pemba distribution network. The quarterly financial estimates in figure 6 show that last mile operating costs would also be lowest when using a stocking point in Chake Chake. Accurately translating these distance reductions to cost savings is difficult without more information about the detailed transportation cost categories—such as fixed labor versus petrol costs—which were not available at the time of this analysis; although a simultaneous effort was underway with CMS to better understand their financial operations. Figure 7 allocates all the transportation costs by distance, and can thus be considered an upper-end for the cost differentials between scenarios.

Figure 6. Network Comparison for Three Potential Pemba Stocking Locations

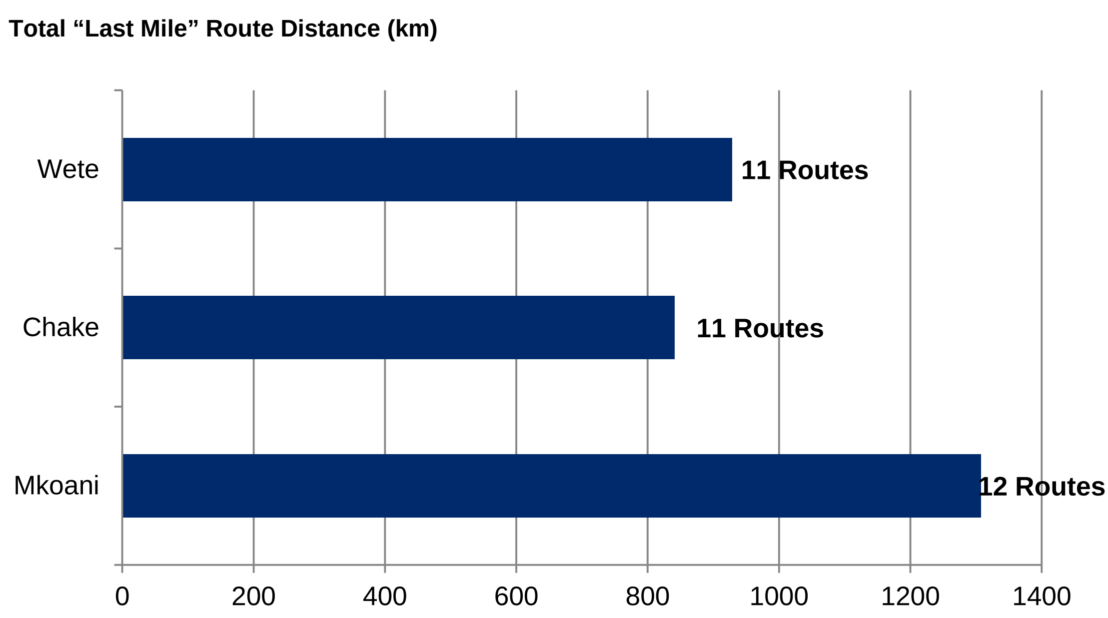
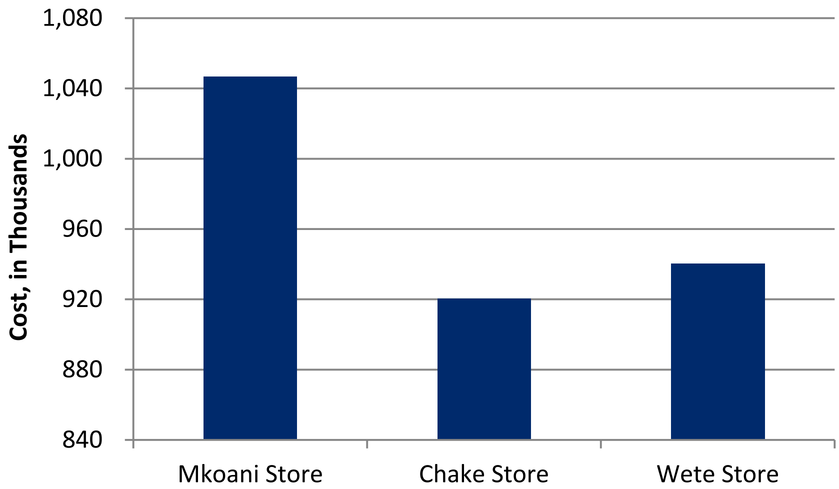


Figure 7. Estimated Quarterly Last Mile Delivery Costs, by Stocking Point



Based on this information, it is recommended that CMS consider adjusting the network on Pemba so products can be stored in a secure location in/around Chake Chake, potentially at the current hospital location, as was done previously at Wete. Should CMS decide to move forward with this, it is recommended that an analysis be done to understand the cost considerations of moving all products directly from the port up to the Chake Chake store before deliveries begin; or, to service the central and northern portions of the island, make deliveries directly from the port to the facilities on the southern half of the island before moving products to Chake Chake.

Transportation Strategy

How do the currently envisioned ZILS distribution route compare to the optimized routes?

In conducting the transportation analysis, a baseline was established using the planned distribution routes for when all health facilities are resupplied through the ZILS system. The baseline has two purposes: it reduced the complexity of modeling a system in constant flux as more facilities transition to the ZILS; and, additionally, the comparison of the planned to the optimized routes gave CMS a representation and output analysis for their potential networks to inform the ZILS rollout.

CMS Zanzibar staff provided the planned routes for both Unguja and Pemba islands. Routes are defined as a single trip from and return to the resupply point (warehouse), including the sequential facilities stops and road network used to deliver all shipments on a given day. On Pemba, the planned stocking location was the Wete store; and, on Unguja, the CMS Zanzibar facility located on the outskirts of Stone Town. Delivery trucks depart their respective warehouses at approximately 9 a.m.; they can deliver to health facilities no later than 3:30 p.m. Given the relatively small size of the system, it was assumed and verified that facility staff all receive phone calls telling them the time they can expect the truck to arrive on the day they are to be resupplied. This reduces truck wait-time at the facilities. CMS Zanzibar reported that it takes an average of 30 minutes to conduct a resupply at a primary healthcare facility (PHCU), 45 minutes at an upgraded Primary Healthcare Facility (PHCU+), one hour at a cottage hospital, and 1.5 hours at the referral hospital on Unguja.

Table 1. Example Output for Two Routes

	Baseline Route Designation X-4 Unguja yellow	Optimized Route Designation 007 blue
Stops	7	12
Distance (km)	49.05	50.41
Volume distributed (max 200 units)	90	165
Fuel costs (TZS)	75,451	75,880

Analysis: In the region north of Stone Town ~TZS$75,000 funds the distribution of 165 units of products to 12 facilities on one single optimized route, but a baseline route in the same region, for the same estimated cost, only funds the distribution of 90 units of product to seven sites.

Figure 8. Example Route Baseline versus Optimized Comparison

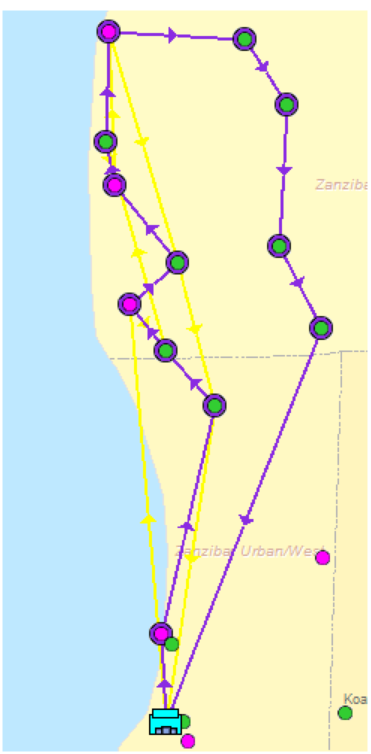


Table 2 summarizes the transportation optimization results. The baseline scenario, CMS Zanzibar planned distribution strategy, needed 29 routes to deliver all products to all facilities, for a total of 1,751 km traveled in one resupply period. The optimized routing uses 24 routes to deliver all products, to all facilities, for a total of 1,343 km traveled. By using the optimized routes, overall distance is reduced by 23 percent. The baseline routes average 5.5 hours per route and require 20 working days to deliver all shipments. The optimized routes are, on average, six hours long; all deliveries can be made in 18 working days.

Table 2. Output Analysis of ZILS Baseline versus Optimized Distribution Routes

Scenario Designation	No. Routes to Deliver to all Facilities	Distance of Routes (km)	Total Distance Traveled per Year	Total Route Time (hrs)	Average Route Duration (hrs)	Days (8 hr. working day)
Baseline	29	1,751.75	7,007.00	160.2	5.5	20
Optimized	24	1,343.20	5,372.80	145.2	6.0	18

Cost drivers of distribution planning—interpreting the data

Many cost saving opportunities are available to CMS if they adopt the optimized routes to support the ZILS distribution system. The CMS drivers and logistics officers who accompany the trucks on delivery runs are full-time, salaried staff. Reducing route times and durations, as defined in table 2 therefore, will not affect staff salaries, in relation to distribution plans. However, staff involved with distributions receive per diem of Tanzania shillings (TZS) $15,000/day; therefore, a reduction in the number of days to deliver to all facilities will result in cost savings to the CMS distribution budget. The optimized routes are longer in terms of hours per route (using an average six of eight available working hours in a day in the optimized plan compared to 5.5 of 8) and they require two fewer days to deliver all shipments to all facilities. Optimized routes are more efficient because they use more of the available working hours in a day; they are also more productive because they deliver to more facilities in a given day. By completing all deliveries two days before the baseline scenario, the optimized routes release delivery trucks for additional deliveries or for other purposes, as required by the CMS.

A critical cost driver of CMS's ZILS distribution system will be the total distance of the routes. Most of the costs are fixed; each of the two islands has access to a single 3.5 ton truck; warehouse staff and drivers are full-time and salaried. Additional costs are incurred for ferrying goods between Unguja and Pemba, as well as for the *last-mile* distribution to a few small islands off the Pemba and Unguja coasts. These costs will remain stable under any future transportation plan, and they were removed from the analysis of the transportation route optimization exercise. The biggest variable in the route planning for this system is fuel costs. The ZILS system operates on a quarterly resupply period. During one year, the baseline route scenario requires the trucks to travel a total of 7,007 km to deliver all shipments, while the optimized routes require only 5,373 km. Using the assumptions detailed in appendix B, the distribution costs for running the baseline routes for one year of quarterly deliveries are $4,315,192.16; while the optimized routes require $2,981,362.20 for one year of quarterly deliveries.

Table 3: Sensitivity Analysis of the Effects of Volume Increases on the Optimized Route Scenarios

Scenario Designation	No. Routes to Deliver to all Facilities	Distance of Routes (km)	Total Distance Traveled per Year	Total Route Time (hrs)	Average Route Duration (hrs)	Days (8 hour working day)	% of Time Truck On Road During 3-Month Distribution Period	Yearly Distribution Fuel Costs (TZS)
Baseline	29	1,751.75	7,007.00	160.2	5.5	20	33%	4,315,192.16
Optimized	24	1,343.20	5,372.80	145.2	6	18.1	30%	2,981,362.20
Optimized + 10% volume increase	28	1,439.68	5,758.72	156.1	5.6	19.5	33%	3,342,693.68
Optimized + 20% volume increase	28	1,449.12	5,796.48	156.3	5.6	19.5	33%	3,323,416.28
Optimized + 30% volume increase	29	1,452.76	5,811.04	157.43	5.4	19.7	33%	3,383,626.40

How will increases in the quantity/volume of products distributed affect the ability of CMS to deliver shipments on time?

CMS Zanzibar expects an increase in health facility demand after sites have transitioned from standard kits to the ZILS system because the kits contain approximately 32–37 products, while the ZILS system expects to distribute 58–67 products. In anticipation of the increased throughput it will need to manage, CMS is interested in seeing how fluctuations in demand volume will affect the distribution model. Table 3 present three different volume increase scenarios—10 percent, 20 percent, and 30 percent—to demonstrate the affect these marginal volume increases will have on the optimized distribution routes.

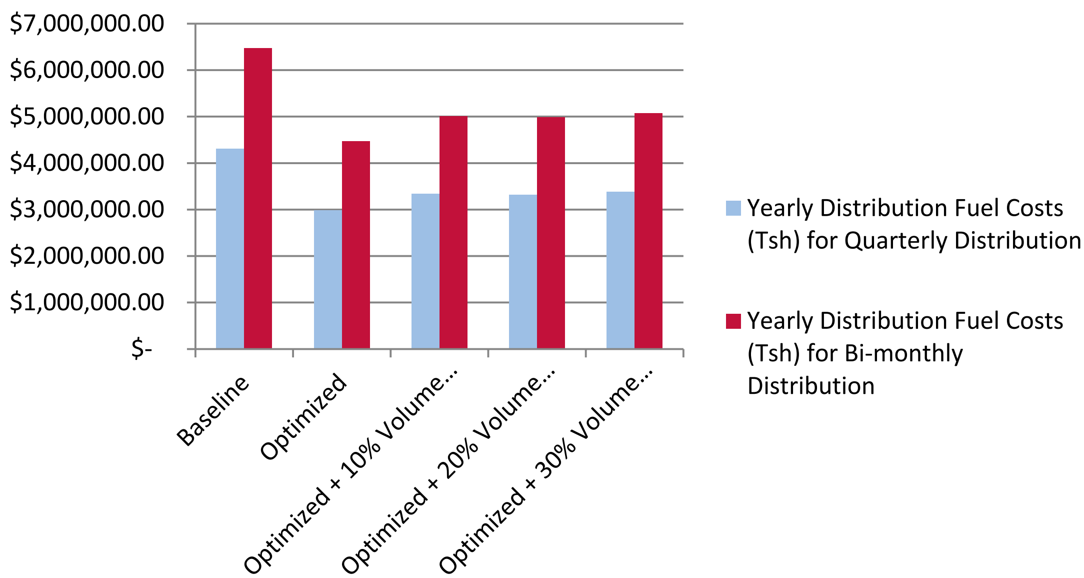
The results of this volume sensitivity analysis show robustness in the optimized routing structure. Volume increases of 10 percent require four additional routes to deliver all shipments to all facilities, indicating that the optimized scenario is moving close to its' maximum volume of throughput. Beneficially, the optimized routing plan can move up to 30 percent more volume than the baseline model, while maintaining the same number of routes, less total distance traveled, and costing TZS$931,566 less. This output shows that even if volume increases significantly, the optimized distribution routing offers major cost saving benefits over the originally envisioned routing plan. The model projects that the current CMS Zanzibar truck capacity—one truck on each island—can easily resupply all facilities, even with the projected increase of ZILS throughput. If the projected

ZILS throughput doubled, the trucks will reach their capacity for being able to deliver all shipments to all facilities within the quarterly resupply period.

The CMS is considering transitioning to a bimonthly resupply period to reduce the amount of inventory being held at health facilities, and to mitigate the expected increase in demand after transitioning to the ZILS systems. The effects of greater throughput require careful analysis because only one delivery truck is available on each island, which constrains the vehicle capacity; associated costs must be determined. Figure 9 illustrates some of the considerations of transitioning to a bimonthly resupply cycle. It is clear that, while increases in demand volume across both quarterly and bimonthly resupply policies have little effect on increasing the yearly costs of the distribution system, transitioning to a bimonthly health facility resupply policy will pose financial implications for CMS.

As seen in table 3, the optimized routes require the trucks to be on the road 18 of the 60 working days during the quarterly resupply period. This means that the trucks will use only 30 percent of their available time to make deliveries within the quarter when using optimized routes. It can be determined that transitioning to a bimonthly resupply period, using optimized delivery routes, will utilize approximately 45 percent of the trucks' availability—18 days to complete all routes/40 working days in a bimonthly resupply period. If CMS Zanzibar were to adopt a bimonthly resupply policy, their trucks would have sufficient space to complete all deliveries to all facilities. If a change in resupply policies is to be considered, the cost advantages of carrying lower inventory levels would need to be simultaneously examined to determine if the increased distribution costs could be potentially offset.

Figure 9. Relative Costs Comparison of the Various Resupply Policies



Inventory Strategy

How do the various network structures and delivery frequencies impact inventory considerations for the CMS Zanzibar?

In any supply chain, network structure and operational changes will have an impact on inventory needs. Those needs include costs and service—perhaps the two most important factors in evaluating supply chain performance. If up-front costs—and expiry—were not a consideration, then a supply chain should push as much stockout to the health facilities as they could handle. If the timely availability of products was not important, then upstream supply orders would only be placed when the downstream demand signal was received. Obviously, this is not the reality of the situation, so it becomes important to understand and evaluate the inventory trade-offs inherent in a supply chain.

The first step in this process is to understand the total value of the inventory in the network. To do this, ZILS order data was obtained from the CMS for January–March 2013; during this time, 98 facilities were operating under the new system. See appendix A for a subset of this information. Using this order data, we can calculate estimates of the total value of goods flowing through the network, across various time periods (see table 4).

Table 4. Total Value of Network Demand during Various Time Periods

Approximate Value of Network Demand (Tanzania shilling)					
	1 month	3 months	6 months	9 months	12 months
98 ZILS sites	$33,103,267	$99,309,800	$198,619,600	$297,929,400	$397,239,200
Full ZILS (est.)	$49,654,900	$148,964,700	$297,929,400	$446,894,100	$595,858,800

A supply chain should, at a minimum, invest in this amount of product to meet the expected demand. This assumes there is no variability and that demand projections are perfectly accurate—neither one is correct. However, with this estimate, we can establish a bottom line for the cost of inventory held in the network, as well as a bottom line for the potential savings in a network with reduced inventory requirements.

Table 5. Estimated Annual Carrying Cost for Different Quantities of Inventory (health facilities only)

Approximate Annual Carrying Cost of Inventory (in TZS, if 20% cost of capital)					
	1 month	3 months	6 months	9 months	12 months
98 ZILS sites	$6,620,653	$19,861,960	$39,723,920	$59,585,880	$79,447,840
Full ZILS (est.)	$9,930,980	$29,792,940	$59,585,880	$89,378,820	$119,171,760

As shown in table 5, with the assumption of 20 percent cost of capital, the CMS Zanzibar network has real costs of 10's of millions of Tanzania shillings per year, at a minimum. Discussions and interviews with CMS staff indicate that, on average, health facilities throughout Zanzibar try to maintain less than six months of stock at each facility to avoid a stockout. With this six-month estimate, and the expected full ZILS roll out by the end of 2013, we can estimate a minimum carrying cost of inventory of ~TZS$60 million for the stock held at all health facilities in 2014.

It is important, particularly in a public health supply chain, to understand the acceptable levels of service; and perhaps, more important, what *service* means in this context. Having immediate availability on the shelf could be one definition, but so could the ability to satisfy demand within two days, one week, or even one month from the time of the demand. For this analysis, we assume that when a patient needs a product, the product must be on-hand and immediately available at the health facility. This assumption is very narrow; it should be noted that expanding this definition to include some slack in the service time would open up additional opportunities for inventory reduction and the resulting cost savings. With this service definition, the question becomes how much inventory is required at each facility to ensure product will be at the facility immediately when the patient needs it. The next important question is to understand—especially in a *pull*-oriented environment, such as the goal of ZILS—how replenishment frequency and demand variability affect inventory requirements.

In a world with perfect future demand information, replenishment frequency would not impact the inventory, only the size of each delivery. Longer times between replenishment equals larger resupply quantity required. Demand variability makes it more complicated, because the longer the time between replenishments, the more opportunity for highly variable demands to impact service levels in the form of stockouts. To protect against this, facilities carry extra inventory, often called *safety stock*, to ensure they are able to meet unexpectedly high-demand quantities. To calculate precisely how many units are necessary to obtain a particular level of confidence in your inventory position, detailed order data—including missed demand!—is needed. Many commercial companies in the developed world do not have accurate data of this kind, so it is not surprising that an organization like the CMS Zanzibar does not have this information readily available. It is still possible to make some informed conclusions about costs, as well as the direction and potential scale of improvement.

If we assume that CMS Zanzibar holds a similar amount of stock, in addition to what is held at the health facilities, we can effectively double the annual costs from table 6. Six months of stock at both the central stocking point and the service delivery point has estimated annual costs higher than $100 million TZS. Therefore, how much inventory can we safely remove from the network without significantly affecting service rates? An accurate answer would require detailed variability information, as mentioned previously. Put another way, however, we can ask—what is an aggressive, but reasonable, amount of variability? Is it enough to cover for up to 50 percent more than expected demand? 75 percent? 100 percent? 200 percent? Currently, with six months of average inventory and quarterly replenishments, CMS Zanzibar is holding 200 percent the expected demand, within a given quarter; in addition to the inventory held at the central warehouse.

More detailed tracking of ordering patterns and stockouts would help inform more precise product-specific inventory planning; but, to start, during replenishment time, it is probably best to keep critical products at their current inventory levels, and to reduce orders up to levels for non-critical products to 150 percent of the expected demand.

It is important to note that the inventory carrying costs at health facilities outlined in table 6 are relatively modest. More frequent replenishment—every two months or every month—will allow for and require more responsive resupply and potential inventory reductions at the facilities, but the actual cost savings potential is not significant. A more important outcome of this change is faster responses to any stockouts that do occur, but this must be weighed against increased transportation and operating expenses that will come with more frequent replenishments.

Based on the historical order data available, the quantities, values, and resulting inventory costs for holding stock in the CMS network, reducing the inventory does not have a large enough potential for cost savings.

Table 6. Health Facility Inventory Cost Estimates in TZS

	Stock Order Up to Level					
Replenishment Frequency	**1 month**	**2 months**	**3 months**	**4 months**	**5 months**	**6 months**
1 month	$4,965,490	$14,896,470	$24,827,450	$34,758,430	$44,689,410	$54,620,390
2 months	NA	$ 9,930,980	$19,861,960	$29,792,940	$39,723,920	$49,654,900
3 months	NA	NA	$14,896,470	$24,827,450	$34,758,430	$44,689,410

Next Steps

Recommend Conducting a Pilot of Optimized Distribution Routes on Unguja

If optimized distribution routes are adopted, CMS Zanzibar can effectively manage the scale up in distribution throughput volume expected with the full roll-out of ZILS. Results from the transportation analysis have shown how using optimized routes can significantly reduce fuel costs, and that optimized routes can accommodate for projected ZILS throughput increases in shipment volumes of up to 100 percent before being unable to deliver all shipments. It is recommended that CMS Zanzibar conduct pilot distributions using optimized routes on Unguja and Pemba prior to adopting a policy of route optimization for all distribution runs. Conducting a pilot will be a small and controlled test of the optimization model where problematic assumptions and bad data can be identified and adjusted before implementing a universal change in distribution policy. Feedback from the pilot will help ensure a smooth transition to the planning and implementation of optimized distribution routing for CMS Zanzibar.

Suggested Pilot Methodology

At direction from the CMS Zanzibar, a month of planned resupply on Unguja can be piloted by executing optimized distribution routing and comparing the results to previous or planned distribution routing. Unguja has 86 health facilities; therefore, approximately 30 facilities are resupplied every month using a quarterly resupply policy. This quantity of facilities is a manageable number for running a route optimization pilot. To plan and prepare for the pilot, the following process timeline is recommended:

- *Three weeks* before the resupply begins, CMS Zanzibar gives the USAID | DELIVER PROJECT/Dar es Salaam a list of facilities that will be resupplied during the pilot.

- *Two weeks* before the resupply begins, the technical leads for the Network and Transportation Optimization Analysis provide optimized transportation routes for the planned resupply.
- *One week* before the resupply begins, the USAID | DELIVER PROJECT/Dar es Salaam and CMS Zanzibar review the proposed routing plan for the feasibility of the proposed optimized routes and to send feedback to the technical leads.
- In *the final week* before the resupply begins, the technical leads, USAID | DELIVER PROJECT/Dar es Salaam, and CMS Zanzibar finalize the routing plans and prepare the delivery teams for the data collection activities planned for the resupply.

*A suggestion, but not a requirement: To provide more consistent results for an analysis of facility demand and facility load/unload (dwell) time, the facilities chosen for the route optimization pilot will all be on ZILS.

* If mSupply data is available for the selected pilot facilities, it will be used instead of the estimated resupply quantities currently in the model.

Pre-pilot preparation and feasibility assessment

After the technical leads produce the initial optimized distribution routes, it is critical that the CMS Zanzibar and USAID | DELIVER PROJECT/Dar es Salaam review the routes, including the following:

- Are the number of facilities to be resupplied during each route feasible?
- Is the facility sequencing—order of deliveries—reasonable?
- Is the driving plan—roads to be used—reasonable for driving between facilities on each route?
- Will the products for each delivery route physically fit on the trucks?

Pilot implementation and data collection

During the implementation of the pilot, the following data pieces will be recorded using the global positioning system (GPS) devices provided and operated by the USAID | DELIVER PROJECT/Dar es Salaam staff:

- confirmation of facility geocodes
- dwell time at each facility to determine the average and standard deviation at each class of facility
- count of resupply quantities—as the number of ZILS or KITS boxes distributed to each facility
- fuel consumption per route, in liters
- mileage per route
- the GPS devices will be pre-set to take readings every five minutes, which will improve the road network and vehicle drive speed.

After completing the pilot routes, the feedback data noted above will be provided to the technical leads, who will revise the data and assumptions within the transportation model, as necessary. After the models are updated, using CMA Zanzibar's monthly resupply plans, a new route optimization analysis will be run for both Unguja Island and Pemba Island. These finalized distribution routes will be provided to CMS Zanzibar and the USAID | DELIVER PROJECT/Dar es Salaam with any other requested results or analyses of the final model. For the final pilot results and output analysis, see appendix 1.

Appendix A

Unguja and Pemba Pilot Results

Results

Unguja Pilot—September 2013

- The original CMS distribution plan was modeled so that 20 facilities were to be resupplied using five routes, over the course of five days.
- Optimization of this delivery cycle produced pilot routes that completed all 20 facility deliveries in three days.
- Table 7 compares the modeled planned delivery routes provided by CMS to the optimized distribution routes.

Table 7. Comparison of Planned CMS Distribution Routes to Optimized Routes for Unguja Pilot

Metric	CMS Plan (model)	Pilot Model (optimized routes)	Efficiency Gains
Routes	5	3	40%
Days	5	3	40%
Total drops	20	20	NA
Total boxes	158	158	NA
Drive time (min)	579	534	8%
Drive distance (km)	365	337	8%
Dwell time (min)	722	662	8%
Dwell/unit (min)	4.57	4.19	8%
Total time (min)	1301	1196	8%

- When the optimized pilot routes are executed, the USAID | DELIVER PROJECT staff provided ride-along data collection to verify assumptions built into the model. See appendix C for the completed data collection template.

- To improve the accuracy of results, information collected during the distribution was used to update the Unguja model so that the optimized routes output closely matched the results documented during the pilot deliveries. Table 8 presents the comparison between the optimized distribution routes and the actual routes executed during the pilot.

Table 8. Comparison of Optimized Routes and Actual September Pilot Route Data for Unguja Pilot

Metric	Pilot Model (optimized routes)	Pilot (actual)	Variance
Routes	4	4	0%
Days	3	3	0%
Total drops	20	20	0%
Total boxes	158	158	0%
Drive time (min)	534	566	6%
Drive distance (km)	337	359	6%
Dwell time (min)	*512	514	<1%
Dwell/unit (min)	3.24	3.25	<1%
Total time (min)	*1046	1080	3%

* For running the model, boat travel was built into the dwell times of the island facilities. For accuracy of comparison, those boat travel times (150 total minutes) have been removed from the data displayed.

- A low degree of variance is seen when comparing the modeled optimized route results to the data collected during the actual pilot distribution. This indicates the Unguja model presents an accurate representation of the distribution network; and, therefore, that the efficiency gains seen in table 8 for adopting optimized routes are illustrative.

Pemba Pilot—October 2013

- The original CMS distribution plan was modeled so that 20 facilities were to be resupplied using five routes, over five days.
- Optimization of this delivery cycle produced pilot routes that completed all 20 facility deliveries in three days—October 21–23.
  - Island deliveries had some challenges, but all pilot routes were completed in less than three days.

Table 9 presents a comparison of the modeled planned delivery routes provided by CMS to the optimized distribution routes.

Table 9. Comparison of Planned CMS Distribution Routes to Optimized Routes for Pemba Pilot

Metric	CMS Plan (model)	Pilot Model (optimized routes)	Efficiency Gains
Routes	5	3	40%
Days	5	3	40%
Total drops	20	20	NA
Total boxes	107	107	NA
Drive time (min)	634	393	38%
Drive distance (km)	343	202	41%
Dwell time (min)	697	697	0%
Dwell/unit (min)	6.51	6.51	0%
Total time (min)	1331	1090	18%

- Similar to the September pilot on Unguja, project staff provided ride-along data collection to verify assumptions built into the model. See appendix D for the completed data collection template. The Pemba model was updated with this information to improve the accuracy of results, so that the optimized routes output closely matched results documented during the pilot deliveries. Table 10 presents the comparison between the optimized distribution routes and the actual routes executed during the pilot.

Table 10. Comparison of Optimized Routes and Actual September Pilot Route Data for Unguja Pilot

Metric	Pilot Model (optimized routes)	Pilot (actual)	Variance
Routes	3	3	0%
Days	3	3	0%
Total drops	20	20	0%
Total boxes	107	107	0%
Drive time (min)	393	408	4%
Drive distance (km)	202	221	9%
Dwell time (min)	697	751	7%
Dwell/unit (min)	6.51	7.02	7%
Total time (min)	1090	1159	6%

Analysis

The results of the pilot have identified efficiency gains realized when using optimized distribution routing, which directly impacts the cost drivers of the CMS distribution system. These results are shown in table 11, which shows several key points:

- ~40 percent reduction in routes, drive days, and drive time.

Efficiency gains seen in reduced LOE: Three CMS staff are allocated for executing delivery runs; each receives TZS$15,000 per day. By reducing the September and October deliveries from a total of 10 days needed for the original CMS distribution plan to the six days required for the optimized route plan, the per diem costs were reduced from TZS$450,000 to TZS$270,000 for both islands distributions.

- 24 percent reduction in drive distance.

The original CMS distribution plan, as modeled, would result in 708 km to complete all the deliveries on both islands. The total miles driven, as calculated in the optimized route models used for the pilot, is 539. This reduction of 169 km is a 24 percent reduction in total driving distance, which translates directly into costs savings for the duration of the pilot distributions. The costs savings would be more substantial if optimized routes were implemented full time.

- ~20 percent reduction in total time requirements.

With it's given resources, CMS Zanzibar can scale network for growth without additional trucks or drivers. Transportation optimization offers CMS greater operational flexibility by helping complete deliveries in less total time, over fewer days, releasing staff and physical resources for alternative activities.

Table 11. Pilot Comparison Metrics

Comparison Metric	Pemba Pilot	Unguja Pilot
Total boxes delivered	107	158
Total distance (km)	221	359
Total drive time (min)	408	566
Avg. drive speed (km/hr)	32.50	38.06
Total dwell time (min)	751	514
Avg dwell time/box (min)	7.02	3.25
Total time/box (min)	10.83	6.84

Appendix B

January–March 2013 ZILS Order Data

Item	Orders	Qty*	Value (TZS)**	Value/Unit (TZS)	Value/Unit ($U.S.)***
Acetyl salicylic acid (aspirin) tab 300mg	8	24,000	$84,000	$3.50	$0.002
Adrenalin inj 1 mg/ml	21	410	$348,500	$850.00	$0.518
Albendazole tab 200mg	42	17,300	$276,800	$16.00	$0.010
Aminophylline inj 25 mg/ml	3	170	$33,600	$197.65	$0.120
Aminophylline tabs 100mg	28	53,000	$323,300	$6.10	$0.004
Amoxicillin suspension 125 mg/5 ml	59	16,344	$12,960,000	$792.95	$0.483
Amoxicilline caps 250mg	44	370,000	$11,100,000	$30.00	$0.018
Anti-rabies vaccine inj 2.5 iu/ml	1	10	$144,000	$14,400.00	$8.770
Anti-toxin tetanus inj 1,500 iu/1ml	1	50	$265,000	$5,300.00	$3.228
Atenolol 50mg tabs	6	20,000	$600,000	$30.00	$0.018
Atropine 1ml inj 1mg/ml	1	50	$11,000	$220.00	$0.134
Bandage hospital quality 7.5 cm	41	3,144	$1,441,000	$458.33	$0.279
Bendrofluazide tabs 5 mg	1	3,000	$0	$0.00	$0.000
Benzyl penicillin (x-pen) 5mu	38	5,400	$1,728,000	$320.00	$0.195
Captopril tabs 25mg	3	6,300	$472,500	$75.00	$0.046
Carbamazepine tab 200mg	2	5,500	$396,000	$72.00	$0.044
Catgut chromic 2/0, 75 cm, 1/2 circle RB 40mm	2	144	$192,000	$1,333.33	$0.812
Ceftriaxone powder for injection 1G VIAL	5	350	$375,000	$1,071.43	$0.653
Chlopromazine inj 25mg/ml	2	170	$153,000	$900.00	$0.548
Chlorhexidine +cetrimide (Savlon) 1.5% + 15% 5lt	38	86	$1,806,000	$21,000.00	$12.789

*Individual dispensing units (i.e., pills)

**Total amount CMS paid to MSD to purchase all units

***1 $U.S. = 1,642 Tanzanian shillings

Appendix C

Model Assumptions

Zanzibar Network and Transportation Optimization—Model Assumptions

Assumption Source/Validation: CMS Zanzibar Pharmacy Technician, Othman Ali Ussi

Network

- Optimized network analysis, all shipments issued from one location (Mkoani, Chake, or Wete warehouse scenarios)
- Model includes the quarterly shipments to each customer facility on Pemba.

Route length

- Graph displays route distance, issuing warehouse to customer site only. Inbound, inland shipping distances not included
- Distances to six health facilities on periphery islands not included.

Wilaya/District		Health Facility
Wilaya Ya Mkoani		Chambani
Wilaya Ya Chake		Mgelema
		Uwandani
Wilaya Ya		Makongeni
		Uondwe
Wilaya Ya		Kiuyu Kipangani
		Shumba Viamboni

- Route is defined as one roundtrip from warehouse to delivery sites, and back to origin warehouse, within one working day.

Route costs

- Includes ocean transit from Unguja to Pemba at 4,000 shilling per box of product.
- Includes inland freight from port to warehouse scenarios.

- Includes delivery route fuels costs calculated: 7 km can be traveled on one liter of fuel, 1 liter is about 2,200 TSH, so the per distance costs is 1 km=315 TSH.
- Delivery to six health facilities on periphery islands calculated as 15,000 shillings/site (boat fee, unloading, local conveyors).

Shipment sizes and truck capacity

- CMS reported that 200 boxes (ZILS, KITS, or BULK boxes) can be packed into each truck max.
- CMS provided average shipment sizes in *numbers of boxes* that are re supplied to type of facility as below:
  - kits boxes

    PHCU = 5

    PHCU+ = 10

    Cottage hospital = 60
  - ZILS boxes

    PHCU = 10

    PHCU+ = 25

    Cottage hospital = 60
  - bulk shipments

    District hospitals = 100

    Referral hospital = 200.
- Facilities that receive KITS or ZILS shipments are resupplied quarterly. Facilities that receive bulk shipments receive supplies monthly.

Transportation assets

- One 3.5-ton truck is available on each island for making deliveries.
- Road speed is 60 km.

Facilities/sites

- CMS Zanzibar provided geo coordinates.
- Operating hours for resupply a facilities is 7:30–15:30.

Road network

- Google 2010 road network with additional cleaning and expansion provided by the USAID | DELIVER PROJECT.

Appendix D

Unguja Ride Report

CENTRAL MEDICAL STORES
CMS
PO BOX 4664 - ZANZIBAR

ZANZIBAR CMS FACILITY DISTRIBUTION ROUTE REPORT

Region: Unguja Island

Name of Driver: Mohamed

Name of Recorder: Andrew

Date: 23rd Sept, 2013

Route Number: One

Kutoka Kituo *(From Health Facility)*	**Kwenda Kituo** *(To Health Facility)*	**Umbali** *(Distance Travelled - km)*	**Muda wa kuondoka** *(Departure Time)*	**Muda wa kufika** *(Arrival Time)*	*(Dwell Time in minutes)*	*(Total Units delivered)*	*(Notes)*
CMS	CMS	0			30min		Initial truck loading
CMS	Mwera	11km	08.05am	08.22am	10min	5	
Mwera	Machui	5km	08.32am	08.42am	13min	4	Machui was re-sequenced as it is very close to Mwera and there is no road network Machui to Miwani
Machui	Dunga	6km	08.55am	09.05am	14min	5	
Dunga	Uroa	7km	09.19am	09.50am	16min	4	
Uroa	Bambi	13km	10.06am	10.37am	13min	5	
Bambi	Kiboje	11km	11.00am	11.19am	15min	3	
Kiboje	Miwani	4km	11.34am	11.45am	15min	3	
Miwani	CMS	13km	12.00am	12.25am			Return leg to CMS

Driver Comments:

Recorder Comments: Route carried out in reverse order from optimized, Umbuji did not submit R&R so no drop there.

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CENTRAL MEDICAL STORES
CMS
PO BOX 4664 - ZANZIBAR

ZANZIBAR CMS FACILITY DISTRIBUTION ROUTE REPORT

Region: Unguja Island

Name of Driver: Mohamed

Name of Recorder: Andrew

Date: 24th Sept, 2013

Route Number: 2&4

Kutoka Kituo (From Health Facility)	Kwenda Kituo (To Health Facility)	Umbali (Distance Travelled - km)	Muda wa kuondoka (Departure Time)	Muda wa kufika (Arrival Time)	(Dwell Time in minutes)	(Total Units delivered)	(Notes)
CMS	CMS	0	07.30am	07.55am	25		Initial truck loading
CMS	Mchangani	29	07.58am	08.34am	19	4	
Mchangani	Pwani Mchangani	24	08.53am	09.21am	12	3	
Pwani Mchangani	Matemwe	7	09.33am	09.42am	31	15	
Matemwe	Kidoti	14	10.13am	10.36am	14	6	Matemwe-Nungwi goes through Kidoti so it was re-sequenced
Kidoti	Nungwi	8	10.50am	11.03am	15	4	
Nungwi	Gamba	22	11.18am	11.50am	15	6	
Gamba	Chaani Masingini	1	12.05am	12.09pm	15	4	
Chaani Masingini	CMS	29	12.24pm	1.00pm			Return leg to CMS
CMS	CMS	0	1.00pm	1.17pm	17		Truck reload
CMS	Unguja Ukuu	29km	1.17pm	1.59pm	15	3	
Unguja Ukuu	Uzi	7km	2.14pm	2.39pm	14	6	
Uzi	CMS	36	2.53pm	04.05pm	NA	NA	Return leg to CMS

Driver Comments:

Recorder Comments: Chaani Kubwa was not resupplied because it did not submit a R&R form

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John Snow, Inc.

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CENTRAL MEDICAL STORES
CMS
PO BOX 4664 - ZANZIBAR

ZANZIBAR CMS FACILITY DISTRIBUTION ROUTE REPORT

Region: Unguja Island

Name of Driver: Mohamed

Name of Recorder: Andrew

Date: 25th Sept, 2013

Route Number: 3

Kutoka Kituo (From Health Facility)	Kwenda Kituo (To Health Facility)	Umbali (Distance Travelled - km)	Muda wa kuondoka (Departure Time)	Muda wa kufika (Arrival Time)	(Dwell Time in minutes)	(Total Units delivered)	(Notes)
CMS	CMS	0	7.30am	8.00 am	30		Initial truck loading
CMS	Kivunge Cottage	47	8.03am	8.47am	60	62	
Kivunge Cottage	Mkokotoni	3	9.47am	9.54am	11	6	
Mkokotoni	Port	1	10.05am	10.10am	35		Unloading truck and boat loading
Port	Tumbatu Jongowe	N/A	10.45am	11.30am	30	4	30min in boat, then 30min unload
Tumbatu Jongowe	Tumbatu Gomani	N/A	Noon	01.00pm	30	6	60 min in boat, then 30min unload
Tumbatu Gomani	Port	N/A	1.30pm	02.15pm	0		
Port	CMS	32	02.15pm	02.51pm	0		Return leg to CMS

Driver Comments:

Recorder Comments:

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John Snow, Inc.

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Appendix E

Pemba Ride Report

Route	Day	Sequence	Source	Destination	Start	Finish	Dwell (min)	Dist (km)	Drive Time (min)	Actual Qty	Notes
1	Monday	0	Mkoani	Mkoani	8:00	8:25	25.00	0.00	0.00	107	Load truck at Mkoani port (Boat unloaded before 7.30 am)
1	Monday	1	Mkoani	Makoongwe	8:25	8:25	120.00	0.00	0.00	3	Delivery from Mkoani port to Makoongwe HF via small boat, and return to Mkoani port and the fully loaded truck
1	Monday	2	Makoongwe	MAKOMBENI	10:25	10:35	10.00	2.00	10.00	1	Delivery via truck from Mkoani port to next HF
1	Monday	3	MAKOMBENI	BOGOA	10:45	11:05	25.00	13.00	20.00	11	
1	Monday	4	BOGOA	SHIDI	11:30	11:35	10.00	2.00	5.00	1	
1	Monday	5	SHIDI	KANGANI	11:45	12:04	11.00	14.00	19.00	2	
1	Monday	6	KANGANI	KENGEJA	12:15	12:35	35.00	13.00	20.00	15	Route resequenced
1	Monday	7	KENGEJA	SHAMIANI (ISLAND)	13:10 PM	13:27 PM	56.00	3.00	17.00	3	Dwell time includes unloading truck time, loading boat time, unloading boat, handling commodities to the SDP
1	Monday	8	SHAMIANI (ISLAND)	MUWAMBE	14:23 PM	14:40:00 PM	15.00	5.00	17.00	5	
1	Monday	9	MUWAMBE	KIWANI	14:55 PM	15:20:00 PM	20.00	7.00	25.00	1	
1	Monday	10	KIWANI	UKUTINI	15:40 PM	16:09:00 PM	33.00	13.00	29.00	11	
1	Monday	11	UKUTINI	CHAMBANI	NA	NA	0.00	0.00	0.00		2 Boxes for Chambani was dropped at Ukitini (due to time constraints) expected to be collected from there
1	Monday	12	UKUTINI	Wete Store	16:42: PM	18:10:00 AM	0.00	52.00	88.00	54	Return to Wete Store and unloading of remaining boxes on truck into secure storage there.
2	Tuesday	0	Wete Store	Wete Store	7:45	8:12: AM	27.00	0.00	0.00	47	only unloaded 7 units (Fundo units) and all infusions
2	Tuesday	1	Wete Store	JADIDA	8:15	8:27AM	19.00	2.00	12.00	9	
2	Tuesday	2	JADIDA	PANDANI	8:46	9:00	13.00	10.00	14.00	5	
2	Tuesday	3	PANDANI	CHWALE	9:13: AM	9:27: AM	23.00	9.00	14.00	7	
2	Tuesday	4	CHWALE	KOJANI (ISLAND)	9:50	9:55	133.00	2.00	5.00	5	Dwell time includes unloading truck time, loading boat time, unloading boat, handling commodities to the SDP
2	Tuesday	5	KOJANI (ISLAND)	KAMBINI	12:08: PM	12:16: PM	19.00	6.00	8.00	4	
2	Tuesday	6	KAMBINI	OLE	12:35	12:50	17.00	11.00	15.00	2	
2	Tuesday	7	OLE	KISIWANI	13:07: PM	13.24 PM	14.00	13.00	17.00	4	
2	Tuesday	8	KISIWANI	MAKONGENI	13:38: PM	14:00:00 PM	28.00	14.00	22.00	8	Route resequenced
2	Tuesday	9	MAKONGENI	UONDWE	14:28: PM	14:31: PM	16.00	7.00	3.00	3	
2	Tuesday	10	UONDWE	Wete Store	14:47: PM	15:15:00 PM	0.00	17.00	28.00		
3	Wednesday	0	Wete Store	Wete Store	7:50	7:50	20.00	0.00	0.00		Morning loading of truck
3	Wednesday	1	Wete Store	Fundo	8:10	8:20	62.00	3.00	10.00	7	Fiber boat was used this time which is a bit expensive, otherwise one way it may take up to an hour
3	Wednesday	2	Fundo	Wete Store	9:22:AM	9:32:AM	0.00	3.00	10.00		Return with empty truck to Wete Store for secure overnight parking

For more information, please visit deliver.jsi.com.

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