WINROCK INTERNATIONAL

MOZAMBIQUE MARKET NEEDS, KAP AND TECHNOLOGY ASSESSMENT REPORT

May 8, 2019

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Green Technologies to Facilitate Development of Value Chains for Perishable Crops and Animal Products

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INTRODUCTION

SunDanzer Refrigeration LLC is implementing the Green Technologies to Facilitate Development of Value Chains for Perishable Crops and Animal Products (GreenTech) program, funded by the International Fund for Agricultural Development (IFAD). GreenTech's overall goal is to develop one or more commercially viable solar cooling products which can be sold, without subsidy, into dairy, fish or agriculture supply chains in east/southern Africa. In Mozambique, GreenTech's goal is to specify and commercialize a solar cooling product for artisanal fisheries. GreenTech seeks to build on IFAD's 2011-2019 ProPESCA project, which supported the artisanal fishery sector through technical training for fishermen, boat builders and mechanics; construction and rehabilitation of fishery-related infrastructure including fish markets, access roads, and cold storage units/ice makers; and provision of credit through rotating credit groups and fisherman-friendly credit terms. This report fulfills Activities 1 and 2 of Component 1, and Activity 4 of Component 2, in SunDanzer's GreenTech contract with IFAD.

In March and April 2019, Winrock conducted a rapid market assessment of chilling and ice making in the artisanal fishery sector in Mozambique, using the cooling-related questions from the Inter-American Institute for Cooperation on Agriculture's Commodity Systems Assessment Methodology.[1] Winrock also gathered information on knowledge, attitudes and practices (KAP), and information on other off-grid technologies for fish chilling and ice making which may be suitable for artisanal fisheries in Mozambique. Winrock visited fish markets and chilling equipment sellers and interviewed artisanal fishery cold chain stakeholders in several locations in Mozambique (**Figure 1 and Table 1**). Market assessment and KAP questions were combined into one survey instrument for each type of stakeholders (fishermen, fish traders, and ice sellers); the survey questions and raw data are attached in **Annex A**.

Figure 1: Mozambique survey locations

Winrock met with the following agencies and companies:

- IDEPA, Maputo: Luis Silva, Technical Assistant, Infrastructure, Markets and Economics; and Luisa Arthur, Fisheries Value Chain Exp
- DPMAIP, Pemba: Beatriz Isidoro, Head of Fisheries Department
- DPMAIP, Ibo Island
- Aga Khan Foundation, Pemba
- Pemba-based equipment suppliers: OK Mobiliaria, CECONUR, EnerLux
- Electricidade de Mozambique (EDM), Maputo
- FUNAE, Maputo
- SolarWorks!, Maputo

[1] LaGra, Jerry, et al. Commodity Systems Assessment Methodology for Value Chain Problem and Project Identification: A first step in food loss reduction. San Jose, Costa Rica: IICA, 2016.

Table 1: Interviews conducted to inform market assessment and KAP survey

Location	Artisanal fish traders	Artisanal fishermen/women	Ice sellers in artisanal fishing communities
Ibo Island	2		1
Quirimba Island	2	3	1
Pemba	1		
Maputo – Costa do Sol and Marítimo landing sites	5	8	3
Inhaca Island	3	1	4
TOTAL	**13**	**12**	**9**

I. ASSESSMENT OF EXISTING ARTISANAL FISH CHILLING BUSINESS MODELS AND KAP

Winrock found evidence of several different business models for fish chilling among artisanal fish traders in Mozambique.

A. ICE SELLERS

Knowledge, Attitudes and Practices: All but one of the 34 individuals we interviewed reported that ice is used in the form of blocks of ice, called *pedras*. One fish trader in Maputo reported purchasing flake ice, but other fish traders mentioned that flake ice melts too quickly. Two sizes of ice blocks were reported: 20 kg, on Inhaca Island (**Figure 2**), and 4-5 kg in all other interview locations. There was a market for ice in all of the artisanal fishing communities we visited. Winrock also conducted phone interviews with fishery sector contacts in Nacala, Mozambique Island, Angoche Island, Moma, Quissanga and Palma, where ProPESCA-funded ice plants have been installed or are under construction. All of these locations reported that ice is made and used in 4 kg *pedras* except for the Moma government ice plant, which produces 5 kg *pedras*. Ice sellers on Quirimba Island were using their chillers to freeze fish and chill bottled drinks, and reported receiving revenues for these activities in addition to selling ice. Similarly, on Inhaca Island, a cruise ship from Durban visits once a week, and ice sellers sell ice to cool bottled drinks in addition to selling ice for fish chilling. Of the 13 fish traders Winrock interviewed, only one reported selling ice to other fish traders.

Figure 2: Freezer in the home of an ice seller on Inhaca Island, showing 20 kg *pedras*

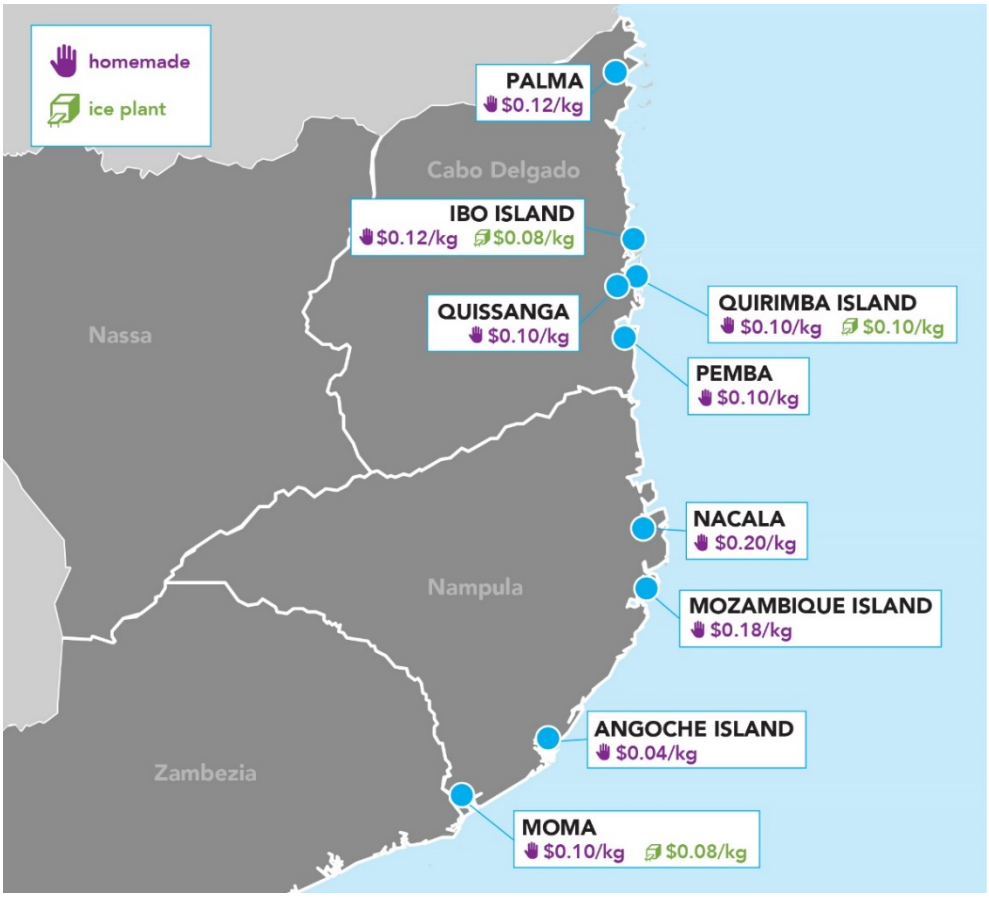
Business models: Winrock identified the following existing business models for ice sellers:

- Commercial investors that have invested in larger (e.g. 10-ton capacity) grid-powered ice makers who sell ice for a range of applications in cities, including to the fishing industry.

- Government constructed grid-powered one-ton capacity ice makers in coastal towns, operated by local governments or individuals. A number of these ice making machines are not currently operational.
- IDEPA-constructed solar chilling systems on eight islands, each with four 500-liter chest freezers, operated by fishing communities. We observed the system on Quirimba Island being used mainly for storing fish and cold drinks; managers there reported that it takes several days to freeze *pedras*.
- Households making *pedras* in a household freezer and selling them to fish traders.
- Gas stations and convenience stores making ice cubes with potable or bottled water for human consumption.

Price of ice: The price of ice reported by fishermen/women, fish traders and people who sell ice to fishermen was consistent at approximately US $0.08 – 0.10/kg (MZN 20 – 25 per 4 kg pedra).[2] As shown in **Figure 3**, government ice at the three working ice plants (Ibo Island, Quirimba Island and Moma) sells for US $0.08 – 0.10/kg. The price of homemade ice ranges from US $0.04 – $0.20/kg, with higher sale prices in tourist locations where ice is also likely used to cool food and drink bottles. Ice made with potable or bottled water for human consumption retails for a much higher price, ranging from US $0.30 - $0.78/kg, but is not used for fish.

Figure 3: Price of ice in Mozambique artisanal fishing centers



[2] For all figures given in US dollars, we assume an exchange rate of MZN 64/USD.

B. FISHERMEN

Knowledge, attitudes and practices: Of the 12 fishermen Winrock interviewed, nine reported that they do not take ice on their fishing boats to chill fish immediately after it is caught. In answer to why they do not use ice, three said ice is too expensive; one said their boat (canoe) is too small to hold the ice; and four said there is no need for ice, since they only fish for part of the day and sell the fish immediately after they return to the beach. Several fishermen mentioned that they realize it would be better to use ice, but they don't want to pay for ice in case they don't catch much fish. Eight of the 12 fishermen, including one who uses ice, said buyers sometimes reject their fish because it is not fresh enough. Two fishermen on Quirimba Island, which does not have electricity, told us they sell 50 – 65% of their fish to buyers who will dry it. This percentage is similar to a 2007 study at Zalala Beach by the Institute for the Development of Small-Scale Fisheries, which found that 70% of the artisanal catch was dried, salted or smoked.[3]

We asked fish traders if they ever give or sell ice to fishermen to improve the quality of the fresh fish; all 13 said no. Fishermen reported catching 5 – 20 kg of fish on an average day, with estimates for a "good" day ranging from 40 – 150 kg in one day. We observed fishermen using strategies other than chilling to keep fish fresh, such as gutting the fish at sea (**Figure 4**).

Figure 4: Inhaca Island catch, gutted to preserve freshness

Three of the 12 fishermen we interviewed reported that they take ice with them on the fishing boat. These fishermen use relatively larger boats, up to 9 meters, and often go with other fishermen in the same boat. All three said they pay cash for home-made ice from a local seller. Two fishermen reported taking 24 kg of ice on the boat, and one reported taking 100 kg of ice for 3-4 days of fishing.

Business models: Winrock identified two key business models for artisanal fishermen:

- Fishermen with small boats (e.g. canoes) who fish each day and sell their fish immediately after returning to shore. These fishermen do not use ice.
- Fishermen with larger boats (e.g. 6-8 meters) who go out to sea for 2-4 days at a time, often with one or more other fishermen on the same boat. These fishermen typically take ice on the boat with them.

C. FISH TRADERS

Knowledge, Attitudes and Practices: All 13 of the artisanal fish traders interviewed by Winrock reported using ice and/or grid-connected home chest freezers to chill fish before selling it. Eight fish traders reported using a ratio of kilograms of ice to kilograms of fish equal to or greater than

[3] IDPPE. 2009. Recenseamento da pesca artesanal 2007. Instituto de Desenvolvimento de Pesca de Pequena Escala, Maputo, Mozambique.

1 (estimates ranged from 1-2 kg ice/kg fish). Five fish traders reported using a ratio of less than 1 (estimates ranged from 0.25 – 0.8). Over time, traders told us they would top up the ice to keep the fish cool while it is transported, and until it is sold. One trader on Ibo Island told us that hotels often complain that the fish is not fresh enough. IDEPA officials told us that hotels in Cabo Delgado province prefer fish that has not been previously frozen. According to IDEPA regulations, fish should be flash frozen to -45°C within 4 hours; this is the standard among large commercial fishing operations. Home chest freezers are not capable of freezing fish this way. As a result, IDEPA as an institution does not encourage fish traders to freeze fish, but instead to cool fish to 2°C, for fish that will be sold fresh.

All 11 of the artisanal fish traders interviewed by Winrock in grid-connected communities reported that they own one or more chillers which they used to chill fish before selling it or shipping it for sale. Fish traders reported home chiller capacity ranging from 350 L to 1,000 L (two 500 L chests). All of the home chillers that we saw being used for fish were chest-type, top opening chillers. Of the 11 fish traders we interviewed who live in grid-connected communities, 8 have a stationary business model where they purchase fresh fish locally near their home, and either sell it directly in the market or ship it to a market for sale. Traders based in Maputo reported purchasing and selling 5 – 30 kg of fish each day, using ice to chill the fish while at the market, and keeping any leftover fish in a home chiller. Traders based on Inhaca Island reported purchasing 15 – 50 kg of fish several days a week and sending 50 – 100 kg of fish at a time to Maputo to be sold by a distributor, using ice to chill the fish while it is transported to Maputo.

In Cabo Delgado province, many artisanal fish traders travel to the Quirimbas Islands to purchase fish, which is then sold on the mainland or even shipped for export. Winrock interviewed traders based in Pemba, Quirimba Island and Ibo Island who reported that they travel for several days at a time when visiting other islands to buy fish, and that they take ice with them so that they can put the fresh fish on ice after purchasing it. One trader reported taking 240 kg of ice on 5-day trips where he visits 4 islands to purchase fish. Another trader reported taking 600 kg of ice on 3-day trips to purchase fish. One trader on Quirimba Island, which does not have grid electricity, reported that he sends someone to Quissanga, on the mainland, to buy 120 kg of ice for each trip he makes to buy fish; he pays extra for loading and transport of the ice to Quirimba Island. Some traders travel to the mainland to sell the fish themselves, while others sell it to a distributor. Traders typically need to buy more ice to keep the fish chilled during transport to the mainland. Some traders reported storing their fish in a grid-connected chiller on the mainland, either at the home of a relative or at the local fish market. Others reported continuing to store the fish on ice in cooler boxes until it is sold, which could take up to a week.

Business models: While the use of ice among fishermen seems to be optional, the use of ice and chilling is consistent among fish traders. Winrock identified two key business models for fish traders:

- Fish traders who travel to islands to buy fish use home freezers for storage and rely on being able to make or purchase fairly large quantities of ice at one time (250 – 1,000 kg) to chill the fish while transporting it by boat from islands to the mainland point of sale.
- Fish traders who stay in one place and buy/sell fish locally use home freezers to store the fish and/or make *pedras* to keep the fish cool until it is sold.

II. FEASIBILITY OF ARTISANAL SOLAR FISH CHILLING WITHIN EXISTING BUSINESS MODELS

A. ICE SELLERS

Ice making using grid electricity is a low margin business if the target market is fish traders. Selling ice is only profitable either at scale (e.g. 10-ton capacity ice makers), or with smaller freezers making higher quality ice for cooling drinks or food, which can be sold at up to US $0.78/kg. For off-grid areas, SunDanzer's estimate is that solar ice made with smaller chillers for fishing applications (50 – 100 kg/day, using non-potable water) would have to be sold at US $0.40/kg or more to deliver a reasonable return on investment. We did not find evidence that fish traders or fishermen would be prepared to purchase ice at this price to chill fish.

A larger solar chiller (700 kg/day) could produce ice which could be sold at US $0.25/kg; such a chiller would require around 20 kWp of solar PV to power it and cost on the order of $160,000. While these larger solar ice makers could be suitable for government subsidized schemes, Winrock has found that government-subsidized schemes typically face two key challenges. One is that a limited number of installations are possible with government subsidies, which does not lead to replication. The second is that these installations often face challenges with community management after they are handed over; communities need significant training and ongoing support to manage these systems profitably and efficiently. Given the relatively higher capital cost of solar ice makers, we conclude that the only market which would be commercially feasible for *solar* ice would be for high-quality ice made with potable or bottled water (e.g. for tourists and cold drinks).

B. FISHERMEN AND FISH TRADERS

In the absence of a feasible business model for investing in a solar ice maker to sell ice to artisanal fish traders and fishermen, we have explored whether a solar chiller/freezer can be an attractive investment for an individual fish trader or fisherman. We conclude that investment in solar fish chilling does not make economic sense for fishermen. Fishing income is determined by the amount of fish and type of fish caught and does not seem to be affected by whether ice was used on the boat. Fish which was caught the same day and arrives to market within a few hours is considered fresh even without the use of ice on the boat. The main risk to fisherman with small boats is the daily variability of fish catch. He is reluctant to pay for ice to take on the boat in case his catch is small, particularly when traders are not demanding ice cooling on the boat. For fishermen with larger boats who do use ice, investing in a solar ice maker would require a large capital investment; we assume they either would not use ice, or would purchase and transport ice from a grid-connected area.

Solar fish chilling does, however, make economic sense for fish traders. Fish traders sell fish at roughly double the price they purchase it from fishermen (e.g., purchase from fishermen at MZN 80/kg (USD1.25/kg), sell to customer or distributor at MZN 160/kg (USD2.50/kg)), with a higher markup for larger, preferred species (e.g. grouper, king mackerel) and shrimp. Traders can take up to a week to sell their fish in the market after they are caught. It is thus essential for traders to have access to a means of keeping the fish refrigerated until they are sold.

In off-grid areas, fish is either sold to customers on the same day it is caught or sent to dry. Fish sold for drying receives around MZN 50/kg (USD0.78/kg), or 40% less than fish sold fresh. Our hypothesis is that solar fish chilling could allow fish traders in off-grid areas to sell a higher volume of fresh fish, because they will be able to store it for up to a week. This would also raise the incomes of fishermen, who would be able to sell more fish fresh instead of for drying.

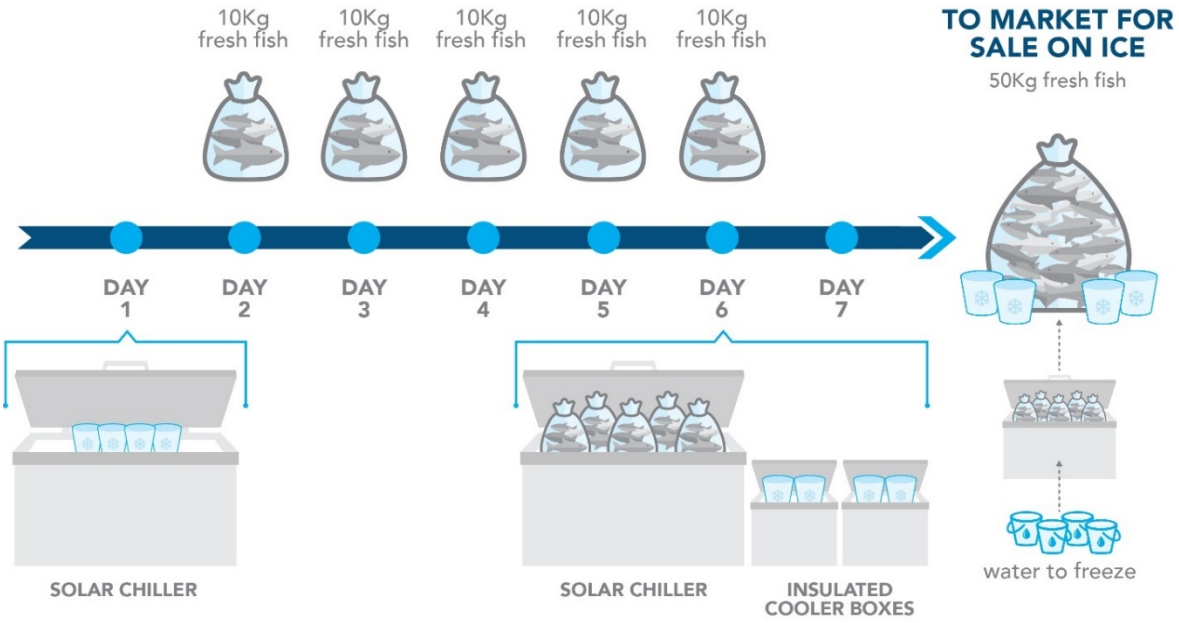
C. PROJECTED ECONOMICS OF ARTISANAL SOLAR FISH CHILLING

GreenTech plans to use use SunDanzer's energy efficient chiller/freezer Model DCR165e (165 liters) to test the market in Mozambique. The unit can cool 15 kg of fresh fish daily to 2°C while storing a total of around 60 kg. We will make modifications to this unit to tailor it to the needs of fish traders. Below is an initial projection of return on investment (ROI) and internal rate of return (IRR) to a fish trader purchasing the DCR165e. For the analysis (**Table 2**) we assume a retail price in Mozambique of US $1,500, based on preliminary discussions with Maputo-based solar distributor SolarWorks!. We assume that the fish trader will purchase the solar chiller with a down payment of 20% or $300. She will pay $87 each month for a total of 18 months through a Pay As You Go (PAYG) platform until the device is fully paid for. We assume the fish trader will purchase an average of 10 kg of fish five days per week from fishermen, and take 50 kg of fish to market once a week (**Figure 5**). Her average buying price for the fish from the fisherman is US$1.25 per kg and the average selling price is $2.50. The expected IRR of the solar chiller investment is 54% over 18 months, with an ROI of 200% within this same period.

Table 2: ROI and IRR evaluation of SunDanzer 165 liter solar chiller sold to fish trader

Fish Trader Profit & Loss	Year 1	1st half Year 2	2nd half Year 2
Fish sold (kg)	2,400	1,200	1,200
Total Revenue (USD)	6,000	3,000	3,000
Fish purchased from fishermen (kg)	2,400	1,200	1,200
Total Expenses (USD)	3,000	1,500	1,500
Gross Profit (USD)	3,000	1,500	1,500
Solar chiller loan + interest payment	1,568	784	0
Earning Before Taxes (EBIT)	1,432	716	1,500
Debt Coverage and Investment Returns (USD)			
Solar chiller upfront investment	1,500	**18-month ROI**	**2.0**
Financed by own savings	300	**18-month IRR**	**54%**
Financed by vendor loan (PAYG, 36% interest)	1,200	Incremental gross profit/initial investment	3.0
Loan principal and interest due in 18 months	1,568	Cash Flow/Total Debt Coverage	3.76
Cash flow generated in 18 months	4,500		

Figure 5: Cycle of solar chiller use for fish chilling and ice making



D. SUPPLY AND ADOPTION OF SOLAR CHILLERS

Uptake of solar chillers will improve the supply of fresh fish to local markets in Mozambique and increase the incomes of both fishermen and fish traders. Ensuring uptake of solar chillers requires addressing both supply and demand side challenges.

***Supply of solar chillers*:** For the introduction of solar chillers to be more than just a technology pilot for chilling fish, it will be important to introduce the technology through a sustainable supply channel and for buyers to pay a commercial price for the product. It will be most attractive for SolarWorks or other PAYG providers to offer solar chillers if the demand will come from a larger base of customers than just fish traders. The advantage of using a product such as the DCR165e is that it can be used as a residential refrigerator, in a restaurant kitchen, or by a vendor selling cold drinks on the beach. The GreenTech team will support SolarWorks to expand their operations to locations with good potential for expansion of the market for solar chillers for use by fish traders. GreenTech will identify other potential buyers of chillers in these communities in order to make it attractive for SolarWorks to market the solar chiller and service it in an area with high potential for its use in fish chilling. Recognizing that there is a significant segment of fish traders who sell 100-200 kg of fish each week, the GreenTech team will also test the market for a 390 liter chiller which SunDanzer is developing, following the same steps as with the 165 liter unit.

***Adoption of solar chillers*:** The analysis above shows how an off-grid fish trader can increase the amount of fish she sells every week, and correspondingly her income, through the use of a solar chiller. Her ability to purchase more fish fresh also means the local fishermen she buys from have to sell less fish at a lower price for drying. The chiller would allow the trader to store freshly-caught fish and either sell the fish at the weekly local market or ship the accumulated fish to a larger market. However, despite the potentially attractive financial returns, the uptake of chillers by artisanal fish traders could be a slow process. Many traders will wait to see how well the first adopters do with the chiller before making a decision to purchase one themselves. Most

fish traders will need financing to purchase the chiller either from a local microfinance institution or through a PAYG solar company such as SolarWorks. GreenTech will work with IDEPA, DPMAIP and local microfinance institutions to target early adopters within groups of fish traders. We will assist early adopters to secure financing and provide training in using the solar chiller to store fish and make ice. Making ice with the solar chiller will be most efficient if traders are able to make a behavior change and use ice cubes rather than *pedras*. We will monitor how successful they are in increasing their sales, and will share their experiences with other fish traders in the area.

III. ESTIMATED TOTAL MARKET SIZE FOR ARTISANAL SOLAR FISH CHILLING

It is useful to make an initial rough estimate of the total market size for solar chillers among fish traders in Mozambique. We will seek to refine this estimate with feedback from DPMAIP, IDEPA and IFAD. We assume that the average artisanal fish trader sells 50 kg/week for 48 weeks/year, or approximately 2.5 tons of fish each year. In 2014 IDPPE estimated the total artisanal fish catch at 137,000 tons.[4] This would mean the population of artisanal fish traders is approximately 55,000. We assume that, conservatively, 30% of fish traders are located in off-grid areas, or approximately 16,000 off-grid fish traders in Mozambique. This would be the target market for different sizes of solar chillers affordable to individuals. In Cabo Delgado province the artisanal catch in 2018 was estimated at 36,508 tons (**Table 3**). This means there are approximately 15,000 fish traders in Cabo Delgado province, of which 5,000 are likely in off-grid areas. This is a sizeable market, and Pemba could be a hub for solar chiller distribution.

Table 3: Artisanal fishery production by district, Cabo Delgado Province, 2018

District	Actual production (tons)
Palma	12,582
Mocimboa da Praia	6,380
Macomia	3,757
Quissanga	2,637
Pemba	7,979
Ibo	1,290
Metuge	164
Mecúfi	1,719
TOTAL	**36,508**

Source: Directorate of the Sea, Inland Waters and Fisheries (DPMAIP) of Cabo Delgado

IV. CURRENT AND POTENTIAL COMPETING PRODUCTS

Current and potential competing solar chiller products are summarized in **Table 4**.

Table 4: Current and potential competing off-grid fish chilling products

Product	Capacity	Power Source	Price ($ US)	Vendor	Availability
Steca solar refrigerator	150 liters	Solar: 2 x 150 Watt panels	$1,800	SolarWorks!	Not yet available for sale in Maputo
Zero Appliances Liquid	180 liters	LPG	$800	OK Mobiliaria, Pemba	Available

[4] Souto, Mario. *Artisanal Fisheries and Climate Change Project: Process Framework*. Instituto Nacional de Desenvolvimento da Pesca de Pequena Escala, October 2014.

Petroleum Gas Freezer					
"Do It Yourself" solar direct drive water chiller/ice storage system	3,000 kWh thermal storage, 800 W max thermal power	Solar: 200 Wp panels, 1 battery (40Ah@12V)	Estimated $1,800	Solar Cooling Engineering UG, University of Hohenheim, Germany	Key components available for sale; technical training and additional materials needed for in-country assembly
Solar ice block maker	2 tons capacity (667 kg over 8 hours)	Solar 20 kWp	$160,000	Various	Components available for sale; EPC contractor will install.

The product which is most similar to the SunDanzer solar chiller is the 166-liter German Steca solar refrigerator, which retails for $1,800 plus the cost of a 150 Watt solar panels and a battery (**Figure 6, left**). The SunDanzer DCR 165e is a smaller and less powerful chiller than the Steca and is expected to be more affordable to fish traders at the low end of the scale, e.g. selling around 50 kg of fish per week. These traders are often women who fishermen bring their fish to. The overall system cost of the DCR 165e unit is expected to come to around 60% of the Steca. The most readily available competitor in the market is a Liquid Petroleum Gas (LPG) refrigerator. However, the ongoing cost of LPG canisters is significant, and it is not clear how many of these chillers are currently being used for fish chilling.

Figure 6: The STECA 150-liter solar refrigerator (left) and the Zero Appliances 180 liter LPG freezer (right)

The University of Hohenheim's "Do It Yourself" solar direct drive water chiller/ice storage system requires procurement of freezer chest materials (plywood, insulation) and training in how to assemble the units. It could be appropriate for a donor-funded project that plans to deliver training to fish traders and facilitate local artisanal manufacturing of chillers, but not for mass market sales. Finding financing for DIY chillers will likely be a challenge.

Solar ice making units can be feasible at a one- or two-ton capacity where there is a market for ice in the 20-30 cents per kg range. These larger units would be appropriate for a fish market in

an off-grid area, similar to the solar chilling systems installed by the ProPESCA project on nine islands in Mozambique. However, our study did not find any fish traders or fishermen using such expensive ice to preserve fish. Where ice was selling at such a high price, it was being used to keep drinks cold.

V. POTENTIAL FINANCE AND DISTRIBUTION PARTNERS

SunDanzer and Winrock have been talking with SolarWorks, a Pay As You Go (PAYG) distributor located in Maputo, about test marketing the SunDanzer DCR165e chiller. SolarWorks would package the chiller with a suitable solar home system, including lights and mobile phone charging ports. SolarWorks would prefer to find a partner microfinance institution to manage the solar chiller loans. Solar chillers are considered a relatively riskier loan because, unlike solar home systems, the chillers do not yet have a built-in PAYG module which allows the distributor to turn off the appliance if the customer defaults on their loan payments. SunDanzer is exploring integrating PAYG modules into the chillers to facilitate local financing.

Another possibility is for SunDanzer to partner directly with a local microfinance institution and one or more equipment distributors in key coastal cities within reach of off-grid artisanal fishing centers, such as Pemba and Beira. Local microfinance institutions offering loan terms that may work for artisanal fish traders include the Aga Khan Foundation, the Fundo de Fomento Pesqueiro's *Programa Mais Peixe*, and the Bayport Financial Services company, which offers a payroll loan program through public employers.

VI. NEXT STEPS

The next step is for SunDanzer to ship one or more DCR165e units to Mozambique. SolarWorks will assess whether buyers might be interested to purchase a solar chiller under their PAYG program as part of a solar home system package or upgrade. The Greentech team will work with IDEPA, DPMAIP and local microfinance institutions to target fish traders interested to purchase the chiller from SolarWorks. We will monitor solar chiller use by early adopters and make technical and price modification to ensure the solar chiller meets their fish chilling and storage needs. GreenTech and SolarWorks seek microfinance partners to provide credit to traders for the purchase of solar chillers in coordination with SolarWorks. Should fish traders express demand for a larger chiller, SunDanzer will ship several 390-liter test units to Mozambique, repeating the process of integrating it into SolarWorks' supply and then making technical and price modifications as necessary.

ANNEX A: SURVEY QUESTIONS AND DATA

FISHERMEN/WOMEN SURVEY

Survey Completion Date	3/4/2019	3/4/2019	3/4/2019	**3/19/2019**	3/19/2019	3/25/2019	3/25/2019	3/25/2019	3/26/2019	3/26/2019	3/26/2019	4/22/2019
Participant Name	Assan	Andlawe Ali	Miquedal	**Paulo**	Armando	Inácio	Fransico	Mauricio	Pedro	Baltazar	Xavier	Inacio
Participant Location	Quirimba Island	Quirimba Island	Quirimba Island	**Maputo**	maputo	Costa do sol	costa do sol	Costa do Sol	Marítimo	Marítimo	Marítimo	Inhaca Island
How many times a day do you go fishing?	2	1	1	**1**	1	1	1	1	1	1	1	1
In which months do you fish?	All 12 months	All 12 months	All 12 months	**All 12 months**	All_12_months	All_12_months	All_12_months	All_12_months	All_12_months	March - December	All_12_months	October - May
Do you take ice with you on the boat?	no	no	no	**no**	no	yes	no	yes	no	no	no	yes - fish for 3-4 days at a time
How much ice do you purchase for each fishing trip? (kg)						24		24				100
Where do you buy ice?						home made near boat launch site		home made				From a local home ice maker
In what form do you buy ice?						Other		Other				Other
Other - In what form do you buy ice?						pedra		pedra				20 kg pedras
How much do you pay for ice?						20/pedra		20/pedra				5/kg
US $						0.08		0.08				0.08
Do you pay cash for the ice?						yes		yes				yes
How far do you transport the ice from the point of sale to your boat?						100-300m		100 m				1-2 km
Is there a reason that you don't purchase ice?	Other	Too_expensive	Other	**Too_expensive**	Other	Other	Other		Other	Other,Too_far_away	Other,Too_expensive	
Other - Is there a reason that you don't purchase ice?	Boat owner doesn't provide ice		Boat is very small (canoe); lack of availability of ice; if you take ice on the boat and don't catch much, then you operate at a loss		no need	na	no need		not enough volume	no need	no cooler box	

Survey Completion Date	3/4/2019	3/4/2019	3/4/2019	**3/19/2019**	3/19/2019	3/25/2019	3/25/2019	3/25/2019	3/26/2019	3/26/2019	3/26/2019	4/22/2019
Participant Name	Assan	Andlawe Ali	Miquedal	**Paulo**	Armando	Inácio	Fransico	Mauricio	Pedro	Baltazar	Xavier	Inacio
Participant Location	Quirimba Island	Quirimba Island	Quirimba Island	**Maputo**	maputo	Costa do sol	costa do sol	Costa do Sol	Marítimo	Marítimo	Marítimo	Inhaca Island
Would you like to use ice, or use more ice?	Yes if it were cheaper	Yes if it were cheaper	Yes if it were cheaper	**no answer**	Would be willing to pay MZN 10/kg if it were close by	N/A	N/A	N/A	Yes if it were cheaper, would be willing to pay MZN 10/kg if it were close by	Yes if I could get it closer, would be willing to pay MZN 10/kg		Would be willing to pay MZN 5-10/kg
How many hours/day do you fish?	Goes fishing 8 days in a row, then rests 3 days	7 days/week	3-4 hours/day, 7 days/week	**6 hrs/day**	4-6 hrs/day	24	12	24	10	10	6	4 days out at sea
How much fish do you catch in an average day? (kg/day)		5-6 kg avg; on a good day 30 kg	10 kg/day	**12-25 kg/day**	10-20 kg/day	5-50	15-150	5-40	0-7	0.5-25 of shrimp	2-20	5-20
Who do you sell your fish to?		Always sells to the same buyer ("patron")	Always sells to the same buyer, almost like an employer ("patron"). This serves as insurance - if he doesn't catch anything, the buyer will give him an advance.	**merchant**	merchant	custumary vendor	customary vendor	custumary vendor	custumary vendor	customary vendor	any vendor	local resellers
Does the buyer (or "patron") ever give you ice to take with you on your boat?		Buyers never ask for fish to be put on ice,, because ice is too expensive. Someone else will always buy it if the buyer rejects it.	No, because they would have to get the ice from Quisanga on the mainland, too expensive	**no**	no	no	no	no	no	no	no	no
Does the buyer (or patron) ever specify a certain type of fish or a certain quality of fish?			Buyer doesn't make special orders. But the ones that buy fish that will be sold fresh/chilled want a minimum size; whatever is smaller than that, they sell to other people who will dry it	**no, they buy all**	they pay more for A grade fish but buy all	buy all	buy all	buy all	buy all	shrimp	buy all	no
Does the buyer ever reject your fish?	Sometimes	Sometimes the patron rejects some of the fish; can sell the rejected fish to another patron who will dry it (get MZN 80/kg for fresh fish, MZN 50/kg for fish that will be dried)	Buyers who buy fish to sell fresh/chilled often reject a particular fish if it doesn't seem fresh enough - says "send this one to be dried"	**yes**	yes	no	no	no	no	yes	yes	yes
What portion of your fish do you sell fresh, and what portion do you sell to buyers who will dry it?		33% sold fresh; 66% for drying	50% sold fresh, 50% for drying	**all fresh**	all fresh	all fresh	all fresh	all fresh	all fresh	all fresh	all fresh	all fresh
How much do buyers pay for fish which you have kept on ice during fishing?												
How much do buyers pay for fish to be sold fresh, which you have NOT kept on ice during fishing?												
How much do buyers pay for fish to be dried?												
How large is your fishing boat?	beach seining technique (standing in shallow water, use net to catch fish)	canoe, owned with a partner/friend; go fishing together (2 people in canoe)	canoe									
Does your boat have room to carry one or more cooler boxes?												
How many days a week do you fish?												4
x	40.60991988	40.60347344	40.60201096	**32.61439637**	32.60195203	32.66006172	32.65987435	32.65998505	32.61550724	32.61454303	32.61534893	32.91631938
y	-12.41603886	-12.41176994	-12.41320742	**-25.95136283**	-25.96626306	-25.90330468	-25.90349257	-25.90318291	-25.95023792	-25.95105204	-25.9501363	-26.00214559

FISH TRADERS SURVEY

Survey completion date	3/5/2019	3/4/2019	3/4/2019	3/4/2019	3/4/2019	**3/25/2019**	3/25/2019	3/25/2019	3/26/2019	3/26/2019	4/22/2019	4/22/2019	4/22/2019
Participant name	Amad ali	Mahmoud Selim	Assumane	Dinho	Issa	**Luisa**	Isabel	Celeste	Marcelo	Lídia	Adelina	Aida	Mezaque
Participant location	Pemba - Paiquitiquete market	Quirimba Island	Quirimiba Island	Ibo Island	Ibo Island	**Costa do Sol (Vila dos pescadores) Maputo**	Costa do Sol (Vila dos pescadores) Maputo	Costa do Sol (Vila dos pescadores) Maputo	Maritimo	Maritimo	Inhaca Island	Inhaca Island	Inhaca Island
In what months of the year do you buy fish?	December - June	All 12 months	All 12 months	All 12 months	All 12 months	**December - July**	All 12 months	December - July	All 12 months	March - December	August - March (June-July = winter, few fish)	August - May	August - May
How many times per week do you buy fish?	Travels to islands 6 times/month for 5 days at a time, visits 4 islands on each trip			Travels to other islands 3 times/month for 3 days at a time to buy fish	2	**7**	7	5	7	6	5 per week	4 (weather dependent)	4
Do you give ice to fishermen to guarantee they will sell you their fish?	No	No	No	No	No	**No**	No	No	No	No	No	No	No
Does the price of ice vary by season?	Yes	No	No	No	N/A	**No, but more ice is needed on hotter days**	No, but more ice is needed on hotter days.	No, but more is needed on hotter days	No	No	No	No	No
In what form do you buy ice?	Pedra	Pedra	Pedra	Pedra	Own ice in plastic containers	**Pedra**	Pedra	Pedra	Flake	Pedra	Pedra	Pedra	Pedra
Do you sell ice to fishermen?				Sells ice to other traders		**No**	No	No	No	No	no	no	no
At what price do you sell ice?				10									
Who do you sell fish to?	Domestic distributor, Local hotels, restaurants, grocery, national exporter	Someone sells it for him to hotels, restaurants, government officials	He sells fish from a local fish market in Paiquitiquete to local hotels, restaurants, grocery, exporters, domestic distributor	Exporters, local hotels, restaurants, grocery, Local fish market, direct customers	Local hotels, restaurants, grocery, local consumers in Pemba	**Local fish market, Domestic distributor**	Local fish market, Domestic distributor	Domestic distributor, Local fish market	Local hotels, restaurants, grocery, Local fish market, Domestic distributor	Local fish market, Domestic distributor	Someone transports the fish for her to Maputo for sale	Someone transports the fish for her to Maputo for sale	Someone transports the fish for him to Maputo, always sells to same person in Maputo
Do you distribute the fish to its final destination?	No	No	No	He takes his car to hotels in Pemba and other cities	Yes	**No**	No	No	Yes	No	No	No	No
How many kg of fish do you buy at a time?	Takes 240 kg of ice with him on each trip to islands to buy fish	Takes 30 stones (120 kg) on each trip to buy fish		Takes 600 kg of ice with him on each trip to islands to buy fish		**1-5 kg prawns**	not sure	10-20 kg	20-50 kg	5-30	15	20-30	15-50
What is the range of value of the fish you buy? (MZN/kg)	100	80 for smaller, 60 for large	80 for smaller, 60 for large	100	90	**150-350**	300-600 for prawns (small or large), 250-300 for fish	50-100	300-350	350	80 (small fish) to 230 (grouper, king mackerel)	100-250 (shrimp)	80 (small fish) to 230 (grouper, king mackerel)

Survey completion date	3/5/2019	3/4/2019	3/4/2019	3/4/2019	3/4/2019	**3/25/2019**	3/25/2019	3/25/2019	3/26/2019	3/26/2019	4/22/2019	4/22/2019	4/22/2019
Participant name	Amad ali	Mahmoud Selim	Assumane	Dinho	Issa	**Luisa**	Isabel	Celeste	Marcelo	Lídia	Adelina	Aida	Mezaque
Participant location	Pemba - Paiquitiquete market	Quirimba Island	Quirimiba Island	Ibo Island	Ibo Island	**Costa do Sol (Vila dos pescadores) Maputo**	Costa do Sol (Vila dos pescadores) Maputo	Costa do Sol (Vila dos pescadores) Maputo	Maritimo	Maritimo	Inhaca Island	Inhaca Island	Inhaca Island
How much ice do you use per kg of fish? (kg)	1.6	1	1.2	3	0.8	**1-2**	doesn't know	0.25-1	2 (especially when buying flake ice)	1	0.5	1	0.5
How much do you pay for ice?	MZN 25/pedra	Sends someone to Quissanga to buy ice for him. Pays MZN 30/pedra + MZN 50 per 10 stones for loading + MZN 30 per 10 stones for transport	MZN 6/kg	MZN 20/pedra		**MZN 5/kg**	MZN 5/kg	MZN 5/kg	MZN 10/kg	MZN 5/kg	MZN 5/kg	MZN 5/kg	MZN 6/kg
US $/kg	0.10	0.12	0.09	0.08		**0.08**	0.08	0.08	0.16	0.08	0.08	0.08	0.09
How much do you sell fish for? (MZN/kg)	MZN 160-200					**250-400**	300-700 for prawns, 350 for fish	250-300	400-500	450	130-300	600	130-300
Do you store your fish before selling it?	Yes, on ice	Yes, in a freezer that's not hooked up, with ice on it	Yes, in the fish market, and buy more ice to top it off	In his own freezer and in cooler boxes if no space left in freezer. Takes 1,200 kg of ice with him on each trip to mainland to sell fish	In his own freezer before taking it to Pemba to sell	**Yes. Keeps it in ice at market during the day, then freezes the unsold fish (around 2-3 kg) at home for the night to sell the next day.**	Yes. Keeps it in ice at market during the day, then freezes the unsold fish at home for the night to sell the next day.	Yes. Keeps it in ice at market during the day, then freezes the unsold fish (around 5 kg) at home for the night to sell the next day.	Yes. Keeps it in ice at market during the day, then freezes or stores in cooler boxes the unsold fish at home for the night to sell the next day.	Keeps fish in ice duriong the day at market. Buys about 20-30 kg per day. Sells all in the same day.	Gather fish during the week, freeze it, then ship it once or twice a week to maputo when reached 60-100 kg	Store in 300L freezer about 50kg per week before shipping to Maputo	Store it in home freezer until 60-100 kg ready to ship to Maputo on ice, about once a week
Do you own a grid-powered fish chiller?				Yes	Yes. Family also owns a grid freezer in Pemba. He uses the large freezer on Ibo island only for overflow from his home freezer	**Yes**	Yes	Yes	Yes, 2 freezers	Yes	Yes	Yes	Yes
How many years have you owned the chiller, and how much did it cost?						**unsure**	unsure	5 years, 40,000 MZN	8 years, 17,000 MZN	1 year, 12,000 MZN	15 years, MZN 9,000, got gov't loan	16 years, MZN 9,000, got gov't loan	1.5 years, MZN 12,000, no loan
How big is the chiller where you store fish?						**500 L**	350 L	500 L	2 X 500 L	350 L	2 x 350L	350L, 50kg of fish will fit	350L
Do you use your chiller to make ice?					Yes	**Yes**	Yes	Yes	Yes	Yes	yes	no	no
In what form do you make ice?						**Pedras (4-5 kg)**	Pedras (4-5 kg)	Pedras (2.5kg)	Pedras (4-5 kg)	pedras (4 kg)	pedra 5 kg		
How many kg of ice do you make each week?						**dependent on freezer space**	unsure	6	40-80 kg	40-60 pedras for personal use	3-6, to use for transporting fish to Maputo		
How many kg of fish do you sell in a day?		Sends 100 kg to be sold on mainland each week	Sells 200 kg 3 times/month	Sells 1.5 - 2 tons, 3 times/month									
x	40.486234	40.59483262	40.59623818	40.60255587	40.59381338	**32.65944078**	32.6594988	32.65938783	32.61433427	32.6148867	32.91456852	32.91459242	32.91456278
y	-12.96255651	-12.40399629	-12.40488565	-12.34567464	-12.3329295	**-25.90372296**	-25.9036981	-25.90368183	-25.95110626	-25.95090211	-26.00330151	-26.00312784	-26.00307954

ICE SELLERS SURVEY

Survey completion date	3/26/2019	3/20/2019	4/17/2019	4/17/2019	4/17/2019	4/22/2019	4/22/2019	4/22/2019	4/22/2019
Name of ice maker location	Ibo cold chamber	Quirimba Island Fish Market	Sra. Florinda's house, Costa do Sol, Vila dos Pescadores	Sr. Rodrigues' house, Costa do Sol, Vila dos Pesacadores	Sra. Flora's house, Costa do Sol, Vila dos Pescadores	Sra. Albertina's house, Inhaca Island	Sra. Joana's house, Inhaca Island	Sra. Manuela's house, Inhaca Island	Sra. Cilda's house, Inhaca Island
Ice maker input power (kW)	7.5	2	?	?	?	?	?	?	?
What is the capacity of the ice maker?	?	?	?	?	?	?	?	?	?
What kind of water is used to make ice?	Well water	Well water	Tap water	Tap water	Tap water	Well water	Well water	Well water	Well water
What form is ice sold in?	4 kg Pedras	4 kg Pedras	4 kg Pedras	4 kg Pedras	4 kg Pedras	20 kg Pedras	20 kg Pedras	20 kg Pedras	20 kg Pedras
How much is ice sold for? (MZN/kg)	5	6.25	5	5	5	5	5	5	5
$/kg	0.08	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08
How much ice is sold per day? (kg) (or per week, or weekend)	600 kg/week	240 kg per 5 days	60 kg/week	80 kg/week	160 kg/week	320 kg/week	240 kg/week	400 kg/week	400 kg/week
What is the cost of electricity (or other fuel) to run the ice maker? (MZN/month)	5,000	-	1,000	700	800-1000	500	600	500	600
US $/month	78.13	-	15.63	10.94	12.5 - 15.63	7.81	9.38	7.81	9.38
How many staff are paid to run the ice maker/sell ice?	2	9	0	0	0	0	0	0	0
What is the monthly cost of all staff who are paid to run the ice maker/sell ice? (MZN)	6000	1/9th of the profits	0	0	0	0	0	0	0
Please describe any other operating costs? (MZN/month)	none	0	250 for water bill	400 For 5L water bottles 200 for water bill	300 for water bill	700 for water bill	300 for water bill	250 for water bill	400 for water bill
US $/month			3.91	9.38	4.69	10.94	4.69	3.91	6.25
What are the total monthly revenues of the ice maker/chiller? (MZN/month)	22,000-36,000	15,000-18,000	1,200	1,600	3,200	7,000	3,000	3,000	3,000
US $/month	344-562	234-281	18.75	25	50	109	47	47	47
Montly net profit (US/month)			**(0.78)**	**4.69**	**29.68**	**90.63**	**32.81**	**35.16**	**31.25**
What is the breakdown of monthly revenues?	ice: 15000-18000 storage: 7000-18000	fish storage: ice sales: about 18000 cooldrinks : unclear	1200 from ice Sales	1600 from ice sales	3000 from ice sales 300 from fish storage	all from ice sales	all from ice sales	all from ice sales	all from ice sales
Source of power for ice maker	grid_electricity	solar	grid_electricity	grid_electricity	grid_electricity	grid_electricity	grid_electricity	grid_electricity	grid_electricity
What is the price of electricity per kWh?	8.44	N/A	8.44	8.44	8.44	8.44	8.44	8.44	8.44
	0.13	N/A	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Has the recent change in the price of electricity changed the price of ice?	no		no	no	no	no	no	no	no
What is the cost of fuel for the ice maker?									
Do people come from other towns to buy ice? If so, from where, and how far away?									
x	40.58278421	40.59587727	32.66051021	32.65846371	32.65927299	32.91737364	32.91889467	32.91744595	32.91809755
y	-12.34367546	-12.40494328	-25.90083906	-25.90000065	-25.89712448	-26.00500166	-26.00471046	-26.00503279	-26.00463729