Volume 8, Issue No. 02

KENYA Aquatica

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SolCoolDry

Solar Drying Solar Cooling

A Scientific Journal of Kenya Marine and Fisheries Research Institute

KMFRI

SPECIAL EDITION

SPECIAL EDITION

KENYA *Aquatica*

A Scientific Journal of
Kenya Marine and Fisheries Research Institute

SolCoolDry

Solar Drying
Solar Cooling

Editorial

This Special Edition of the Kenya Aquatica Journal covers the proceedings of the Workshop on the Solar Cooling and Drying (SolCoolDry) project and other climate-smart technologies, including the poster session, as well as the exhibition event hosted by the local community of Mwazaro. The Workshop and related events were held on February 7th – 8th 2023 to inaugurate the launch of the SolCoolDry technology in Kenya, a first of its kind in this region of Africa. The technology uses 100% solar-powered and off-grid system for cooling and drying fish and other perishable commodities including vegetables, fruits and seaweeds for value addition by local communities.

Community involvement in this technology through a tripartite collaboration with partner institutions from three key sectors comprising research, academia and industrial development will ensure sustainability of the SolCoolDry approach. Furthermore, it promises to be long lasting, with options for replicability along the Kenya coast and in other localities nationally, where aquatic systems comprising lakes, rivers and big dams exist.

As the mouthpiece for reporting aquatic research development in Kenya, the Aquatica Journal of the Kenya Marine and Fisheries Research Institute (KMFRI) creates an ideal platform for reporting this functional tripartite of new research development that addresses an important aspect of Kenya's Blue Economy. The research is refined through a blend of practical research by KMFRI, academic knowledge emerging from the Technical University of Mombasa (TUM), while implementing related viable adaptive technologies from the Kenya Industrial Research and Development Institute (KIRDI), Fraunhofer Institute for Solar Energy (Fraunhofer ISE) and INNOTECH Ingenieursgesellschaft mbH (INNOTECH). The funding of this project was from the Federal Agency for Agriculture and Food (BMEL), Germany.

The SolCoolDry technology couples the solar-powered production of both ice-flakes for cooling and hot air for thermal drying. The Workshop demonstrated how the innovative application of photovoltaic and electrical storage technologies on the one hand and solar thermal storage on the other hand can generate and supply the required driving energy for the technology. Furthermore, the technology opens up new avenues for applied development by KIRDI and new avenues of electrical technology for students at TUM – a novel and most applicable possibility to establish new curricula and build capacity in the academia. One of the emerging outcomes of the SolCoolDry technology is that KMFRI is able to fulfill one of its key mandates on the Blue Economy, namely, to conduct research on fish quality, post-harvest preservation and value addition.

Kenya Aquatica, in collaboration with partners, will continue to provide the platform for science communication that links the community, academia and practitioners in the aquatic environment.

About Kenya Aquatica

Kenya Aquatica is the Scientific Journal of the Kenya Marine and Fisheries Research Institute (KMFRI). The Aim of the Journal is to provide an avenue for KMFRI researchers and partners to disseminate knowledge generated from research conducted in the aquatic environment of Kenya and resources therein and adjacent to it. This is in line with KMFRI's mandate to undertake research in marine and freshwater fisheries, aquaculture, environmental and ecological studies, and marine research including chemical and physical oceanography.

Manuscripts may be submitted to the Chief Editor through aquatica@kmfri.go.ke

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Featured front cover picture: Logo of the SolCoolDry Project denoting drying and cooling of fish and other perisheable products using solar energy

Featured back cover picture Sample of Porcupine fish bycatch from Lamu, Kenya (Source: Almubarak Athman)

Kenya Aquatica Journal - Volume 8, Issue No. 02

SPECIAL EDITION

PROCEEDINGS

SOLAR COOLING AND DRYING (SolCoolDry) PROJECT

Proceedings of the Workshop and Technology Day, 7th - 8th February 2023, Mombasa, Kenya

Fostering green innovations and use of renewable energy for food security, employment and Blue Economy empowerment of grassroot communities in Kenya

The SolCoolDry project partners and a section of attendees of the workshop held at KMFRI on 7th February 2023 (Source: Anne A).

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

Fraunhofer ISE

INNOTECH Ingenieursgesellschaft mbH

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

Project manager Federal Office for Agriculture and Food

The SolCoolDry Workshop together with the Technology Day were jointly organized by Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Industrial Research and Development Institute (KIRDI) and Technical University of Mombasa (TUM) in partnership with Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) and INNOTECH Ingenieursgesellschaft mbH (INNOTECH), with financial support from the Federal Ministry of Food and Agriculture (BMEL) in Germany.

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Contents

LIST OF ACRONYMS

AI	Artificial Intelligence
BMEL	Federal Agency for Agriculture and Food, Germany
BMU	Beach Management Unit
BoM	Board of Management
CEO	Chief Executive Officer
CFO	County Fisheries Officer
DCF	Discounted Cash Flow
DDC	Deputy County Commissioner
DG	Director General
DOCS & BE	Director, Ocean and Coastal Systems and Blue Economy
EEZ	Exclusive Economic Zone
GHG	Greenhouse Gas
HACCP	Hazard Analysis Critical Control Point
IMTA	Integrated Multi-Trophic Aquaculture
IoT	Internet of Things
ISE	Institute for Solar Energy Systems
KIRDI	Kenya Industrial Research and Development Institute
KMFRI	Kenya Marine and Fisheries Research Institute
KTN	Kenya Television Network
LCA	Life Cycle Assessment
MRI	Max Rubner-Institut
NPV	Net Present Value
PCM	Phase Change Materials
PI	Principal Investigator
PPP	Public-Private Partnership
PRI	Partnership, Research and Innovations
STEM	Science, Technology, Engineering and Mathematics
TV	Television
SolCoolDry	Solar Cooling and Drying
TUM	Technical University of Mombasa
UV	Ultraviolet
WIOMSA	Western Indian Ocean Marine Science Association
WIO	Western Indian Ocean

FOREWORD

It gives me great pleasure to introduce to you Volume 8 (2) of the Kenya Aquatica Journal, a special edition featuring the proceedings of the Solar Cooling and Drying (SolCoolDry) project Workshop and Technology Day held on 7th and 8th February 2023 respectively. The two-day event marked a significant milestone in the implementation of the SolCoolDry project, a collaborative project involving Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Industrial Research and Development Institute (KIRDI), and Technical University of Mombasa (TUM), in partnership with INNOTECH Ingenieursgesellschaft mbH (INNOTECH) and Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) from Germany.

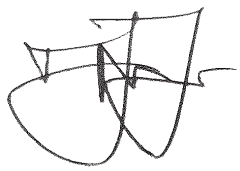
The SolCoolDry project represents a significant step in our journey towards the sustainable exploitation of the Blue Economy. As the Chief Executive Officer of KMFRI, I have witnessed the pivotal role that innovative research plays in addressing the challenges faced by our coastal communities. Post-harvest fish losses have been a persistent issue, impacting the livelihoods of communities that depend on fishing for their sustenance and income. The project aimed at addressing this challenge by designing and installing a solar-powered system for cooling and drying fish using solar energy.

At KMFRI, we remain steadfast in our commitment to conducting research in collaboration with national and international partners, with the goal of sustainable exploitation of Kenya's Blue Economy. The SolCoolDry project exemplifies this commitment, as it brings together the expertise and resources of multiple institutions and organizations, fostering a dynamic exchange of ideas and knowledge. The success of this project demonstrates the power of collaboration in driving innovation and propelling our fisheries sector towards a more prosperous and sustainable future.

Furthermore, the SolCoolDry project aligns seamlessly with the Government of Kenya's bottom-up development agenda, which places paramount importance on community empowerment. By reducing post-harvest fish losses, we are not only enhancing economic opportunities for local fisherfolk but also contributing to the overall development of coastal communities. This special edition of the journal serves as a demonstration of our dedication to community empowerment and our unwavering pursuit of sustainable growth.

This special edition showcases the research, technological advancements, and practical applications implemented by the partner institutions to foster green innovations for the empowerment of local communities, promotion of food security and creation of employment opportunities by unlocking the potential of the Blue Economy in Kenya.

I extend my most sincere appreciation to all the contributors, stakeholders and all participants who played a crucial role in making the SolCoolDry Workshop and Technology Day a resounding success. I am confident that the knowledge shared within these pages will inspire further research, innovation, and collaboration in our collective efforts to unlock the full potential of Kenya's Blue Economy.



Prof. James M. Njiru
Chief Executive Officer, Kenya Marine and Fisheries Research Institute (KMFRI)

PREFACE

This document summarizes the outcomes of the SolCoolDry Project Workshop and Technology Day on fostering green innovations and use of renewable energy for food security, employment and empowerment of grassroot communities in the Blue Economy in Kenya, held on 7^{th} and 8^{th} February 2023. The first part was a one-day Workshop convened at KMFRI Headquarters in Mombasa, where presentations from the local and international project partners were made, while the second part was the Technology Day and official launch of the SolCoolDry facility in Mwazaro, Kwale county.

During the one-day Workshop, presentations were received from the following institutions: Technical University of Mombasa (TUM), Kenya Industrial Research and Development Institute (KIRDI), Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE), INNOTECH Ingenieursgesellschaft mbH (INNOTECH) and Kenya Marine and Fisheries Research Institute (KMFRI), where existing scientific information, capacity needs in research and fish value addition and infrastructure were presented and reviewed. The Workshop attracted 108 participants drawn from a variety of local institutions. There were 10 oral and 15 posters presentations made, discussing the research conducted in Kenya in terms of the application of climate-smart technologies utilizing green-energy. The workshop was officially opened by the Guest of Honour, Eng. Lucy Wanjiku Mutinda, a Board Member of KIRDI and officiated by KIRDI CEO Dr. Ing. Calvin Onyango, accompanied by his colleagues Dr. Linus K'Osambo, Dr. George Wanjala and Dr. Arthur Onyuka. From the German team, representation was by Dr. Alexander Morgenstern (Fraunhofer ISE), Dr. Ing. Albert Esper (INNOTECH), Dipl. Ing. Norbert Pfanner (Fraunhofer ISE) and Dr. Marcus Schmidt (MRI). TUM was represented by Dr. Huxley Makonde, Dr. Hamisi Mwaguni and Mr. Thoya Maitha. The consortium appreciated the contribution of the funders from Germany and hoped that this technology would be replicated to other areas of the Kenya coast.

On the second day, the project hosted the Technology Day (highlighting food processing, off-grid/ renewable energy-based, Blue Economy innovations) at the SolCoolDry site at Mwazaro in Kwale County. The local leadership, County Fisheries Officers (CFOs), local communities and other stakeholders were also invited. The SolCoolDry facility will benefit not only the fish mongers and local Beach Management Units (BMUs) but also other community members who will use the system to dry, not only fish, but also other products such as mangoes, pineapples, coconuts and potatoes, among other types of agricultural produce, which can be value-added, packaged and sold at competitive prices. As a result, this will enhance the livelihoods of the local community.

Generally, it was concluded that the there is need for studying, optimizing and adapting the system for local fabrication, training in the design and implentation of Hazard Analysis Critical Control Point (HACCP) systems, online marketing on all products and services being offered at the site, development of a structured food safety implementation framework for coastal Kenya and more research to increase the efficiency of the SolCoolDry technology.

Dr. James Mwaluma

Director, Ocean and Coastal Systems & Blue Economy

1. BACKGROUND

By Dr. Peter Oduor-Odote

Fish production & consumption in Africa

The per capita annual consumption of fish in Kenya is 4.5 kg whereas for Africa it is 10.0 kg and 20.0 kg for the rest of the world. Kenya therefore needs to increase its per capita fish consumption. The fisheries landings in Kenya are estimated at 140,000 metric tonnes and about 24 metric tonnes from aquaculture. About one in every three individuals in Kenya is below the "food poverty" line (i.e., lack of financial capacity to maintain food consumption that satisfies adequate daily calorific requirements); 24% of the population is undernourished; and the growth of 26% of children under five years of age is stunted. Food-insecure people in Kenya are often vulnerable to malnutrition and, young children and youth, particularly women of reproductive age are the most vulnerable.

There is need to increase the production of fish to reach Africa's per capita fish consumption level and to curb any losses from the landings. Additionally, the fish that is landed from the wild or produced through aquaculture though inadequate, does not still reach the consumer in total owing to post harvest losses estimated at 30% to 50%, occasioned by lack of proper handling and preservation facilities.

Preservation technologies in the African fish value chain

The most preferred preservation method for fish is by cooling. The cold chain in Africa is dotted with cold stores at the landing sites for maintenance of quality. However, such cold chain efforts are not adequate, have high running costs and lack technical skill management and are more often than not closed. In Kenya, just like the rest of Africa, the failures in the cold chain are repeated, going by the number of fish cold stores producing ice blocks which are initially received with enthusiasm, only to be abandoned because of high costs of electricity, lack of technical know-how and responsibility eventually leading to most of them either shutting down or operating below capacity.

Alternative traditional fish preservation methods are very common and mainly performed by women. Nevertheless, the quality of the dried fish is poor, both irregular and uncontrolled. Microbial contamination and insect infestation occur frequently during drying, storage and marketing. The processors lay the fish on the ground (Fig. 1), on mats on the ground or on sand occasionally covered with fishing nets or hanging them from frames of raised racks. The disadvantage of these traditional drying methods is that the slow drying process makes it unhygienic and also contributes to partial destruction of proteins and lipid oxidation. The fish has to be brought inside every time it rains and each evening to avoid dew and its consequences such as moulds. Dust contamination, insect infestation, and exposure to harmful human and animal handling are the other disadvantages of natural outdoor drying.

Figure 1. Broadcast drying of sardines on the ground by artisanal processors (Source: Oduor-Odote P.).

The solar cooling and drying (SolCoolDry) system

Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Industrial Research Development Institute (KIRDI), Technical University of Mombasa (TUM) and two German engineering institutions - The Fraunhofer Institute for Solar Energy Systems (ISE) and INNOTECH Ingenieursgesellschaft mbH (INNOTECH) through funding by the German Federal Agency for Agriculture and Food (BMEL) collaborated to design, implement and roll out a climate-smart innovation for post-harvest control in fish as well as other farm produce like meat, vegetables, spices and fruits to help farmers and fishermen reduce spoilage and loss of their products and to bring more superior quality products to the market. The innovation known as the Solar Cooling and Drying (SolCoolDry) system (Fig. 2) uses solar energy to generate flake ice for use in chilling fish and has a drying component with capability of drying in both sunny and damp weather and at night.

This technology is a 100% off-grid, solar powered, cooling and drying system for improved quality and value addition of fish and agricultural produce. This intervention, if up-scaled, will help improve handling and processing of fish in other landing sites. It will subsequently enhance the shelf-life of fish, reduce post-harvest losses, contribute to food security, increased income and improved livelihoods of coastal communities.

The first part of the SolCoolDry system consists of a 15 kWp photovoltaic system that feeds electricity into a three-phase, battery-supported, stand-alone grid, which is used to power the ice machine and ice collection unit. A maximum of 700 kilograms of ice can be produced within 24 hours. Excess solar power is fed into batteries with a total storage capacity of 19.2 kWh. The second part the SolCoolDry system has two solar tunnel dryers in which air is heated and distributed by fans over the drying goods throughout the day. In order to be able to continue drying throughout the night, one of the tunnel dryers contains heating pipes. These are supplied with heat from a 12 m^2 flat-plate collector and a 2,000 L hot water storage tank.

The SolCoolDry Workshop and Technology Day

The climax of the SolCoolDry project was the Workshop and Technology Day which had one pre-workshop activity, a workshop on the 7th of February 2023 at KMFRI and the open day and launch of the SolCoolDry system on the 8th of February 2023 at Mwazaro in Kwale County.

Figure 2. The SolCoolDry system installed at Mwazaro in Kwale County, Kenya (Source: K'Osambo L.).

2. PRE-WORKSHOP ACTIVITIES

By Morine Mukami and Winnie Jefwa

Planning of the SolCoolDry Workshop and Technology Day

Planning meetings for the workshop were conducted online in December 2022, immediately after the completion of the SolCoolDry system installation. Two main committees, the organizing and drafting committees, were formed comprising technical experts in different fields to ensure the successful implementation of the Workshop and Technology Day. The teams comprising the committees were drawn from Kenyan partner institutions, i.e., KMFRI, KIRDI and TUM. The organizing committee (Annex VII) developed the workshop programme, call for abstracts, exhibits and posters and invited the relevant stakeholders and presenters. The drafting committee, whose members were mainly drawn from KMFRI, was formed a few weeks before the workshop in preparation for the compilation of the information necessary for developing the workshop proceedings.

Training of fish processors and traders

A week before the SolCoolDry workshop, experts from KMFRI, Mombasa, conducted a capacity-building program on 28th January and 31st January 2023 at the Mwazaro BMU site. Six fried fish processors (*Mama Karanga*) from Shimoni, Mwazaro, Fikirini and Kanana areas underwent the two-day training.

The objective of the workshop was to train the processors on: (i) identification of critical points in post-harvest fish handling where contamination and spoilage of fish occur; (ii) fish preservation techniques to reduce post-harvest losses and (iii) fish value addition to produce safe, high-quality fish products that meet consumer preferences while increasing the profitability of artisanal fish processing.

A theoretical training session (Fig. 3) was conducted on the first day, covering relevant topics including good fish handling practices, with an emphasis on hygiene and sanitation requirements at the fish processing site, food handlers, and food contact surfaces to prevent introduction of hazards along the fish processing line. The trainees were also introduced to best practices in the mitigation of fish post-harvest losses through application of preservation techniques such as solar drying, salting, freezing, chilling and smoking.

Practical sessions (Fig 4.) proceeded on the second day, where demonstrations of the theory were done. The trainees underwent a hands-on session on fish filleting and the production of fish fingers to enable the *Mama Karanga* diver-

Figure 3. Theoretical training of *Mama Karanga* on best practices in fish handling and value addition conducted by Winnied Jefwa from KMFRI at Mwazaro in Kwale County, Kenya (Source: Marigu J.).

Figure 4. Practical training of fish processors on fish value addition conducted at Mwazaro in Kwale County, Kenya, by Maureen Kinyua (standing far right) **and Winnie Jefwa** (bending) **from KMFRI** (Source: Marigu J.)**.**

sity their product range and thus improve their profit margins. It was expected that the fish processors would apply the acquired knowledge and skills to improve on fish handling practices thus contributing towards the reduction of post-harvest losses along the fried fish value chain and eventually increase their income due to production and sale of high quality value-added fish products. With the introduction of the SolCoolDry system, the skills acquired by the processors would enable them maximize on the productivity of the system through acquisition of for preservation of fresh fish and proper handling of fish processed using the system.

Moving forward, the SolCoolDry project team aims at capacity building more fish value chain actors (fishermen, seaweed farmers, processors and traders) on fish handling, preservation and value addition using the SolCoolDry system available at Mwazaro.

Call for poster presentations, oral presentations and exhibits

In January 2023, the organizing committee made a call for submission of abstracts, posters and exhibits (Fig. 5) by experts conducting research on climate-smart technologies in food preservation and value addition.

The submissions of posters (Annex 1) and exhibits (Table 1) were received from KMFRI, KIRDI, TUM and community members and harmonized into key thematic areas, while abstracts were received from Kenyan and German project partners as well as other researchers for oral presentations made during the workshop held at KMFRI (Annex II). 15 posters, 22 exhibits and 10 presentations were featured during the SolCoolDry Workshop and Technology Day.

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

Fraunhofer ISE

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

Project manager Federal Office for Agriculture and Food

INNOTECH Ingenieursgesellschaft mbH

SolCoolDry Workshop, Technology and Innovation Open Day

Call for Papers, Posters and Exhibits

BACKGROUND: Solar Cooling and Drying (SolCoolDry) research consortium will host a dual Workshop and Technology Open Day in Mombasa and Kwale from 7th-8th February 2023. The events will be hosted at the SolCoolDry technology site at Mwazaro in Kwale and KMFRI in Mombasa counties. The events will mark the official launch of SolCoolDry Innovation Hub.

CALL: You are invited to submit papers, posters and/or exhibits that showcase renewable energy-powered food processing technologies and sustainable utilization of Blue resources under the Workshop theme.

WORKSHOP THEME: *Fostering green innovations and use of renewable energy for food security, employment and Blue Economy empowerment of grassroot communities in Kenya.*

IMPORTANT DATES:

- **10/01/2023:** – Call for papers, posters and exhibits.
- **20/01/2023:** – Deadline for submission of papers, posters and sketches of exhibits
- **25/01/2023:** – Selection of papers, presentations and exhibits for the Workshop and Technology Day
- **27/01/2023:** – Deadline for registrations and confirmations of attendance
- **31/01/2023:** - Sharing of the program for the Workshop and Technology Day
- **07-08/02/2023** - Workshop at KMFRI (Mombasa) and Technology Day at Mwazaro (Kwale)

For further information and submissions contact:
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Figure 5. Call for papers, posters and exhibits for the SolCoolDry Workshop and Technology Day.

3. THE SOLCOOLDRY WORKSHOP

By Maureen Kinyua, Derrick Gitari, Immaculate Kinyua and Peter Thuo

Overview of workshop events

The SolCoolDry Workshop was held at KMFRI, Mombasa on 7th February 2023. Following the arrival and registration of the guests drawn from different partner institutions, a brief poster session was conducted, where the guests appreciated research work relevant to the event's theme presented by different experts.

The Workshop then started with the opening session, chaired by Dr. Arthur Onyuka (KIRDI) and moderated by Dr. Peter Oduor-Odote (KMFRI), who welcomed all the guests and gave a brief introduction to the Workshop agenda and program (Annex III). Dr. Linus K'Osambo then gave a presentation on the background of the SolCoolDry project and partnerships followed by Dr. James Mwaluma's opening and welcoming remarks on behalf of the Chief Executive Officer (CEO), KMFRI. He then declared the Workshop officially open at 10:20 am.

The first session of presentations, chaired by Mr. Thoya Maitha (TUM), started at 11:00 am, and consisted of oral presentations made by five scientists on the SolCoolDry project background, evolution of drying technologies and the research on the development of a Hazard Analysis Critical Control Points (HACCP) plan for the SolCoolDry site.

The afternoon session was a continuation of the oral presentations from five more scientists with Dr. Melckzedeck Osore acting as the session chair. The presentations revolved around the implementation of climate-smart technologies, using green energy, to enhance the sustainable exploitation of the Blue Economy. The session was concluded with a 20-minute plenary session where participants gave feedback on the event and suggested action points.

Sector analysis of workshop participants

The participants of the Workshop (Annex IV) were affiliated to a variety of institutions, with the host, KMFRI representing the highest proportion of attendees at 75%. Participants from local project partners, KIRDI and TUM, accounted for 13% and 3% respectively; while partners from Germany and media represented 3% and 4% respectively (Fig. 6a). Researchers drawn mainly from the partner institutions accounted for 35% of all participants followed closely by interns and technologists mainly from KMFRI, representing 29% and 14% respectively (Fig. 6b).

Youth participation accounted for an impressive 43% (Fig. 7a). The forum thus provided an ideal platform for young upcoming scientists to interact with and learn from experienced researchers on matters related to post-harvest loss mitigation using climate-smart technologies. In terms of gender, male attendees were the majority at the workshop at approximately 60% in comparison to their female counterparts (Fig. 7b). This is illustrative of the current status of the research landscape in Kenya, which is predominantly male-dominated.

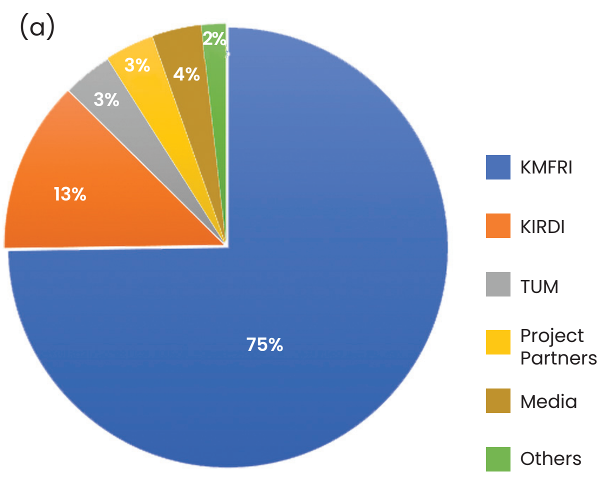


Figure 6a. Institutional affiliations of workshop attendees.

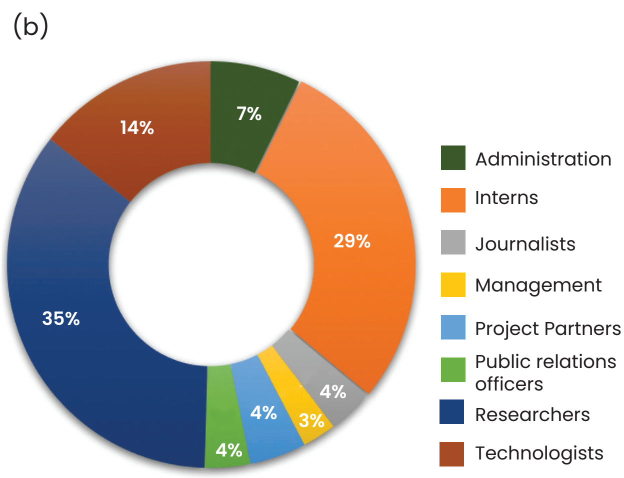


Figure 6b. Designations/roles of workshop participants.

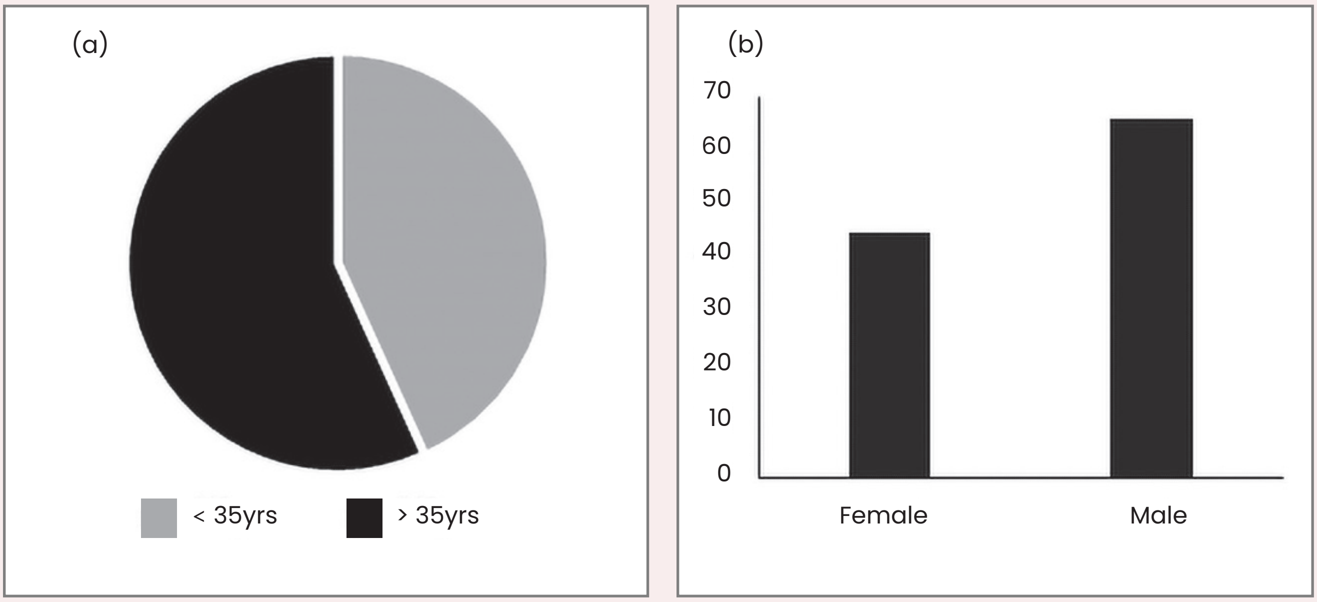


Figure 7. Disaggregation of the workshop participants by (a) age and (b) gender

OPENING SESSION

Welcome remarks and agenda by: **Dr. Peter Oduor-Odote**, *Principal Research Scientist, KMFRI*

SolCoolDry background and partnerships by: **Dr. Linus K'Osambo**, *PI, KIRDI*

SolCoolDry overview by: **Dr. Alexander Morgenstern**, *PI, Fraunhofer ISE*

TUM VC address by: **Dr. Hamisi Mwaguni**, *Assistant Registrar - PRI, TUM*

Opening remarks by: **Dr. (Ing.) Calvin Onyango**, *Director General, KIRDI*

Opening remarks and workshop flag-off by: **Dr. James Mwaluma**, *Director DOSC & BE, KMFRI*

Session Chair: **Dr. Arthur Onyuka** *(KIRDI)*

Session Rapporteur: **Dr. George Wanjala** *(KIRDI)*

Dr. Peter Oduor-Odote, a Principal Research Scientist at KMFRI kick-started the session with a brief introduction to the workshop agenda and program. He then invited the SolCoolDry PI from KIRDI and Kenyan team leader, Dr. Linus K'Osambo who started off the program by welcoming all the guests and giving an overview of the SolCoolDry project. He highlighted the post-harvest loss challenges that necessitated the development of a climate-smart fish preservation and processing technology to reduce the losses. He introduced the main project partners drawn from KIRDI, KMFRI, TUM, Fraunhofer ISE and INNOTECH and welcomed the institutional leaders to introduce their respective team members and give their remarks.

The Director General, KIRDI, Dr. Ing. Calvin Onyango, highlighted the mandate of the Institute, which is responsible for conducting research, development, and innovation in industrial and related technologies and disseminating findings to support industrial development. KIRDI conducts research and development in diverse fields, including civil engineering, mechanical engineering, electrical engineering, and food technology, among others. The Institute also has a network of pilot sites throughout Kenya which serve as platforms for technology incubation and feedback acquisition on emerging technological needs. KIRDI is a strategic partner for institutions seeking to develop locally-adapted technological solutions to address societal challenges.

Dr. Ing. Onyango explained that the SolCoolDry Project, which aims to introduce a technology package for 100% off-grid, solar-powered cooling and drying to improve fish quality, was supported by KIRDI in consortium building, system importation, installation, HACCP system development, and project coordination, among other areas. He also mentioned that the project will have a significant impact on the post-harvest handling of fish and reduction of losses, thereby improving food security among the technology recipients. The SolCoolDry Research, Innovation, and Business Hub will be a significant element in the envisaged industrial parks, and it is relevant to the government's "Bottom-up" approach to development. He concluded his speech by reiterating that the Blue Economy sector is endowed with huge potential for capture fisheries and aquaculture of fish and seaweeds, which can address food insecurity, and KIRDI plays a significant role in driving the manufacturing sector through technology development and transfer.

Dr. Alexander Morgenstern of Fraunhofer ISE, Germany, gave an overview of the SolCoolDry system. He highlighted that the solar thermal drying and cooling system design consists of solar thermal collectors, ice machines, an ice collection unit, plate collectors, solar thermal dryer and sensors (for controlling and monitoring temperatures and humidity and data transfer). He explained the process that was involved in setting up the system at Mwazaro in Kwale County and expressed optimism that the system would add significant value to the community.

The TUM representative, Dr. Hamisi Mwaguni, gave the Vice Chancellor, Prof Laila Abubakar's remarks in which she appreciated all the partners and collaborators for the hard work, commitment and determination to make the SolCoolDry project a success. She highlighted that Kenya faces food insecurity, attributed to frequent droughts, high cost of food production, high post-harvest losses, high global food prices and low purchasing power for a large proportion of the population. He then explained that the SolCoolDry project technology package is designed to reduce the time taken for fish drying and preservation. Fish cooling and drying will enable fisherfolk to reduce post-harvest losses and provide fish to local and national consumers throughout the year, with higher quality and longer shelf-life dried products for better livelihoods. She concluded by stating that as a university and partner to the innovative project, TUM was committed to offering tailor-made short courses that will help community members in Mwazaro acquire the requisite skills for maintaining the system to ensure its sustainability.

Dr. James Mwaluma, the Director, Ocean and Coastal Systems and Blue Economy, KMFRI and SolCoolDry project PI gave opening remarks, on behalf of KMFRI CEO, Prof. James Njiru. He began by appreciating the dignitaries and workshop attendees present. He then expressed concern about the decline in fish stocks and high post-harvest losses, which threaten food and income security. The issue of post-harvest losses is particularly problematic in the coastal areas of Kenya during peak landings when unfavourable weather conditions also hinder traditional sun-drying. He explained that to combat this challenge, KMFRI partnered with KIRDI, TUM, INNOTECH and Fraunhofer ISE to develop the SolCoolDry system, which utilizes solar-driven cooling & drying, energy storage materials, and food processing technologies for fish preservation and value addition. In addition, KMFRI believes that this innovative approach will introduce new technology to local communities and improve their livelihoods. He concluded that the Institute is committed to supporting technology transfer to local communities and hopes to replicate the success of the project in other counties with significant fishing activity, such as Tana River, Kipini, and Vanga.

PRESENTATIONS SESSION 1

Session Chair: **Mr. Thoya Maitha** (*TUM*)

Session Rapporteur: **Mr. Kassim Ziro** (*TUM*)

SolCoolDry Research, Innovation & Business Hub: - Installation and recommendations for processes engineering for sustainability

Dr. Linus K'Osambo, a Senior Research Scientist, KIRDI PI and coordinator of the Kenyan SolCoolDry project team gave an overview of the Mwazaro BMU self-help group, its composition and the activities undertaken by the group. He expounded on the background of the SolCoolDry project, including its justification based on the high post-harvest losses encountered by the artisanal fisherfolk, site selection for the project, material purchase & delivery and installation of the system. He shed light on the importance of the SolCoolDry system as a Research, Innovation and Business hub for the Mwazaro community and the Blue Economy in Kenya. From his presentation, he stated that the SolCoolDry hub would be important for several functions including production of ice for fish preservation, fish handling and processing, drying and packaging; an outdoor recreational space; onsite research, training and educational tourism platform; leveraging local innovations and resources; marketing of value added products and promotion of the sustainable exploitation of the Blue economy.

Solar ice production and drying in an off-grid system in Mwazaro, Kenya – Project review

Dr. Alexander Morgenstern from Fraunhofer ISE, Germany commenced by giving a brief history of the project idea and system design. He explained that the initial idea of the project focused on the cooling and drying of mangoes due to their high demand in the export market. However, cooling and drying of fish was adopted later owing to its higher nutritional value and reliance on fishing as a main livelihood for local coastal communities in Kenya. He described the operation of the system, including how the system makes use of off-grid power supply by utilizing solar energy and how the components of the system work together to dry fish & farm produce and generate ice flakes for chilling of fresh fish. Dr. Morgenstern highlighted the preparative work done in Germany leading up to the setup of the SolCoolDry system in Kenya, emphasizing that the materials used to fabricate the system were of the best quality to ensure the longevity of the system. He mentioned that this might have contributed to the relatively high cost incurred in setting up the system and advised that for subsequent projects, modifications could be made to accommodate budgetary constraints, while maintaining high quality of materials. In addition, he shared some of the shortcomings experienced during the implementation phase and how a test setup enabled the team to identify and troubleshoot challenges during installation of the system. Finally, he expressed confidence that the SolCoolDry system would benefit the local community at Mwazaro and its environs by improving their livelihoods and reducing post-harvest losses.

The evolution of dry chain technologies in Kenya

Dr. Peter Oduor-Odote, a Principal Research Scientist from KMFRI and project co-PI highlighted the cold chain preservation technologies and gave an indepth account of the fish preservation technologies, namely fish smoking, fish frying and fish drying used by artisanal fishermen and fish traders at the Kenya coast. He explained that over the years, KMFRI has developed a variety of climate-smart innovations to support different fish value chains in the reduction of post-harvest losses. These include improved fish smoking ovens with higher production capacity and less fuelwood consumption to reduce the carbon footprint, while enabling the production of high quality smoked fish. He, however, emphasized that more research is required on the variation of size of the smoking oven and the smoking time in order to maintain optimal fish quality. He then highlighted the improved fried fish display boxes used by fried fish traders (*Mama Karanga*) which consists of a food-safe display shelf which is lit using a solar-powered lamp. Dr. Oduor-Odote explained that the innovation has reduced the exposure of fried fish to contaminants and lowered the incidences of respiratory health conditions among the female traders while mitigating against climate change by eliminating the use of the conventional kerosene lamps (*korobois*) used for lighting. He also gave an overview of improved drying technologies innovated by KMFRI researchers such as rack dryers, solar dryers, solar tunnel dryers and the hybrid windmill solar tunnel dryer. The hybrid dryer is designed to dry to dry during damp weather conditions, produce ice and generate electricity for use in the neigbhourhood. These innovations have improved the dried fish value chain and significantly contributed towards the production of high quality dried fish products by artisanal coastal communities. He concluded that these innovations are evidence of the strides that have been made in post-harvest technologies research in Kenya and provide support in other areas where the SolCoolDry system is yet to be installed.

Future perspectives of drying

Dr. Ing. Albert Esper from INNOTECH, Germany gave an overview of his organization and stated that it acts as a link between universities, research institutions and practical application. He explained that INNOTECH is one of the companies worldwide leading in the utilization of renewable energy for food processing, including rolling out dryers powered by solar energy. He went ahead to explain how Artificial Intelligence (AI) and the Internet of Things (IoT) have been embraced and incorporated in some of the drying equipment to ease monitoring and data collection.

Situational analysis on establishment of a Hazard Analysis and Critical Control Point (HACCP) plan for the SolCoolDry fish processing facility at Mwazaro Beach Management Unit self help group

Dr. George Wanjala, a Senior Research Scientist from KIRDI, explained that HACCP is a systematic approach to the identification, assessment and control of hazards in food operations. He gave a brief overview of the recommended procedures for conducting an HACCP analysis and the prerequisite programs. Dr. Wanjala then described the methodology for the development of a HACCP plan for the SolCoolDry fish handling and processing facility at Mwazaro. He explained that an assessment on fish sourcing, handling and processing had been done at five landing sites in Kwale County i.e., Kibuyuni, Kijiweni, Bati, Gazi and Shimoni.

He reported that the focus of the intervention for the first four sites was to enhance safety and quality of fish from capture, at the landing sites and delivery to market while at Shimoni landing site the intervention's focus was to enhance hygienic practices, repair of facilities, and capacity development of personnel. He argued that according to the study findings, there were significant food safety risks in the fish handling and processing value chain, with most landing sites lacking basic preservation and handling facilities. Additionally, capacity gaps among fishermen and traders on basic food safety further exacerbate the risks. However, he stated that the development and implementation of the HACCP plan for the SolCoolDry site at the Mwazaro BMU would serve as a model for the development of the same in other landing sites along the coast of Kenya.

The PowerPoint presentations of all the oral presentations made during the first session are annexed to this document (Annex II).

PRESENTATIONS SESSION 2

Session Chair: **Dr. Melckzedeck Osore** (*KMFRI*)

Session Rapporteur: **Dr. George Wanjala** (*KIRDI*)

KIRDI fostering industrial research in the Blue Economy: - Opportunities and perspectives in the new horizon

Dr. Linus K'Osambo of KIRDI commenced his presentation by stating that Kenya has a huge potential in the Blue Economy, considering the underexploited resources present in the country's Exclusive Economic Zone (EEZ). He explained that products such as seaweeds have multiple uses, from food to cosmetic and pharmacological applications. Other materials like fish skin could also be used in the tanning industry to produce leather products. On the other hand, products like algae can be used to generate energy and manufacture fertilizers. He stated that KIRDI has been actively involved in contributing towards the sustainable exploitation of the Blue Economy through the design and fabrication of marine cages that are used for Integrated Multi-Trophic Aquaculture (IMTA) of seaweed and fish farming. In addition, KIRDI has contributed towards the establishment of the Kibuyuni seaweed processing facility and trained the seaweed farmers in value addition of seaweed into a variety of products for improved livelihoods. He finalized by highlighting some research projects and development initiatives including Co-Marifish project, SolCoolDry project, Sea-Fort project and Blue-Empowerment project which have all been implemented by KIRDI to improve the livelihoods of coastal communities and enhance food & nutritional security in Kenya.

Seaweed- and sweet potato-based nutritious food alternatives for sustainable food systems in Kenya and Indonesia through solar powered innovations (NUTRI-KI)

Dr. Marcus Schmidt of the Max Rubner-Institut in Germany gave a brief overview of the Institute and its structure. He explained about an ongoing pilot plant project that focuses on processing of French fries and sweet potato crisps for the production of high quality products. The resultant products are passed through a series of tests including organoleptic testing to ensure they meet the required standards for human consumption before they are packaged for sale. He highlighted the key projects that MRI is currently running and those that are already completed. He also explained some improvements that have been made on sweet potato frying equipment, including the use of a vacuum fryer. He argued that such improved technologies are highly suitable for frying sugar-rich fruits and vegetables, unlike traditional ways of frying that usually leads to browning of the end-products, rendering them organoleptically unacceptable. He stated that such vacuum fryers reduce the oil absorption rate of potato chips significantly as compared to traditional frying. As a way of reducing wastage in the processing plant, Dr. Schmidt concluded by highlighting the utilization of side streams from sweet potatoes and seaweed where by-products from sweet potato and seaweed wastes are re-introduced into the plant and upcycled into finished products.

Renewable Energy and Climate Change Research Center at the Technical University of Mombasa

Mr. Thoya Maitha gave a presentation on behalf of **Dr. Huxley Makonde,** a Senior Lecturer and Dean, School of Health and Applied Sciences at TUM. He gave a brief overview of the University's Renewable Energy and Climate Change Research Centre, its vision and objectives. He explained that the Centre is currently running a research project about a hybrid solar-assisted biogas production plant that seeks to supply green and clean energy to the University's kitchen. He stated that the purpose of the thermosyphonic solar water heater in place is to utilize the solar energy to heat water for use in the University's kitchen. This reduces the cooking time by over 50%. Dr. Huxley's presentation was an illustration of the diverse sources of renewable energy that are being explored through the innovation of climate-smart technologies to reduce the carbon footprint, while reducing overheads associated with the use of conventional sources of energy.

Techno-economic assessment of a hybrid solar-biogas system to mitigate environmental impact of cooking with fossil fuels at the Technical University of Mombasa kitchen

Mr. Thoya Maitha, a Teaching Assistant and Researcher from TUM presented highlights on a project utilizing biogas at the University and stated that it is a collaborative project between TUM and Hasselt University, Belgium, funded by the VLIR-UOS South-South Initiative. He stated that the main objective of the project was to design, model, simulate and construct a green energy cooking system consisting of a hybrid solar production system coupled with a solar water heating system for generation of energy required for cooking in the university's kitchen. The objectives of the project included conducting a technological and ecological analysis of the system based the Life Cycle Assessment (LCA) method and performing an economic assessment of the system using the Discounted Cash Flow (DCF) micro-economic assessment method.

Mr. Thoya explained that the shift from using fossil fuels to adopting biogas in the University's kitchen was due to the unhealthy soot, expensive costs and environmental impacts that come with the use of firewood and coal. The findings of the DCF analysis projected savings of up to 45.56% when biogas is used in comparison to fossil fuels; while the Net Present Value (NPV) analysis projected economic profitability of approximately 120%. In the LCA analysis, Mr. Thoya projected that an energy saving of 45.36% and a forest cover saving of 55.56% would be achieved. He stated that the average payback period of the project is six years, making it a worthwhile investment, considering that the average lifespan of the system is 25 years. He recommended the use of such a system in learning institutions as it is a worthwhile economic and ecological investment.

Profiling the status of direct SolCoolDry technology recipients in Kwale County, Kenya and their perspectives on fish preservation technologies

Ms. Morine Mukami and Ms. Josephine Marigu of KMFRI gave an overview and preliminary results of a study conducted in Kwale County in January 2023. The study aimed at understanding the status of the direct recipients of the SolCoolDry technology, evaluating the production potential of raw resources and obtaining feedback from the locals who have utilized the system and their perspectives. Ms. Mukami explained that the study used questionnaires for collection of data in Gazi, Shimoni, Mwazaro and Kibuyuni

According to the preliminary results, it was established that the technology recipients were mainly organized into Beach Management Units (BMUs) and several other community groups that are actively involved in capture fisheries and aquaculture. It was reported that 62.5% of the recipients use community-owned land/fishing grounds. The recipients of the SolCoolDry system acknowledged that the system has played an important role in preservation of their products, due to the ease of access to and constant availability of ice.

However, Ms. Josephine stated that the system also had its shortcomings, which include inadequate drying racks especially when the products such as sardines and seaweeds are harvested in bulk. The price of ice was also seen to be prohibitive and the recipients proposed a reduced price of KES 6-7 per kg from the current KES 10 per kg. The recipients suggested the introduction of similar systems in multiple landing sites in the region as this would help reduce the significant post-harvest losses experienced during transportation of fresh products from areas further away from the system. It was recommended that there should be increased capacity building for the direct technology recipients of the SolCoolDry system to ensure the project's sustainability. Sensitization was also encouraged as a way of creating awareness of the presence of the SolCoolDry innovation and increasing the uptake of the technology by local communities within the region.

PowerPoint presentations of all the oral presentations made during the second session are annexed to this document (Annex II).

PLENARY SESSION

Session Chair: **Dr. Melckzedeck Osore** (*KMFRI*)

Feedback analysis and comments

In the plenary sessions, participants aired their views on the way forward to ensure the sustainability of the SolCoolDry system beyond the project lifetime. The main suggestions raised were: -

- Continuous capacity-building of the local community in Mwazaro on the use and maintenance of the facility;
- Diversification in the use of the system beyond drying of fish products to include value addition of crop produce for enhanced food security and livelihood improvement;
- Ensure direct involvement of the community members in the day-to-day running of the facility to foster a sense of ownership of the system, which will guarantee proper stewardship;
- Involve a broader variety of stakeholders such as county governments in the planning and implementation of subsequent phases of the SolCoolDry project for the achievement of a greater impact;
- Involve communities in such forums where research outputs are being discussed since they are the direct users of the information being disseminated, hence it would be very beneficial to them;
- Translate the project information into the local Kiswahili language to ensure consumption of the findings by the user communities and increase awareness on all project activities;
- Encourage small and medium enterprises to adopt the developed technologies since it benefits more people than when done on a larger commercial scale;
- Build capacity for utilization of green energy in coastal towns and local areas to reduce Greenhouse Gas (GHG) emissions and mitigate against climate change.

Dr. Osore, the Chief Editor of Kenya Aquatica, mentioned that a special edition of the Kenya Aquatica Journal covering the Workshop Proceedings would be published.

Dr. Nina, the Assistant Director of the Marine Fisheries Research Department in KMFRI encouraged the workshop attendees to join the Western Indian Ocean Marine Science Association (WIOMSA), which consists of a wide network of professionals undertaking marine research in the Western Indian Ocean (WIO) region.

Dr. Mwaluma thanked the participants for their active participation in the workshop and declared the workshop closed. A closing prayer was then led by Mr. Alexander Fulanda of KMFRI.

Figure 8. A cross-section of posters illustrating the various aspects of SolCoolDry project and other climate-smart innovations presented during the Technology Day held at Mwazaro Grounds, Kwale County (Source: Dr. Osore M.).

Poster session

During the workshop, stakeholders including KMFRI, KIRDI and TUM were invited to present the results of relevant research inform of posters. All poster presentations highlighted research-based innovations which contribute towards the improved livelihoods of coastal communities, in line with the theme of the Workshop *"Fostering green innovations and use of renewable energy for food security, employment and Blue Economy empowerment of grassroot communities in Kenya"*. The posters highlighted the themes, background information, results and recommendations of each study. A total of fifteen posters were displayed, illustrating research conducted to develop diverse technologies geared towards improving livelihoods and enhancing food security, particularly among coastal communities. The key thematic areas that were presented in the poster sessions were:

- Climate-smart innovations designed to mitigate against post-harvest losses particularly among artisanal fishermen and fish processors. These included the improved fried fish display box and the hybrid windmill solar tunnel dryer. The improved box reduces contamination of fried fish and lowers the carbon footprint by replacing the conventional kerosene lamp used for lighting with a solar-powered lamp. The hybrid dryer utilizes green, renewable energy to power fish preservation by drying and ice production.
- Sustainable aquaculture techniques to maximize on the benefits of the Blue Economy through production of alternative insect-based feeds and capacity building of communities on the best practices in mariculture.
- Green energy production and utilization to reduce carbon emissions while using food waste in a total utilization concept model. Here biogas production and solar energy technologies were featured by different presenters.
- The design of the SolCoolDry system and its applications in fish value addition and preservation; drying of fish and vegetables and production of ice for fish preservation.

All the presented posters are appended to this document (Annex I).

Figure 9. Dr. Linus K'Osambo from KIRDI (a) and Mr. Raymond Ruwa from KMFRI (b) explain concepts presented in their respective posters displayed during the Technology Day at Mwazaro (Source: Anne A.).

4. TECHNOLOGY DAY

By Josephine Marigu & Winnie Jefwa

Session 1 : Arrival and registration of guests

The SolCoolDry Technology Day was held on 8th February 2023, at the SolCoolDry system site in Mwazaro, Kwale County. The guests arrived from 8.00 am, registered and proceeded to view the posters (Annex I) and exhibits (Table 1) displayed by KIRDI, TUM, KMFRI and community members from Mwazaro, Shimoni, Gazi and Kibuyuni (Fig. 10).

Session 2 : Introduction and opening remarks

Several representatives of the project partners gave their opening remarks to kick-start the event (Fig. 11). KIRDI PI and coordinator of the Kenyan SolCoolDry project team, Dr. Linus K'Osambo officially opened the event by welcoming all the guests and giving an overview of the SolCoolDry project. He highlighted the post-harvest challenges that necessitated the development of the climate-smart fish preservation and processing innovation to reduce the losses. He introduced the main project partners who were drawn from KIRDI, KMFRI, TUM, Fraunhofer ISE and

Figure 10. Community members drawn from Mwazaro and adjacent communities participate in the Technology Day held at Mwazaro in Kwale County (Source: Anne A.).

Figure 11. Representatives of local and German project partners give their welcoming remarks and introduce their teams during the Technology Day held at Mwazaro in Kwale County. From top left, (a). Dr. Mwaluma J. (KMFRI); (b). Dr. Ing. Calvin Onyango (KIRDI); (c). Eng. Lucy M. (KIRDI, BoM member; (d). Dr. Hamisi Mwaguni (TUM); (e). Dr. Linus K'Osambo (KMFRI) and (f). Dr. Alexander Morgenstern (Franhoufer ISE) (Source: Anne A.).

Figure 12. Dr. Alexander Morgenstern (with microphone) gives distinguished guests and event attendees a guided tour of the SolCoolDry system at Mwazaro during the Technology Day (Source: Anne A.)

INNOTECH. Thereafter, he invited each institutional leader to introduce their respective team members and give their remarks. Dr. Alexander Morgenstern, the overall Project Coordinator, gave an overview of the SolCoolDry equipment assembly and installation process. Dr. Alexander highlighted the technical components of the system, detailing the process that was involved in designing the system, fabricating the different components, importing the equipment and assembly at the site. He mentioned that the system had been fabricated using the materials of the highest quality and optimized based on the Kenyan conditions to ensure efficiency in its functionality and guarantee its longevity.

Representatives of the local SolCoolDry partner institutions and local administrations gave brief remarks in which they appreciated the project implementers and urged the community members to take full ownership of the SolCoolDry system and ensure its success beyond the project's lifetime. Dr. Arthur Onyuka (KIRDI) and Dr. Hamisi Mwaguni (TUM) reiterated that their institutions are committed to capacity-building the community members on basic skills that will enable them to effectively operate and maintain the system. The DCC, Kwale County, Mr. Alexander Mativo finalized by urging the development partners to consider setting up similar projects in other areas within the country that have conducive environments and are impacted by significant post-harvest losses.

Session 3 : Guided tour of the SolCoolDry system

The project team from Germany led by Dr. Alex ander Morgenstern gave a guided tour of the SolCoolDry system to the Chief Guest and other distinguished guests (Fig. 12). The experts described the design and operation of the three main components of the system *viz.*, the solar power harnessing and storage system, the tunnel dryers and the ice production and storage unit. Dr. K'Osambo then highlighted the Public-Private Partnership (PPP) framework and how diverse partnerships had been leveraged to work towards the development of the research-based innovation and production of high quality, market-ready, value-added products using the climate-smart system for reduction of post-harvest losses and improvement of livelihoods.

Session 4- Guided tour of other exhibits

After the detailed tour of the SolCoolDry system, the guests were guided through the exhibition area where tangible products obtained from the SolCoolDry system were displayed together with other related value-added products and exhibits

Table 1. Exhibits displayed by different participants during the technology day held at Mwazaro in Kwale County

Thematic area	Nature of exhibits	Exhibitor
Post-harvest loss reduction in crops	Dried mangoes	KIRDI
	Dried, shredded coconut	
	Dried, shredded sweet potatoes	
	Virgin coconut oil	
	Seaweed, amaranth and wheat bread	
	Seaweed and amaranth cookies	
	Seaweed and millet cookies	
Post-harvest loss reduction in fisheries	Dried fish	Mwazaro BMU
	Dried seaweed	Kibuyuni seaweed farmers
Climate-smart innovations	Improved *Mama karanga* box	KMFRI
	Hybrid wind solar tunnel dryer model	
	Drying racks models	
	Dome dryer model	
	Light-weight, insulated cold-chain container	
Value addition in fish and seaweed.	Fish value added products (fish fillet, fish fingers and fish kebabs)	
	Seaweed value added products (shampoo, shower gel, lotion, soap)	Kibuyuni seaweed farmers
Biowaste treatment for sustainable fish feed production.	Black soldier fly farming.	KMFRI
Fish feed formulation	Fish feed formulation	

presented by different institutions and community members (Table 1). Two community groups presented their exhibits in line with the event's theme, *"Fostering green innovations and use of renewable energy for food security, employment and Blue Economy empowerment of grassroot communities in Kenya"*. Kibuyuni seaweed farmers showcased a community-based seaweed value chain, from farming to value addition for production of diverse products including soap, lotion, shower gel and hair food from dried seaweed. Fish processors from Mwazaro exhibited fish and agricultural produce dried using the SolCoolDry system at Mwazaro. The exhibits presented by community members illustrated the direct role that research-based technologies and innovations have played in contributing towards the sustainable exploitation of Blue resources to improve community livelihoods and enhance food security.

KIRDI and KMFRI exhibited a variety of climate-smart innovations designed to mitigate post-harvest losses in fisheries and agricultural value chains and ensure the production of quality products. KIRDI researchers displayed a wide variety of value-added products developed using the SolCoolDry system, including fish products and plant produce (including mangoes, sweet potatoes, pineapples, cassava and coconuts), value-added baked products such as cakes and cookies made from seaweed and oil extracted from fish and coconuts (Fig.13). These exhibits illustrated the system's potential to enable the diversification of the fish and agricultural product-range for food security and livelihood improvement of coastal communities.

The KMFRI research team showcased a variety of relevant exhibits aligning with the theme (Fig. 14). These included innovations such as an af-

Figure 13. Scientists and technical staff from KIRDI exhibit a wide variety of value added products developed using the Sol-CoolDry system to distinguished guests and attendees during the Technology Day at Mwazaro, Kwale County (Source: Anne. A)

fordable, lightweight, insulated cold-chain container for storing ice used for fish preservation and the *Mama Karanga* box, an improved, food-safe, fried fish display shelf designed for fried fish processors to reduce post-harvest losses in the fried fish value chain. The improved shelf also includes a solar-powered lamp, which replaces the kerosene lamp, which is conventionally used by the processors for lighting. It, therefore, also reduces the carbon footprint associated with burning kerosene. KMFRI also exhibited models of climate-smart post-harvest technologies (Fig. 14) used in the dried fish value chain including drying racks for the sardines and seaweeds. A model of the hybrid windmill solar tunnel dryer which utilizes wind and solar energy to dry fish and farm produce, generate ice and provide electricity for adjacent homesteads was also exhibited. The KMFRI mariculture team demonstrated black soldier fly breeding to produce an alternative protein source for the formulation of affordable aqua feed and to manage biowaste.

These processing and preservation technologies displayed the capacity present within Kenya's research and academic platforms to design climate-smart innovations for improved food security and socio-economic development.

Session 5 – Official launch

A brief session of speeches presented by representatives of the project partners preceded the official launch of the SolCoolDry Research, Innovation and Business Hub. Representing the KMFRI CEO, Dr. James Mwaluma (DOCS & BE, KMFRI) lauded the project partners for the collaboration and cooperation throughout the implementation of the project and urged the community to take advantage of the innovation to improve the

Figure 14. Researchers and technical staff from KMFRI showcase a variety of exhibits on different post-harvest mitigation technologies developed by the Institute and value added seaweed products developed by communities in Kibuyuni with the technical support from KIRDI and KMFRI (Source: Phionalorna N.).

preservation and processing of fish and agricultural products. Dr. Mwaluma then invited Dr. Ing. Calvin Onyango, the DG, KIRDI, who commented on the benefit of integrating research and innovation into the process of developing tangible solutions to address the many challenges that affect the artisanal fish and agricultural value chains. He invited Eng. Lucy Wanjiku Mutinda, the Chief Guest and a member of the KIRDI Board of Management, who emphasized on the need for the local community to empower the upcoming generation, particularly girls, through education to ensure sustainability of development projects such as the SolCoolDry system. She urged the community to empower their youth to develop solutions that will address future challenges. The representative of TUM, Dr. Hamisi Mwaguni read a speech prepared by the Vice Chancellor, TUM, Prof. Laila Abubakar. She reiterated the importance of education, particularly in Science, Technology, Engineering and Mathematics (STEM), in fostering commmunity development. She emphasized that the government was focused on providing affordable education for all Kenyans and therefore communities ought to take advantage of the available opportunities to ensure that their children are educated for guaranteed advancement of the society. Speaking on behalf of the Governor, Kwale County, the Deputy County Commissioner (DCC), Mr. Alexander Mativo appreciated all the partner institutions that had participated in the implementation of the project for the benefit of the local community. Taking note of the different Beach Management Units (BMUs) that were represented at the event, the DCC called upon the community members to own the project and utilize it to draw maximum benefit. With much pomp and excitement from all in attendance, Eng. Lucy Wanjiku Mutinda, in collaboration with Mr. Mativo unveilled the plaque and conducted the ribbon-cutting ceremony, symbolizing that the project had officially been launched (Fig. 15). This marked the conclusion of the event, at which point the guests left at their own pleasure after a brief vote of thanks from Dr. Peter Oduor-Odote and a closing prayer led by one of the community members.

Figure 15. Engineer Lucy Mutinda from KIRDI (left) and Mr. Alexander Mativo the DCC, Kwale County officially launch the SolCoolDry system with onlooking project partners and community members during the SolCoolDry Technology Day at Mwazaro (Source: Phionalorna N.).

5. MEDIA CONTRIBUTIONS AND STAKEHOLDER INTERVIEWS

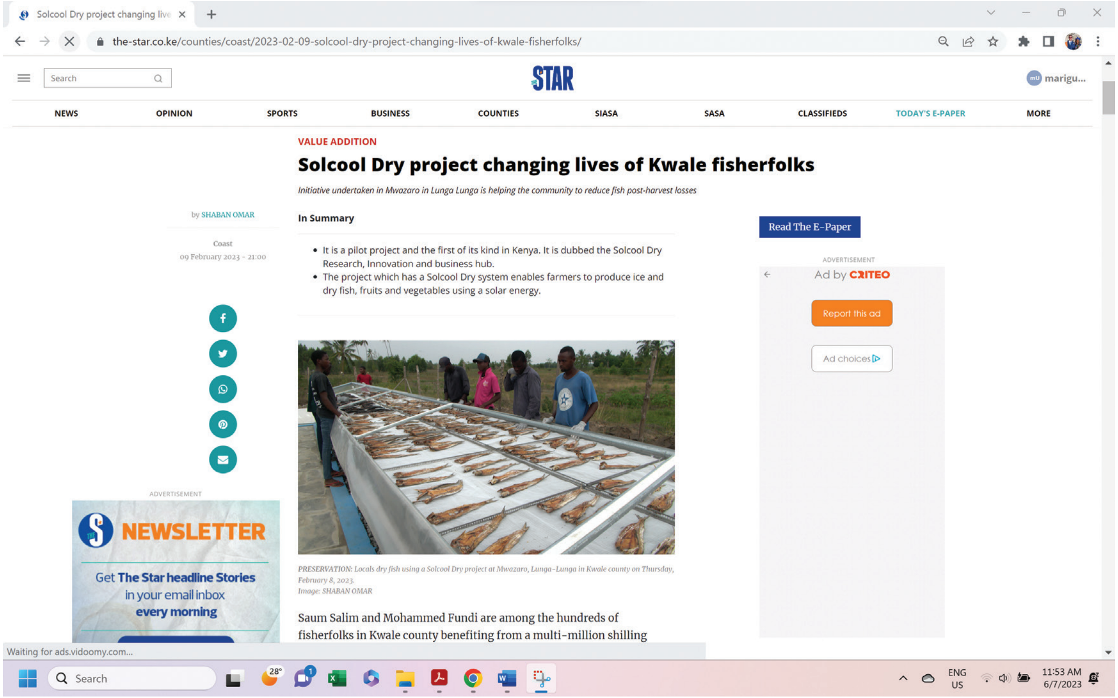
By Immaculate Kinyua, Maureen Kinyua and Josephine Marigu

Media coverage

The information from the SolCoolDry Workshop reached a wide audience through coverage by local media outlets which included Royal Media Services, the Standard Media Group and Mediamax Network. During a press conference held at KMFRI before the workshop, the key stakeholders emphasized on the benefits of the SolCoolDry project to the community, particularly in reducing post-harvest losses and promoting food security and livelihood improvement. In the electronic media, prominent broadcasters: Citizen TV, Kenya Television Network (KTN) and Radio Maisha gave an overview of the SolCoolDry project launch, covering the comments of Dr. Linus K'Osambo, Dr. James Mwaluma, Dr. Ing. Calvin Onyango, Eng. Lucy Wanjiku Mutinda and Dr. Alexander Morgenstern. They all emphasized the project's significance in reducing post-harvest losses and advancing the government's bottom-up development agenda which, aims to improve the livelihoods of communities at the grassroot levels through the sustainable exploitation of the Blue Economy (Fig. 16).

Fig. 16. Coverage of the SolCoolDry Technology by Citizen TV and KTN showing interviewed representatives of project partners giving their views on the expected impact of the project. From top left, clockwise, Eng. Lucy W. Mutinda (KIRDI), Dr. Alexander Morgenstern (Franhoufer ISE), Dr. Linus K'Osambo (KIRDI), Mr. Waihiga Mwaura (Citizen TV), Dr. Ing. Calvin Onyango (KIRDI) and Dr. James Mwaluma (KMFRI) (Source: https://twitter.com/citizentvkenya/status/1623037025342394378?t=Z_gSUlh5R2Gs3gfP4Y5pdQ&s=08 and https://www.youtube.com/watch?v=Dv6dFQYz2SQ)

Fig. 17. Coverage of the SolCoolDry Technology by Citizen TV and KTN showing interviewed representatives of project partners and community members giving their views on the expected impact of the project. From top left, clockwise, Ms. Salim Abdallah (Mwazaro BMU), Dr. Peter Oduor-Odote(KMFRI), Mr. Mshemanga Hamisi Riziki (Mwazaro BMU), Dr. James Mwaluma (KMFRI), Mr. Aloise Musyoka (K24)and Dr. Linus K'Osambo (KIRDI) (Source: https://www.youtube.com/watch?v=TFwmv28YN00).



VALUE ADDITION

Solcool Dry project changing lives of Kwale fisherfolks

Initiative undertaken in Mwazaro in Lunga Lunga is helping the community to reduce fish post-harvest losses

by SHABAN OMAR

Coast

09 February 2023 - 21:00

In Summary

- It is a pilot project and the first of its kind in Kenya. It is dubbed the Solcool Dry Research, Innovation and business hub.
- The project which has a Solcool Dry system enables farmers to produce ice and dry fish, fruits and vegetables using a solar energy.

PRESERVATION: Locals dry fish using a Solcool Dry project at Mwazaro, Lunga-Lunga in Kwale county on Thursday, February 8, 2023.
Image: SHABAN OMAR

Saum Salim and Mohammed Fundi are among the hundreds of fisherfolks in Kwale county benefiting from a multi-million shilling

Figure 18. Excerpt of The Star newspaper article on the SolCoolDry project, its background and impact on community members (Source: https://www.the-star.co.ke/counties/coast/2023-02-09-solcool-dry-project-changing-lives-of-kwale-fisherfolks/).

The Technology Day at Mwazaro received coverage from Citizen TV and K24, featuring interviews with various stakeholders including project partners and community members (Fig. 17). The partners primarily emphasized on the anticipated impact of the SolCoolDry system on the Mwazaro community and surrounding areas. They further elaborated on the challenges involved in post-harvest fish handling that necessitated the implementation of the project. Community members expressed great gratitude for the system and expressed optimism that its use would greatly enhance their livelihoods by adding significant value to their fish and agricultural value chains.

Comprehensive newspaper articles (Figure 18; Annex VI) were published by The Standard and The Star, providing detailed information on the background, implementation and potential impact of the SolCoolDry project on food security and economic empowerment of coastal communities.

Stakeholder interviews

1. Fishermen representative

Mr. Mshemanga Hamisi Riziki (Fig. 19), a fisherman who also doubles as the Project Coordinator at the Mwazaro BMU expressed appreciation for the installation of the one-of-a-kind SolCoolDry system at Mwazaro by the partners from Germany and Kenya.

> *Tuna imani kuwa tumepata bahati kubwa, bahati adimu ambayo haijapata watu wengine Pwani na Kenya. Tumepata mtambo huu wa kwanza wa aina yake Kenya. We feel so much priviledged. Huu mradi umetuodolea dharubu za kula samaki ambao wameoza.*
>
> **Translation:** *The Mwazaro community feels so privileged to host the SolCoolDry system, which is the first innovation of its kind at the Coast and in Kenya. Thanks to the SolCoolDry system, we no longer consume low quality, rotten fish.* - **Mr. Mshemanga**

Figure 19. Mr. Mshemanga, the Mwazaro BMU Project Coordinator expounds on the many benefits that the community has gained from the installation of the SolCoolDry system at Mwazaro (Source: Phionalorna N.).

He explained that in comparison to traditional outdoor fish drying, which takes up to 7 days, using the SolcoolDry system now takes only 18 hours and the end product is of high quality due to the significantly reduced contaminants such as flies and maggots, characteristic of conventional open-air sun drying. Speaking of the versatility of the system, he gave examples of drying other non-fish products such as fruits, sweet potatoes and coconuts (for extraction of pure coconut oil) as other value-added products that have been produced using the system.

Further, he said that the fishermen who use traditional fishing methods without ice, spending up to 6 or 7 hours at sea, always end up with spoiled fish. However with the SolCoolDry system now, the fishermen who purchase and use the ice during their fishing trips have fresh fish of higher quality at landing time. He also mentioned that the system has contributed significantly towards the reduction of quality losses in fresh fish since fish traders from neighbouring towns such as Kibuyuni and Shimoni travel all the way to buy ice at the site at KES 10 per kg for the preservation of fish while on transit and at the market.

Mr. Hamisi emphasized that the all-inclusive novel fish drying and cooling system has improved the quality of fish along the entire value chain, from harvesting to the final consumer, by reducing spoilage and ensuring high quality products. He concluded by mentioning that the project was geared towards improving community livelihoods and that the funds received from the sale of ice and drying of fish were being channelled back to the maintenance of the system to ensure its sustainability beyond the lifetime of the project.

2. Fish processors' representative

Ms. Salim Abdallah (Fig. 20), a member and treasurer to the Mwazaro BMU, expressed the community's appreciation for the SolCoolDry system and highlighted its potential benefits for the community. She engages in seaweed farming and occasionally sells fried fish. She stated that the system would bring significant value to the community by providing ice to fish processors, enabling them to preserve their purchased fish until more fish could be obtained. This is because fishermen use traditional fishing methods (dugout canoe) that result in delays during fishing. The SolCoolDry system would ensure that the quality of the fish is maintained, and prevent fish spoilage before processing, which would reduce the losses incurred by the fish processors.

Additionally, Ms. Abdallah mentioned the potential benefits of the system's drying capabilities, particularly during periods of high fish yields, when the fresh fish market is often oversaturated and prices are low. Therefore, by enabling the drying of fish, the system would increase its shelf life, enabling traders to sell it later when demand is higher in the market. She explained that the local market currently offers lower prices for the dried fish. However, prices at distant markets are significantly higher. For instance, while the local market offers a price of KES 120 per half a kilogram of dried fish, other distant markets such as Kikoneni can offer up to KES 200 to 300 per half a kilogram. Ms. Abdallah also mentioned that dried fish would also be much easier to transport to distant markets without encountering the high

> *Huu mradi wa SolCoolDry utatusaidia sana kwa upande wetu kama wanajamii kwa jumla kupata barafu ya kuhifadhi samaki na mvuke wa kukausha samaki na kuwauza soko za nje ili tupate hela, tujisaidie kuwaelimisha watoto wetu.*
>
> **Translation** *The SolCoolDry system will provide us with ice to preserve fresh fish and also enable us to dry fish especially when the harvest is in plenty. The sale of dry fish will improve our livelihoods and help us educate our children.* - **Ms. Saumu Abdalla**

Figure 20. Ms. Saumu Abdalla gives her input on the benefit of the SolCoolDry system to the fish processors in Mwazaro (Source: Phionalorna N).

losses associated with fresh fish. She concluded that the community will benefit from increased income by utilizing the SolCoolDry system to dry more fish, which can be transported to distant markets for higher prices. This additional income can then be directed towards improving the community's livelihood, such as investing in education for their children.

3. SolCoolDry Kenyan Coordinator and PI, Dr. Linus K'Osambo (KIRDI)

Dr. Linus K'Osambo (Fig. 21), a Senior Research Scientist from KIRDI mentioned that the aim of the SolCoolDry system is to help in cutting down post-harvest losses to take care of the fish deficit of over 300 tonnes in Kenya. He explained that the system has two 24-metre-long drying beds, each with 24 trays. Each tray can carry 5-10 kgs of fish, depending on the type of fish being dried, thus each dryer has the capacity to dry a maximum of 240 kgs of fish at a go. Thus, 480 kgs of fish can be dried in a day using the system. Additionally, he stated that the SolCoolDry system

> *The SolCoolDry system has the capacity of drying approximately half a tonne of fish daily. We are targeting mainly the inland markets where the demand for dried fish is high. The system will provide direct employment for a minimum of 50 individuals and improve the livelihoods of many more through the reduction of post-harvest losses.* - **Dr. Linus K'Osambo**

Figure 21. Dr. Linus K'Osambo, the project PI and Senior Research Scientist at KIRDI explains the challenges in the fish value chain associated with post-harvest losses and the aim of the SolCoolDry project in mitigating against the losses to ensure food security and improved livelihoods (Source: Phionalorna N.).

is beneficial to the fishermen since the ice produced is sold to them for the preservation of fish harvested nearshore and in the deep sea. When there is a surplus of fish exceeding the market's demand, the excess fish is preserved by drying. The fish is washed, split, gutted, washed and rinsed again and spread out in the dryer to dry. The solar-powered system can thus extend the shelf-life of fish to more than a year, which guarantees zero food losses during harvest, transit and storage.

Dr. K'Osambo explained that the SolCoolDry system can also be used to preserve other food products, other than fish, either through drying or by chilling using the ice produced. He explained that in terms of business, the system can either be used to dry fish or other food products for the local communities at a small fee or the team managing the system can buy fish or food products and then dry, package and sell them to the bigger markets which are located in dry areas or inland. He added that the project's long-term goal is to install the SolCoolDry systems in off-grid areas that lack electricity and build systems for all the 48 coastal BMUs from Lamu to Vanga. This will ensure the production of high-quality fish that meets the recommended quality standards. He also mentioned that there were plans to install a water processing and purification plant at the SolCoolDry site in order to utilize the available space and provide clean water for fish processing. Further, he stated that the project would also focus on capacity building the community on fish handling in order to enable the sale of fish from Kenya in high-end markets. Dr. K'Osambo concluded by saying that the SolCoolDry system has offered a source of direct employment to around 50 youths.

4. SolCoolDry PI, Dr. James Mwaluma, (KMFRI)

Dr. James Mwaluma (Fig. 22), the Director of Ocean and Coastal Systems, & Blue Economy in KMFRI indicated that the SolCoolDry project was launched at the ideal time since the Government of Kenya is keen on advancing the sustainable exploitation of the Blue Economy. He explained that various institutions are collaborating to provide data or suggest interventions for sustainably utilizing the underexploited Blue resources within Kenya's 142,400 km^2 Exclusive Economic Zone (EEZ) and the coastline whose length is 640 km. Dr. Mwaluma reported that research shows that the nearshore fishery has been overfished and

> *The SolCoolDry system could not have come at a better time, given that the Government is now focusing on the exploitation of the Blue Economy, which is poised to increase catches from the deep sea. KMFRI is also developing a marine hatchery, which will increase the productivity of local fish farmers. The system will therefore support the preservation of both wild-caught and farmed fish for enhanced food security and improved livelihoods. The project should be upscaled to other counties such as Tana River where the post-harvest losses are extremely high. As KMFRI, we are proud to be associated with the climate-smart SolCoolDry project.* - **Dr. James Mwaluma**

Figure 22. Dr. James Mwaluma, the Director, Ocean and Coastal and Blue Economy at" after Systems, KMFRI and SolCoolDry PI emphasizes an important point on the relevance of research in the development of innovations towards the mitigation of fish losses for improved livelihoods and enhanced food security (Source: Phionalorna N.).

thus efforts are underway to find ways of exploiting deep-sea fisheries and boosting aquaculture production. He stated that KMFRI is constructing a marine hatchery at Shimoni and once it is completed, it will produce fish seeds that will help the 48 BMUs located along the Kenya coast to sustainably engage in aquaculture. He reported that some farmers are culturing prawns in the ponds and the seeds will also enable them to enhance prawn production. The SolCoolDry system will therefore come in handy when drying the additional fish produced from fish farming and deep sea fishing. The system will help with the prevention of fish post-harvest losses by drying the harvested fish and preserving them with ice produced by the system. He reiterated that the solar-powered system would help preserve fish for more than a year and eliminate food losses during the harvest. The products from the system will have a longer shelf-life hence local communities will be able to supply their products to far-off markets.

Dr. Mwaluma highlighted counties like Tana River, which experience a significant scale of prawn spoilage of about 50-70%, especially during the high yield seasons. This is mainly due to the lack of preservation equipment that can enable the transportation of fresh products to distant markets. He also explained that in April, a lot of sardines are landed in Gazi and Vanga areas in Kwale County, thus the system can be used to dry them and hence preserve them for consumption during the low-yield seasons. He mentioned that an additional advantage of the project is that it is an off-grid system, meaning that it can operate in areas without electricity. He highlighted that beside preserving fish, the solar panels can be used to generate energy for pumping water for use in agriculture and for lighting in adjacent homesteads. Additionally, the system will help in the drying of seaweed farmed by communities in the South Coast of Kenya. Dr. Mwaluma concluded that the project will significantly contribute towards enhancing food security and the socio-economic development of coastal communities.

5. SolCoolDry PI, Dr. Huxley Makonde, (TUM)

Dr. Huxley Makonde (Fig. 23), a Senior Lecturer and Dean School of Health and Applied Sciences at TUM explained that TUM is responsible for the quality control component of the SolCoolDry project. The role of the team from the University was to ensure that the SolCoolDry production system meets the requisite health and safety standards for the consistent production of quality food that is safe for human consumption. This was done by identifying potential food safety hazards and implementing mitigation measures to address these hazards throughout the SolCoolDry processing system. He acknowledged the importance of academic institutions in training future experts who can further develop and scale-up systems such as SolCoolDry. He concluded by urging the Kwale County Government to adopt similar innovative technologies to address high post-harvest losses, improve food security, and enhance community livelihoods.

The SolCoolDry hub is a model that will be used to create awareness and demonstrate the utilization of climate-smart technologies to mitigate against post-harvest losses. We call upon County Governments to adopt such projects to ensure its sustainability and scaling up to other coastal regions. -**Dr. Huxley Makonde**

Figure 23. Dr. Huxley Makonde, a lecturer at TUM explains the role of academia in supporting the research and development of innovative technologies. He calls upon County governments to adopt innovative projects such as the SolCoolDry hub (Source: Phionalorna N.)**.**

6. SolCoolDry Co-PI, Dr. Peter Oduor-Odote, (KMFRI)

Dr Peter Oduor-Odote, a Principal Research Scientist at KMFRI, stated that the main objective of the SolCoolDry project is to improve the preservation of fish. He stressed that fish preservation is important because the spoilage process starts immediately after the fish is caught and hauled out of the water at the fishing grounds. He stated the different ways of preserving fish, including cooling, smoking, frying and sun drying. In the SolCoolDry system, drying and cooling through flake ice production is made possible.

He then gave a background about fish drying at the coast, ranging from sardines to bigger fish. Dr. Odote stated that in Vanga, sardines are traditionally dried on the sand and the challenge of this method is in the eating quality, where you find sand particles when eating the dried fish. He highlighted that the *"ng'onda"* (bigger fish that are dried when split open) are sometimes dried on rooftops, stones and some rudimentary racks. He explained that the challenge with such traditional drying methods is that it takes a longer time for the fish to dry because the ambient drying temperatures are low. Fish requires around 50°C to dry. He highlighted the various benefits of drying fish at 50°C including reduced drying time and elimination of insect infestation during drying.

Dr. Odote then explained how the drying system would ensure all-season drying for the production of high-quality products, which would penetrate high-end markets for the benefit of the community members. He said that since the drying will be on raised racks, the dried products from the system would be free of sand and other contaminants that are common in fish dried conventionally on the ground in open spaces. The system would also ensure that the

Fish preservation is imperative because fish spoilage begins immediately after harvest. We must embrace sustainable, affordable technologies that rely on renewable, green energy to ensure efficient preservation of fish along the entire value chain for reduced losses and production of high quality products to reduce poverty among coastal communities. If you want good results, you must invest in sustainable technologies. - **Dr. Oduor-Odote**

Figure 24. Dr. Oduor-Odote, a Principal Research Scientist at KMFRI explains a key point on the dynamics of fish drying using the SolCoolDry system *vis-a-vis* **conventional drying methods** (Source: Phionalorna N.)**.**

The intention of this project is to reduce post-harvest losses which occur whether it is dry or wet. This system ensures all-season drying by using UV-treated polythene to concentrate solar insolation and a water system for drying when the weather is damp.- **Dr. Oduor-Odote** drying process occurs faster due to sustained high temperatures within the drying racks in comparison to ambient drying conditions. These drying conditions would further guarantee the production of dried products with extended shelf lives due to the reduction of moisture levels to the recommended levels beyond which spoilage agents such as microbes would not grow.

He gave an insight on how the thickness of the fish determines the drying period. He said that the recommended thickness is half an inch or one inch. He then explained that if the fish is a half inch thick, two days of drying at 50°C are enough to complete the drying process and to reduce the moisture content to 15 - 20%. He stated that if the dried fish is of higher quality, they will be sold in the supermarkets. He also mentioned that since the HACCP system is also being introduced at the SolCoolDry site, the fish would even penetrate the more lucrative export markets. These markets with higher income prices will have a trickle-down effect back to the fishermen for improved livelihoods.

Dr. Odote explained that most landing sites lack operational ice production infrastructure due to the high costs associated with meeting the power requirements for running such systems. The SolCoolDry system would therefore provide a reliable source of flake ice, which would be run on green energy, ensuring the sustainability of the system. He finalized by remarking that due to the high demand for ice and drying systems along the Kenya coast, there would be need to scale up the project and/or replicate the system at other sites to address the challenge of high post-harvest losses and improve the livelihoods of coastal communities.

7. KIRDI Board of Management representative, Eng. Lucy Wanjiku Mutinda

Eng. Lucy Wanjiku Mutinda (Fig. 25), a Board member of KIRDI, who was present at both Workshop at KMFRI and Technology Day at Mwazaro expressed elation at the launch of the SolCoolDry system. She explained that the system is aimed at reducing post-harvest fish losses, which occur due to inadequate preservation infrastructure along artisanal fish value chains. She pointed out that during bumper harvest, fishermen encounter a significantly high proportion of losses. Additionally, delays during artisanal fishing and the lack of ice for the preservation of fish immediately

> *The importance of multi-stakeholder collaborations is that the SolCoolDry project will realize greater impact; not only increasing the income of fisherfolk but also as a training site for upcoming technicians to learn how to maintain and scale up such innovations.* - **Eng. Lucy Mutinda**

Figure 25. Engineer Lucy Mutinda, a member of the KIRDI BoM explains the role of strategic multi-stakeholder collaborations in implementing innovations geared towards addressing challenges affecting local communities (Source: Phionalorna N.).

after harvest result in the spoilage of fish harvested early in the fishing trip, making it unfit for the market. She mentioned that when fishermen use the ice flakes provided through the SolCoolDry system to preserve the fish directly in the cooler boxes while fishing, the post-harvest losses will be reduced.

Eng. Mutinda explained that KIRDI implemented the multi-stakeholder project as part of its mandate to innovate, design and develop technologies that can be disseminated to industries and communities towards tangible impacts. She acknowledged the local and international partners that had collaborated to implement the project, noting that the partnership would increase the project's impact by providing a pilot training site for learners to build capacity in the maintenance, design and development of such systems to ensure sustainability and scalability of such projects. She reiterated the importance of having collaborations with capable partners like KMFRI, Fraunhofer ISE, Innotech and TUM in the project. Eng. Mutinda summed up her remarks by noting that the project would enhance food security, create employment opportunities for the youth and improve livelihoods while contributing towards the realization of the sustainable development goals through promoting the utilization of green energy and building a circular economy.

6. ACKNOWLEDGEMENTS

We are grateful for the funding received from the Federal Ministry of Food and Agriculture (BMEL), Germany to undertake the research on the "Development of Milkfish (*Chanos chanos*) and Kimarawali (*Stolephorus delecatulus*) Solar Drying-Cooling Technology, Value Addition and Quality Assurance" and develop the SolCoolDry system. The hard work of the project team members that developed and implemented the proposal including scientists from KMFRI, KIRDI, TUM, Fraunhofer ISE and INNOTECH is highly appreciated. A special vote of thanks goes to our Chief Guest, Eng. Lucy Wanjiku Mutinda.

The organisers would also wish to give special thanks to the chairs, rapporteurs and speakers of the workshop sessions. All the participants drawn from different stakeholders (including county government officials, community members, researchers, NGOs, media and people from the industry) who showed interest and participated actively in the different sessions made the Workshop and Technology Day a resounding success. The effort of the organizing and drafting committee members, who tirelessly planned the conference and drafted the proceedings is highly treasured. Finally, the dedication of the secretariat, accounts department and the logistics team who did the behind-the-scenes organization is sincerely appreciated.

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K.M.F.R.I.

TECHNICAL UNIVERSITY OF MOMBASA

With support from
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by decision of the German Bundestag

Project manager
Federal Office for Agriculture and Food

7. CONFERENCE RESOURCES

Annex I. Posters

Poster	Authors
The improved Mama Karanga fried fish display box: Climate-smart innovation improves small-scale fisheries trade	Dr. Peter Oduor-Odote, Josephine Marigu, Raymond Ruwa, Winnie Jefwa, Rael Achieng' and Maurice Omega
Hybrid windmill solar tunnel dryer with integrate ice production unit	Dr. Peter Oduor-Odote, Josephine Marigu, Raymond Ruwa, Rael Achieng' and Maurice Omega
Commercialization potential & energetics of hybrid windmill solar tunnel dryer	Dr. Peter Oduor-Odote, Raymond Ruwa and Grace Gacanja
Hybrid windmill solar tunnel dryer with integrate ice production unit	Dr. Peter Oduor-Odote, Josephine Marigu, Raymond Ruwa, Rael Achieng' and Maurice Omega
Biowaste treatment using BSFL (*Hermertia illucence*) to produce fish, poultry, pig feed and organic fertilizer	Gladys Mwaka, Peter Thuo and Mary Opiyo
"Go blue, Grow blue": Building a vibrant mariculture sector	Drs. Morine Mukami, Anthony Nzioka, Dr. James Mwaluma, Dr. David Mirera, Dr. Esther Wairimu, Miriam Wainaina, Alex Kimathi, Hirizano Mdzomba and Gladys Mwaka
Industrial Entrepreneurship support by EICT-RC Engineering workshop equipped with modern computer numerically controlled (C.N.C) machines for the production of high precision and standardized products	Justus Kithuka, Stephen Midega and Linus K'Osambo M.D.O
Development of milkfish (*Chanos chanos*) and Kimarawali (*Stelophorus delecatulus*) Solar Drying-Cooling Technology, value addition and quality assurance	Huxley Makonde (PhD), Kassim Ziro and Edith Muwawa (PhD)
A pilot project to introduce renewable energy and reduce environmental pollution by using a solar collector in Kenya	John Maitha, Kjel Van Schijndel, Salsabila Abdulhalim, Leon Vandenberghe and Khawla Khalid
Design and implementation of a hybrid biogas plant to reduce environmental pollution and food waste	John Maitha, Daan Vanhoudt, Salsabila Abdulhalim, Toblas Corthouts and Khawla Khalid
Climate smart dehydration and value addition technologies for indigenous fruits and vegetables in Kenya	George Wanjala, Shadrack Makori, Linus K' Osambo M.D.O, and Stella Wanjiku
Climate smart agriculture as a novel approach in the valorization of fruits and vegetable wastes as sustainable Eco materials for high value added products	Shadrack Isaboke Makori, George Wafula Wanjala and Linus K' Osambo M.D.O
Development of milkfish (*Chanos chanos*) and Kimarawali (*Stelophorus delecatulus*) Solar Drying-Cooling Technology, value addition and quality assurance	Linus K' Osambo, Jackis Auka, Sarah Kwach, Winston Asugo, Stephen Midega, James Mwaluma, Peter Odote, Morine Mukami, Huxley Makonde, Albert Esper, Norbert Pfanner and Alexander Morgenstern
Aquaculture of seaweeds and fish: Opportunity for Blue economic empowerment and covid-19 resilience of fisher women in Kenya (Blue empowerment project)	Linus K' Osambo, M.D.O, Justine Anyango Ochieng, Stella Wanjiku, Eva Komba, Fatuma Usi, Tei Usi, Morine Mukami, Caroline Wanjiru, Josephine Obondo, Elsie Wanjiku, Victor Opondo, Catherine Kilelu and Joel Onyango
Refractance window drying technology for production of high quality bio products: Integration in the SolCoolDry system	Dr. George Wanjala, Prof. John Muyonga, Prof. Arnold Onyango, Eng. Joseph Kamau, Mr. Nicholas Ngetich, Linus K' Osambo M.D.O, Dr. Shadrack Makori and Ms. Stella Ndungu
The evolution of drying technologies along the Kenyan Coast	Dr. Peter Oduor-Odote, Josephine Marigu, Raymond Ruwa, Winnie Jefwa and Rael Achieng'

THE IMPROVED *MAMA KARANGA* FRIED FISH DISPLAY BOX

Dr. Peter Oduor-Odote, Josephine Marigu, Raymond Ruwa, Winnie Jefwa, Rael Achieng' and Maurice Omega

Fried Fish Mongers (*Mama Karanga's*)

Koroboi smoke *:* Pollutant; Cause diseases; Contaminant

Other Challenges associated with the use of Conventional Display Containers	Traders Affected	% (*n=36*)
Accidental dropping of the fish (Quantity losses)	17	47%
Predation by rats, cats, birds and other predators (Quality losses)	14	39%
Contamination by dust and vehicle exhaust fumes (Quality losses)	18	50%
Infestation by flies and other pests (Quality losses)	22	61%

Delivering the Innovation to the County for Distribution

Mama Karanga's using the Innovation

CLIMATE-SMART INNOVATION IMPROVES SMALL-SCALE FISHERIES TRADE

→ **Reduction of quality and quantity losses of the product by minimizing contamination**
→ **Carbon footprint reduced due to elimination of burning kerosene burning for lighting**
→ **Attracts more customers due to sanitary food handling; Customizable to suit user needs**
→ **100% smoke elimination has led to reduction of respiratory illnesses among the traders**
→ **Less operational costs: Lamp is solar powered hence replaces kerosene/battery purchases**
→ **Future applications: Other small-scale food vendors e.g pastry vendors need the display box**

HYBRID WINDMILL SOLAR TUNNEL DRYER WITH AN INTERGRATED ICE PRODUCTION UNIT

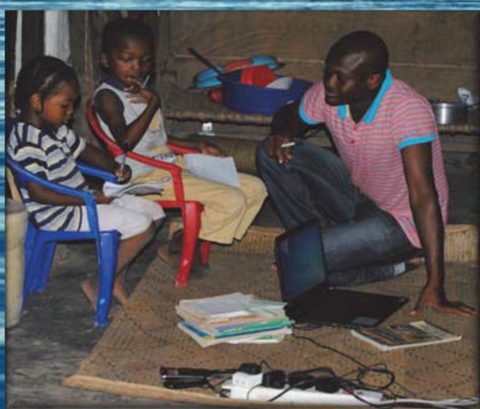
Dr. Peter Oduor-Odote, Josephine Marigu, Raymond Ruwa, Winnie Jefwa, Rael Achieng' and Maurice Omega

The Hybrid Windmill Solar Tunnel Dryer (with Ice-production Unit) in Kipini

24/7 Operation: Drying Fish at Night

Drying Vegetables & Fruits

Ice Production Unit



Powering Homesteads in the Viscinity

HOW DOES THE CLIMATE-SMART INNOVATION IMPROVE AGRICULTURE AND TRADE?

→ Uninterrupted 24/7 production: All weather drying
→ Higher quality, higher value products for high end markets e.g. supermarkets
→ Ice production for upstream maintenance of high quality fish during harvesting
→ Purely operated through clean renewable energy hence affordable and pollution-free
→ Electricity supply to power home appliances and support small scale community shops
→ Future applications: Production of ice flakes: Better than ice cubes for preservation of fish
Drying high value micro algae eg spirulina (Ksh.20,000/kg dry prdct)

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

COMMERCIALIZATION POTENTIAL & ENERGETICS OF HYBRID WINDMILL SOLAR TUNNEL DRYER

Initial cost (Kshs)	1892000	
Drying capacity	100 kg fillet (200 pieces)	
Drying time	2 days	
Thickness	½ inch to 1 inch	
Cost of fresh 100 kg fish (Kipini) in Kshs	15,000	
Sell 200 pcs @150/= (Gross)	30,000	
Drying times in a month for 3 days for 6 months (15000 by 10 by 6)	900,000	
Equaling cost of equipment and no maintenance	2-3yrs	
Dry other farm produce-mangoes, spices etc	Extra income all year	
Dry high value fish hydrolysates and bipetides	High value low volume products	
Energy value of innovation		
Surface area of collector	6.6m^2	
Average daily heat output of collector	24kWHrs	
Power supply from wind generator	3 phase. 1000w. 41 amps	
24 batteries each 500 Ah, 2V Connected in series	1000ah @ 24 V	
Wind turbine generates 900Watts per hour;	Equivalent to 450Amps in 12 hrs and enough to fully charge the batteries on a windy day	
Wind /solar hybrid system powers electronic systems	With consumption not exceeding 650 amps with constant wind flow	
Power consumption at the site in Kipini		
Heater elements 4pcs. 300W (50Amps) , 2 Fan 50W (4 Amps), Water pump 50W (4 Amps) and community lighting system at home; Lighting in office; mobile phone charging; radio TV	These items consume about 650amps in a day less. Excess power available is 100 amps	
Drying capacity 100 kg in 2 days for fish less than an inch thick; Dry other farm produce;		
Use/advantages of electricity is wide. Drying capacity can be increased by expanding the drying chamber upwards		
Beneficiaries	Women, youth (Better product, higher income, easy to use equipment	
Solar Ice Maker 96w @ 24v 4amps.	Produces 10kgs of ice cubes per day	
Further research on optimization		

RECOMMEDATIONS;

1. *Increase production of power by doubling up the size of wind turbine and increase no.s of solar panels.*
2. *Re-locate the wind mast – to Increase power efficiency and for security reasons.*
3. *Increase size of ice maker, to produce more ice cubes.*
4. *Solar water tank requires construction of shade to avoid direct sunshine and increase its life span*

Biowaste treatment using BSFL(*Hermertia illucence*) to produce fish, poutry and pig feed and organic fertiliser.

Thuo, P., Holeh G.M.*, Kimanga, F.
Kenya Marine and Fisheries Research Institute, P.O Box 81651-80100, Mombasa, Kenya

The high increase in global population has consequently led to increase in waste. An average kenyan produces 90Kg organic waste per year which ends up in ladfills and udersignated diposal areas.
Black soldier fly lavae (BSFL) provides a solution to treat organic waste, produce organic fertilisers as well as providing alternative source of protein whose availability is limited.

Kongowea Market

Black soldier fly (BSF)

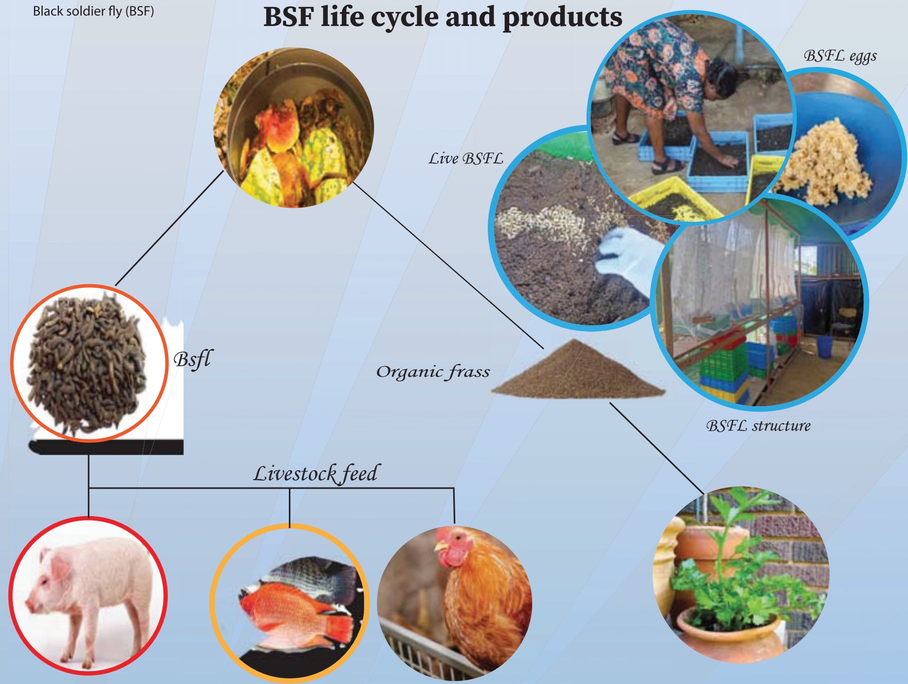
Why Black Soldier Fly(BSF)?

1. Quickly and efficiently converts organic waste into high quality protein food for fish , pigs and paultry as well asorganic fertilizer.

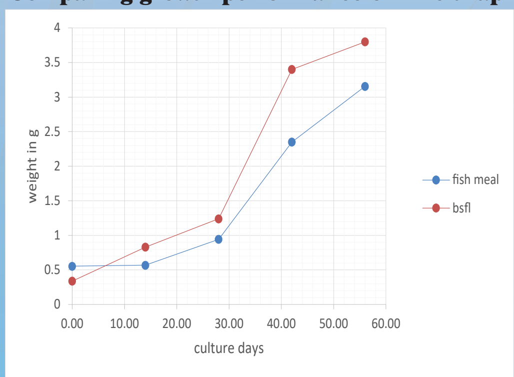
2. Reduces greenhouse gases emmision from landfills.

3.Does not transmit diseases.

BSF life cycle and products



Comparing growth performance of Nile tilapia fed on BSFL and fish meal

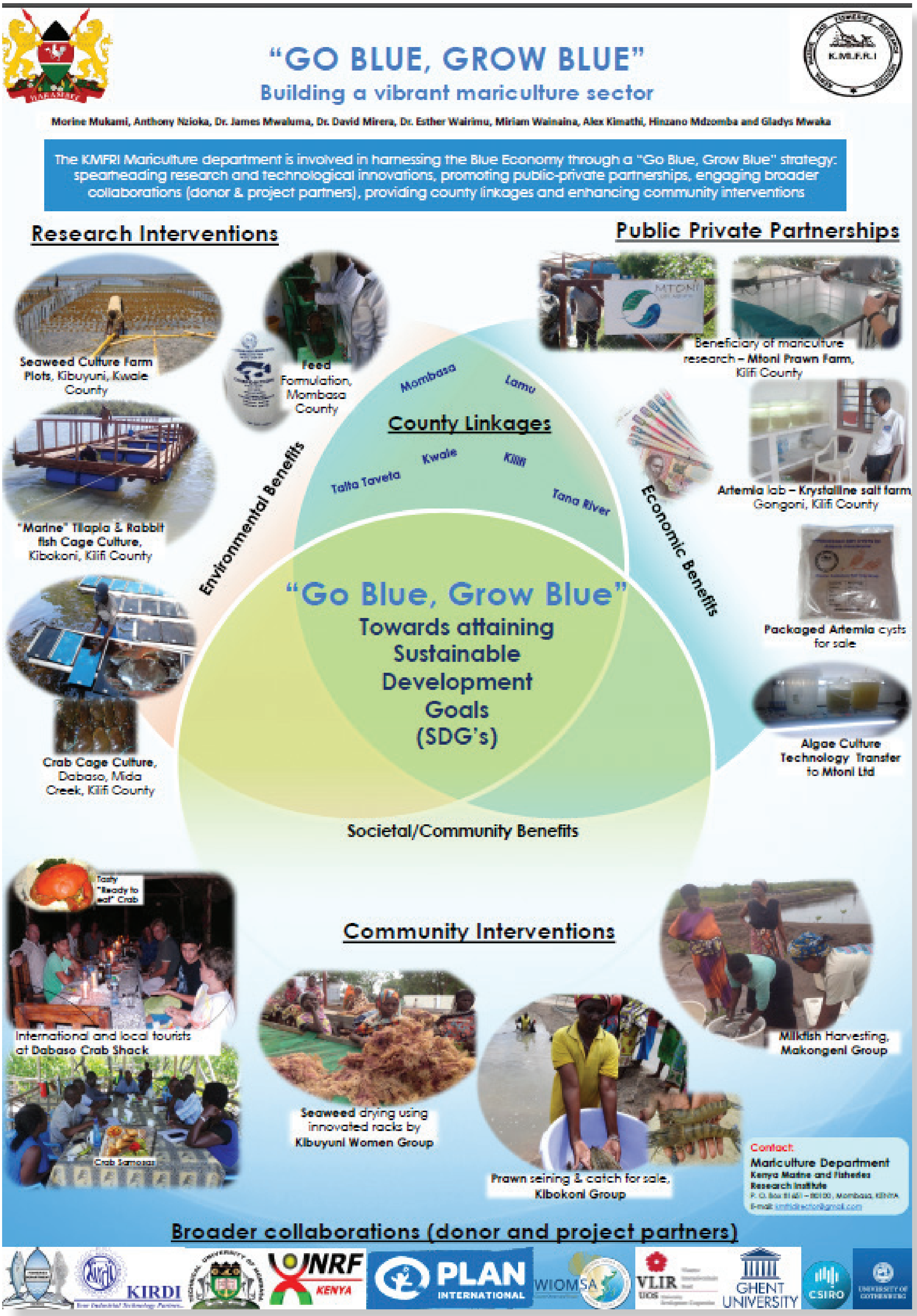


1. The growth rate in BSFL fed tilapia was significantly higher than fish meal.

2. BSFL is also cost effective.
   - Producing 1000 kg of fish feed using BSFL reduces the ammount of protein cost by 1/2 (from 133,200 to 66600).

3. BSFL feed shows higher palatability.

For more information contact: Director KMFRI, holegladys@gmail.com or petethuo520@gmail.com


"GO BLUE, GROW BLUE"
Building a vibrant mariculture sector
Morine Mukami, Anthony Nzioka, Dr. James Mwaluma, Dr. David Mirera, Dr. Esther Wairimu, Miriam Wainaina, Alex Kimathi, Hinzano Mdzomba and Gladys Mwaka
The KMFRI Mariculture department is involved in harnessing the Blue Economy through a "Go Blue, Grow Blue" strategy: spearheading research and technological innovations, promoting public-private partnerships, engaging broader collaborations (donor & project partners), providing county linkages and enhancing community interventions
Research Interventions
Seaweed Culture Farm Plots, Kibuyuni, Kwale County
Feed Formulation, Mombasa County
"Marine" Tilapia & Rabbit fish Cage Culture, Kibokoni, Kilifi County
Crab Cage Culture, Dabaso, Mida Creek, Kilifi County
Public Private Partnerships
Beneficiary of mariculture research – Mtoni Prawn Farm, Kilifi County
Artemia lab – Krystalline salt farm Gongoni, Kilifi County
Packaged Artemia cysts for sale
Algae Culture Technology Transfer to Mtoni Ltd
County Linkages
Mombasa
Lamu
Kwale
Kilifi
Taita Taveta
Tana River
Environmental Benefits
Economic Benefits
"Go Blue, Grow Blue"
Towards attaining Sustainable Development Goals (SDG's)
Societal/Community Benefits
Community Interventions
Tasty "Ready to eat" Crab
International and local tourists at Dabaso Crab Shack
Crab Samosas
Seaweed drying using innovated racks by Kibuyuni Women Group
Prawn seining & catch for sale, Kibokoni Group
Milkfish Harvesting, Makongeni Group
Contact:
Mariculture Department
Kenya Marine and Fisheries Research Institute
Broader collaborations (donor and project partners)
KIRDI
NRF KENYA
PLAN INTERNATIONAL
WIOMSA
VLIR UOS
GHENT UNIVERSITY
CSIRO


REPUBLIC OF KENYA
KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE
Engineering and ICT Research Center
Industrial Entrepreneurship Support by EICT-RC Engineering workshop equipped with modern Computer Numerically Controlled (C.N.C) machines for the production of high precision and standardised products.
Justus Kithuka, Stephen Midega, Linus K'osambo M.D.0
Intervention Partners
With support from Federal Ministry of Food, Agriculture and Consumer Protection by Decision of the German Bundestag
K.M.F.R.I.
INNOTECH
Fraunhofer ISE
Strategic Technology Intervention:
Capacity building and partnerships with industrial entrepreneurs to develop high quality and reproducible industrial products and services to support the manufacturing sector and national development.
Pasteurizers
Rolling
CNC Laser Cutting Machine
KIRDI Engineering Workshop – CNC laser cutter, press break, pipe cutter, pipe bending, rolling, power coater, & other machines (milling, lathe, drilling, etc.)
Gasfier Stoves
SolCool Drier System Installation
FOCUS: DESIGN AND DEVELPMENT OF MACHINES & PLANT INSTALLATION
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Research | Innovate | Commercialize

Development of Milkfish (Chanos Chanos) and Kimarawali (Stolephorus delecatulus) Solar Drying-Cooling Technology, Value Addition and Quality Assurance

Huxley Makonde (PhD), Kassim Ziro, Edith Muwawa (PhD)

General Hazard Analysis and Critical Control Points (HACCP) plan for Fish Processing using the SolCoolDry System at Mwazaro

Fig. 1: SolCoolDry System

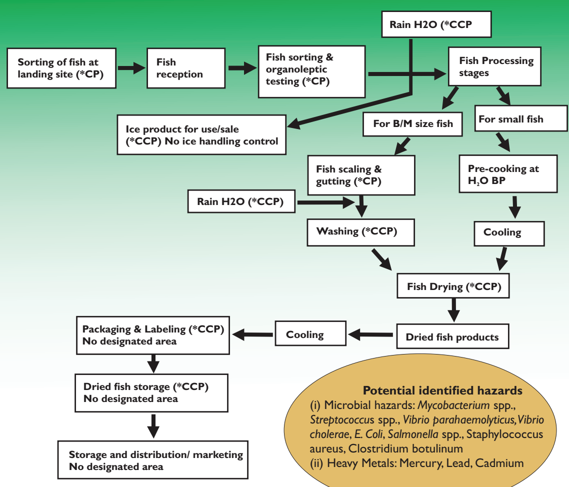


Fig. 2: Fish Processing flow chart at the SolCoolDry system

Introduction

HACCP stands for Hazard Analysis Critical Control Point. It is an effective tool of ensuring food safety. It prevents food safety problems from developing rather than testing food after production. There are two major parts to HACCP; Hazard analysis and the critical control point for that hazard. A hazard is a biological, chemical or physical agent in, or condition of, food with a potential to cause an adverse health effect. All sections of the SolCoolDry processing operation were examined for hazards including raw materials, processing steps, and storage. A hazard analysis was conducted and for each hazard, critical control points were identified where the potential food safety problem can be controlled. In addition, pre-requisite programs essential for the HACCP plan were considered.

Objectives

- To identify and document a typical fish handling and processing system
- To identify key hazards, critical control points and limits for the HACCP System.
- To review and recommend processes to control of hazards

Pre-requisite programs

- Sanitation standard operating procedures (SSOPs) (Not available).
- Good manufacturing practices (GMPs) (to be improved).
- Sanitation*- the site status is not meeting the right standard. (Needs to be improved).
- Personal hygiene (To be improved via training of staff).
- Personnel/public training (Yet to be conducted).
- Supplier control* (Not available but needs to be implemented in future).
- Receiving and dispatch storage areas/units* (Needs to be designated).
- Pest/ insect/ rodent control program* (Needs to be established).
- Recall procedure* (Not available but highly recommended).

Acknowledgements

This work was principally funded by the German Federal Ministry of Food and Agriculture. We acknowledge all our SolCoolDry Project Partners (Fraunhofer-ISE, Innotech, KIRDI and KMFRI).

2020-2021

A pilot project to introduce renewable energy and reduce environmental pollution by using a solar collector in Kenya

Kjel Van Schijndel
Salsabila Abdulhalim
John Maitha
Leon Vandenberghe
Khawla Khalid

Introduction

Figure 1: Technical university of Mombasa

This master's thesis is conducted in collaboration with the nonprofit organization **Students for Energy in Africa** [1]. This non-profit organization realizes annually recurring projects in function of sustainable energy in Africa.

This Master's thesis consists of two parts and includes the placement of **renewable energy sources** to reduce environmental pollution. These energy sources are placed in the **kitchen** of the **Technical University of Mombasa (TUM)** (Figure 1) in **Kenya** [2].

In this kitchen, 3 meals a day are served for the students. Because of these meals, there is a high consumption of **hot water**. This hot water is now heated 70% by wood and 30% by LPG.

Problem definition

Every kitchen of large institutions require **large amounts** of boiling water. In the Technical University of Mombasa, this water is heated in large kettles up to 50 liters. To get these amounts of **water to a boil**, large amounts of energy are needed. In the kitchen of TUM (Figure 2), this energy is provided by a combination of **firewood and LPG**. The use of these fuels poses following **problems**:

- high energy costs;
- harmful atmosphere for kitchen staff;
- wood usage leads to deforestation;
- fossil fuels emit greenhouse gasses.

The shortcomings occur not only at the **economic** level, but also at the **ecological** and **ergonomic** level.

Ultimately, the goal is to heat the water to 70°C. This temperature must be reached at the end of the day.

Figure 2: The kitchen

Methods

Based on the literature review, a **flat plate solar collector** is chosen, and it is placed at an angle. Throughout the matrix structure (Figure 3) of the collector, an **intermediate fluid** consisting of 30% glycol and 70% water flows. Due to this percentage, the boiling point is higher than the boiling point of water. The intermediate fluid heats up uniformly due to the **absorption of the sun's rays**. This heated intermediate fluid releases its heat into the **storage tank** filled with water. The cooled intermediate fluid is returned to the collectors so that the **cycle** can start again. This cycle is powered by **natural convection** (Figure 4). By repeating the cycle, the water in the tank heats up. This warm water can be used in the university's kitchen.

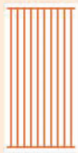


Figure 3: Matrix structure

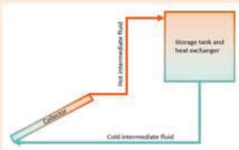


Figure 4: Schematic representation natural convection

Figure 8: The solar collector, top view

Conclusion

The main objective of this master thesis was to **reduce the energy costs** of the kitchen with a solar collector. The intended goal was to preheat the water needed for cooking to **70 °C**. This would reduce the needed energy by **65%**. From the results on figure 5, the actual situation reaches a temperature of 70 °C so this **goal** has been **achieved**.
Figure 6, 7 and 8 give the actual solar collector installed at the Technical University of Mombasa.

Figure 6: Selfie with Sollatek and the collector

Figure 7: The solar collector on the roof, side view

Results

To get a better idea of the effectivity of the installation before it is constructed, **simulations** were done in **Python**. These simulations take in account the design parameters, as well as the **environmental conditions** of the location, Mombasa. Together with the actual measurements we can see of the simulations are correct and if they gives us a qualitative result. Figure 5 gives an example of the simulations and measurements.

The temperature of the water in the storage tank reaches a **temperature of 80°C** according to the **simulations**. The **actual situation** reaches a temperature of 70°C. These are slightly different, but they **align perfectly** between **10 AM and 3 PM**.
The **deviation** from the simulation is due to **usage of hot water** for cooking around 12 PM. This is **not yet implemented** in the simulation.

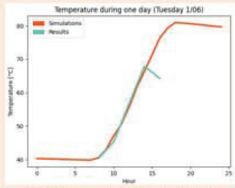


Figure 5: The temperature variation trough the day

Supervisors / Co-supervisors / Advisors: Prof. Dr. Ir. Wim Deferme, Dr. Michael J. Saulo

[1]: S. f. e. i. Afrika. [Online]. Available: https://studentsforenergyinafrica.com/nl/. [Accessed February 2021].
[2]: T. u. o. Mombasa. [Online]. Available: https://www.tum.ac.ke/. [Accessed February 2021].
[3]: G. maps. [Online]. Available: https://www.google.be/maps/. [Accessed May 2021].

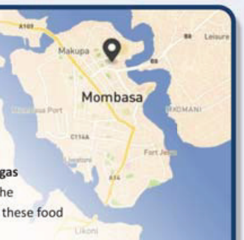
UHASSELT KU LEUVEN

2020-2021

Design and implementation of a hybrid biogas plant to reduce environmental pollution and food waste

Daan Vanhoudt
John Maitha
Tobias Corthouts
Salsabila Abdulhalim
Khawla Khalid

Situation



The **Technical University of Mombasa (TUM)** provides hot meals for about 2,000 students per day. To achieve this, **800 kg of wood and 120 kg of LPG** per month is needed.

Problem definition

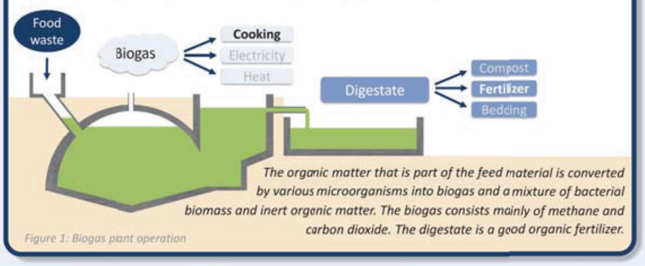
The use of fossil fuels is **expensive** and contribute to **greenhouse gas emissions and climate change**. Providing hot meals every day in the university results in **100 kg of organic (food) waste** per day, while these food residues could be used as an energy source.

Objectives

This master's thesis focuses on designing a biogas plant that converts food waste into biogas. The food waste from TUM will be converted as efficiently as possible into biogas which will be used for cooking.

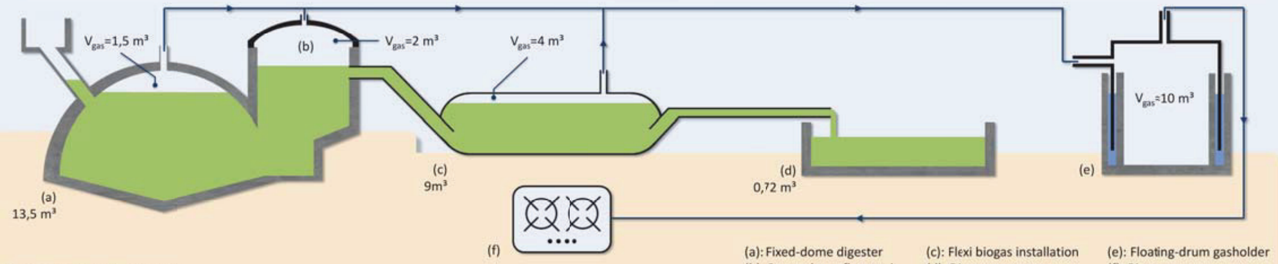
Method

To begin with, an extensive **literature study** on the different types of biogas digesters took place. The selected digester was conceptually **developed and dimensioned**. On site in Mombasa the plant was expanded to a hybrid biogas installation. Finally, the biogas plant was **implemented** in TUM.



The organic matter that is part of the feed material is converted by various microorganisms into biogas and a mixture of bacterial biomass and inert organic matter. The biogas consists mainly of methane and carbon dioxide. The digestate is a good organic fertilizer.

Figure 1: Biogas plant operation



(a): Fixed-dome digester
(b): Covered overflow tank
(c): Flexi biogas installation
(d): Digestate storage
(e): Floating-drum gasholder
(f): Biogas stove

Figure 2: Hybrid biogas installation

(a) Fixed-dome digester

The **fixed-dome digester** is one of the simplest and most common digesters in developing countries. A well-founded installation can withstand high **external loads** and high **internal pressure**, resulting in a **lifespan of up to 25 years**.

Properties

- Robust design
- No moving parts
- Underground construction
- Low efficiency (= biggest disadvantage)
- Building materials: bricks and cement

Figure 3: Fixed-dome digester, overflow tank and inlet reservoir

Hybrid biogas installation

Purpose of the hybrid installation

- Eliminating the disadvantages of the fixed-dome digester
- Making the installation more interesting for educational purposes

(b) Covering the overflow tank

- Eliminate gas losses in the overflow tank
- Reducing greenhouse gas emissions

(c) Expansion with a flexi biogas installation

- Improve efficiency
- More complete digesting process

Figure 4: Biogas site

(e) Floating drum gasholder

Properties

- Provides constant pressure
- Adjustable pressure by placing weight on the drum
- Buffer difference between consumption and production
- Visual representation of gas content by height of the drum

A **simulation** shows that a **total gas storage** of **15,09 m³** is required. Considering a safety margin of 20% and the other gas storages, **10,4 m³** should be stored in the floating drum gasholder.

The size of the gasholder depends on:

- Size of the gas storage in the other digesters
- Production = 11,88 m³/day
- Consumption

Figure 5: Biogas consumption

Conclusion

By the beginning of the month of June the plant was completed (as shown in figure 4) and started functioning. As the plant goes through the first steps of innoculation, fermentation and rotting some amount of gas can be seen produced as evidenced. The project is considered a pilot plant for research on studies of how to enhance use of similar plants in the University and elsewhere too.

Supervisors / Co-supervisors / Advisors
Prof. dr. ir. Wim Deferme
Dr. Juma Saulo Michael

[1] Y. Vögeli, C. Riu Lohri, A. Gallardo, S. Dierer and C. Zurbrügg, Anaerobic Digestion of Biowaste in Developing Countries, Dübendorf,: Eawag, 2014.

[2] S. Ludwig, K. Christopher and K. Ainea, Improved Biogas Unit for, Eschborn: Deutsches Zentrum für Technische Zusammenarbeit, 1991.

[3] E. C. Bensah, Technical evaluation and standarisation of biogas plants in Ghana, Kumasi: Kwame Nkrumah University of Science and Technology, 2009.

UHASSELT
KU LEUVEN

REPUBLIC OF KENYA

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

CLIMATE SMART DEHYDRATION AND VALUE ADDITION TECHNOLOGIES FOR INDIGENOUS FRUITS AND VEGETABLES IN KENYA

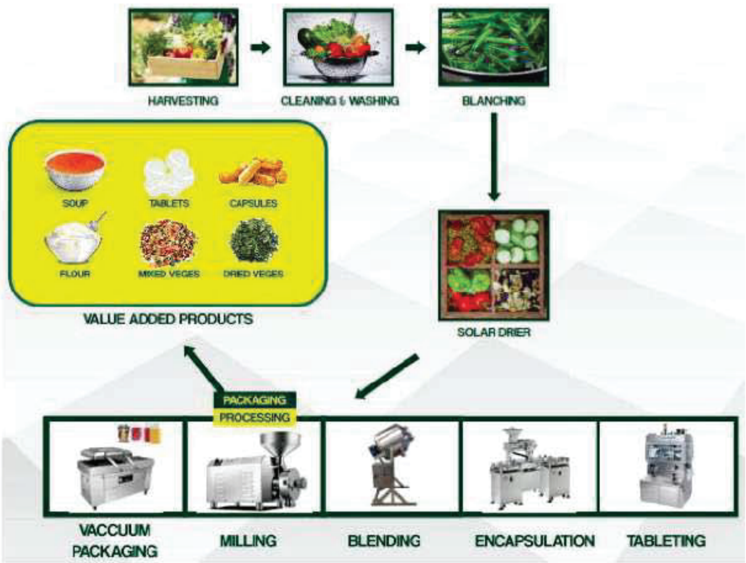
George Wanjala, Shadrack Makori, Linus K'osambo M.D.0, Stella Wanjiku,

Intervention Partners

INNOTECH

Fraunhofer ISE

Technology Intervention: Working with communities and partners at the Coast to respond to climate change and socio economic barriers by embracing solar drying of fruits and vegetables



Fruits and vegetables challanges

- High postharvest losses
- Seasonal production resulting in glut and scarcity (unreliable supply)
- Low value addition

Opportunities for fruits and vegetables

- Growing demand for dehydrated products
- Unique applications for culinary and health applications

Objective: Enhance quality and safety of fruits and vegetables for production of higher value products

Approach: (Solar processing 100% off grid) optimizing on climate smart energy hence reduce GHG emissions

FOCUS: Industrial Research on dehydration and new product development for increased productivity, income generation, food and nutrition security and reduction in posthaverst lossess

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CLIMATE SMART AGRICULTURE AS A NOVEL APPROACH IN THE VALORIZATION OF FRUITS AND VEGETABLE WASTES AS SUSTAINABLE ECO MATERIALS FOR HIGH VALUE ADDED PRODUCTS.

Shadrack Isaboke Makori, George Wafula Wanjala, Linus K'osambo M.D.0

Intervention Partners

With support from Federal Ministry of Food, Agriculture and Consumer Protection by Decision of the German Bundestag

KMFRI

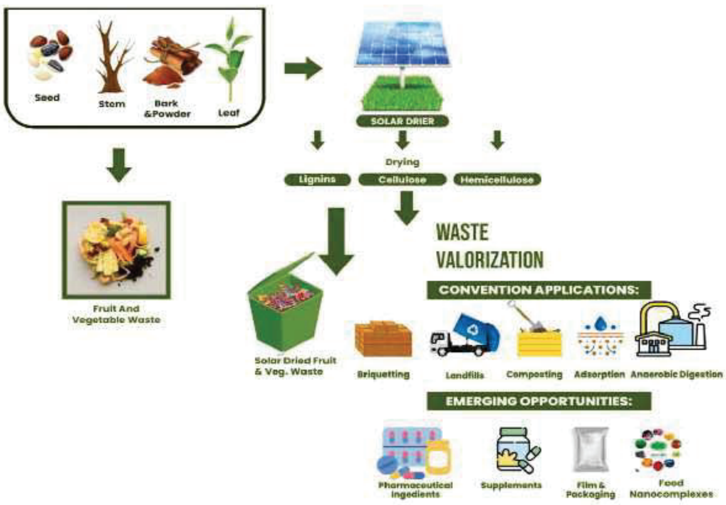
INNOTECH

Fraunhofer ISE

Strategic Technology Intervention:

Working with farmers, marketers, Industrial processors and partners at the Coast to utilize the high amounts of wastes generated from fruits and vegetable for sustainable socio economic development

Concept: Circular Bioeconomy



Required Inputs Design:

- Fruits and vegetable wastes
- Valorization station
- Product development Research, Technology and Innovation concept
- Sustainability for the production of Eco friendly innovative products

Expected Output

- Natural Eco friendly products
- Industrialization and employment creation

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Development of Milkfish (Chanos chanos) and Kimarawali (Stolephorus delecatulus) Solar Drying-Cooling Technology, Value Addition and Quality Assurance

Linus K'osambo M.D.O, Jackis Auka, Sarah Kwach, Winston Asugo, Stephen Midega, James Mwaluma, Peter Odote, Morine Mukam, Huxley Makonde, Alber Esper, Norbert Pfanner and Alexander Morgenstern

Intervention Partners

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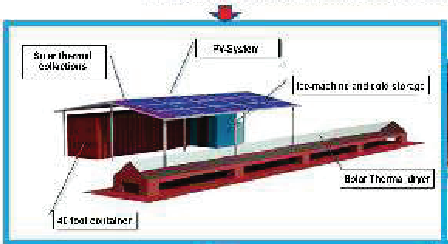
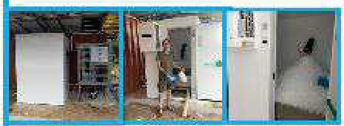
Technology Intervention: Improving Pre and Post Harvest Handling and Processing of Agri Produce through SolCoolDry System

Diagramatic representation of the SolCoolDry System





Cold Room, Ice machine and ice production

Installed SolCoolDry System at Mwazaro in Kwale

FOCUS: High Impact renewable energy-powered food processing technologies

SolCoolDry Innovation Objectives: 100% Off-Grid Solution

- Develop a model solar powered hybrid cooling and drying system
- Establish fish handling and processing centres
- Establish quality system and recommended good production practices
- Produce longer shelf-life milkfish in Coast and Inland Markets

SolCoolDry System Components and Functionalities

- Solar powered system equiped with battery storage units.
- Can produce ice for fish and agro-produce cold-chain.
- Solar Thermal collectors connected to calorimeter for heat storage for night time drying.
- Has two tent solar dryers equipment with solar powered ventilators and sensors
- Each solar dryer is 22 meters can run in rainy days.
- Integrated Solar Dryer is designed to operate day and night
- SolCoolDry System to be operated as an Industrial Research, Innovation and Business Hub
- Leverage public-private sector partnership for sustainability and profitability.

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AQUACULTURE OF SEAWEEDS AND FISH: OPPORTUNITIES FOR BLUE ECONOMIC EMPOWERMENT AND COVID-19 RESILIENCE OF FISHER WOMEN IN KENYA (BLUE EMPOWERMENT PROJECT)

Linus K'osambo M.D.O, Justine Anyango Ochieng, Stella Wanjiku, Eva Komba, Fatuma Usi, Tei Usi, Morine Mukami, Caroline Wanjiru, Josephine Obondo, Elsie Wajiku, Victor Opondo, Catherine Kilelu and Joel Onyango

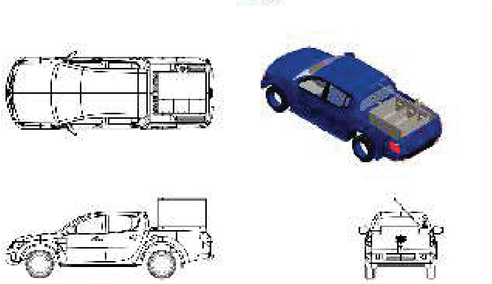
Intervention Partners

SEA MOSS CORPORATION LTD

Technology Intervention: Working with community members and partners at the Coast to respond to climate change and socio-economic barriers that limit access to the sea by embracing Insert Integrated Multi-Trophic Aquaculture (IMTA) innovation of seaweed and fish

Participatory cage construction and launch into the sea with community members at Mwazaro in Kwale County

Fabrication of an Innovative Fish Fingerling Transport Unit: optimizing low carbon technology promoting restorative biological diversity.



FOCUS: Industrial research on IMTA and new horizons for higher produtivity in the inland and marine Blue Economy sectors

Objective: Enhance higher production of cottonii and spinosum seaweed in IMTA systems

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KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

REFRACTANCE WINDOW DRYING TECHNOLOGY FOR PRODUCTION OF HIGH QUALITY BIOPRODUCTS; INTERGRATION IN THE SOLCOOLDRY SYSTEM

Dr. George Wanjala, Prof. John Muyonga , Prof. Arnold Onyango, Eng. Joseph Kamau, Mr. Nicholas Ngetich, Linus K'osambo M.D.0, Dr. Shadrack Makori and Ms. Stella Ndungu

Intervention Partners

With support from Federal Ministry of Food, Agriculture and Consumer Protection by decision of the German Bundestag

K.M.F.R.I

INNOTECH

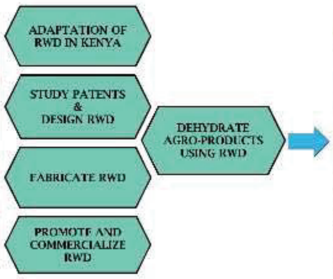
Fraunhofer ISE

INTRODUCTION: The utilization of Refractance Window Drying (in production of high value bio products RWD uses Refractance energy to drive the dehydration process This reduces postharvest loss that causes food insecurity, livelihoods loss and malnutrition Many drying mechanisms are slow, expensive, inefficient and not easily adaptable

PROBLEM STATEMENT

- High postharvest losses results food spoilage
- Dehydration technologies for sensitive products are expensive poorly adaptable
- RWD retains nutrients, bioactive compounds, colour, flavour and aroma
- It is versatile, innovative for flexible operations and 100 off grid compatibility

RWD TECHNOLOGY ADAPTATION AND DEPLOYEMENT IN KENYA


CONCLUSION AND RECOMMENDATIONS

- Designed and fabricated a two station RWD
- Reduced drying time from 8 hours to 2 hours indigenous vegetables, mango puree, herbs and ripe avocado puree
- Current interests Fruits cooperative, Agro processors and Agro enterprises
- RWD can be integrated with the SolCoolDry system 100 off grid

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@kirdi_kenya kirdi.kenya kirdi_kenya kirdikenya

Research | Innovate | Commercialize

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

A Centre of Excellence in innovative Research in Marine, Fisheries and the Blue Economy for Development

THE EVOLUTION OF DRYING TECHNOLOGIES ALONG THE KENYAN COAST

Oduor-Odote Peter, Marigu Josephine, Ruwa Raymond, Jefwa Winnie & Achieng' Rael

A. THE DRIED SARDINES (DAGAAA) VALUE CHAIN

1. Ground: Outdoor sardine drying on the ground

2. Drying racks: Outdoor solar drying on raised racks

3. Dome dryer: Ventilated indoor solar drying of sardines

B. DRIED TABLE-SIZE FISH (NG'ONDA) VALUE CHAIN

4. Solar tunnel dryer: Drying of fish/ produce with high moisture content

5. Hybrid windmill solar tunnel dryer: 24-hour drying fish/ farm produce; integrated ice production unit

C. INTERGRATED SYSTEM

6. SOLCOOLDRY System : 24-hour, All-season, High capacity drying with increased volume of ice flake production for fish preservation

Contact us: Kenya Marine and Fisheries Research Institute **P.O. Box** 81651-80100, Silos Road, Mombasa, KENYA.
Phone: +254 (20) 8021561, (20) 8021560, 0712003853. **Website:** https://www.kmfri.co.ke/

Annex II. Workshop Presentations

Session 1, Presentation 1

KIRDI
Your Industrial Technology Partner...

KENYA VISION 2030

SolCoolDry Research, Innovation & Business Hub: Installation and Recommendations for Processes Engineering for Sustainability

Dr. Linus K'osambo M.D.O.
Senior Research Scientist - KIRDI

PRESENTED AT THE SOLCOOLDRY WORKSHOP AT KMFRI MOMBASA

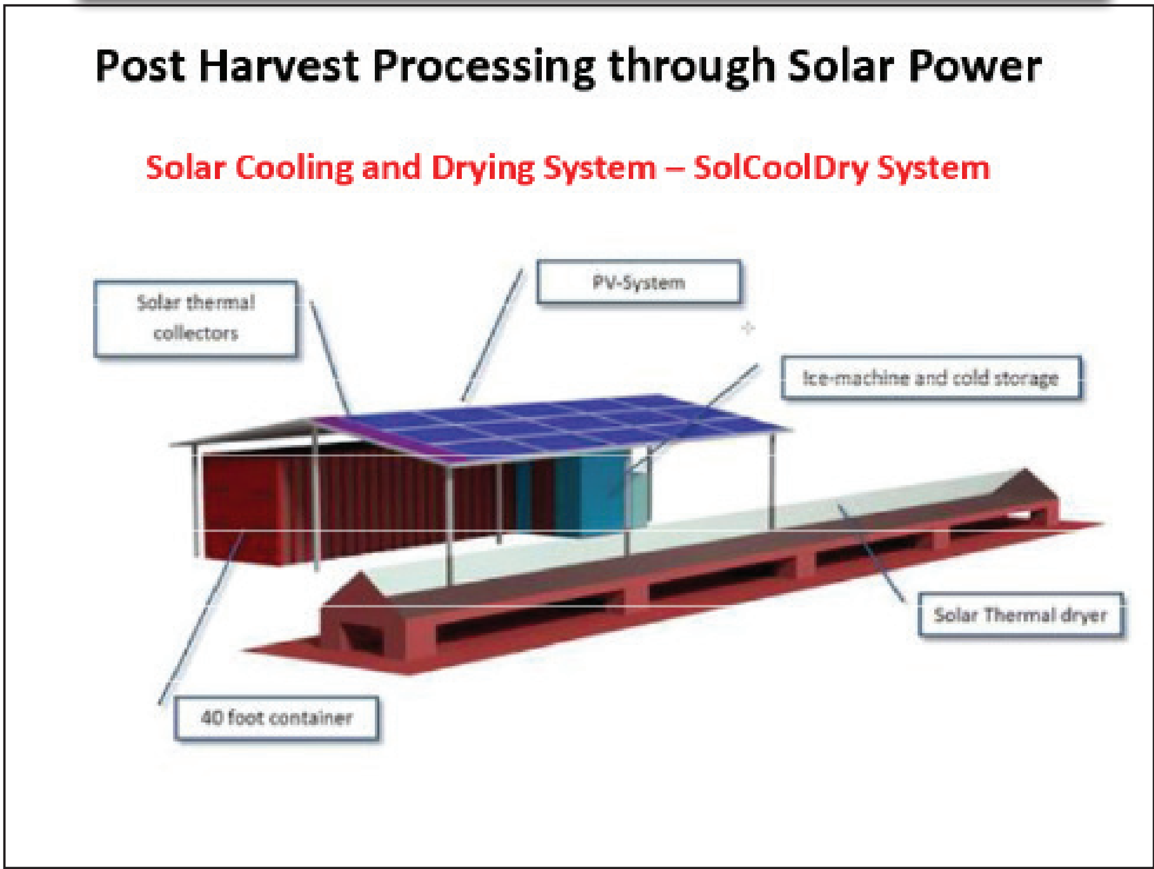
SOLCOOLDRY HOST- MWAZARO BMU SELF HELP GROUP

SolCoolDry Host: Mwazaro BMU SHG

- Mwazaro BMU Self Help Group is a registered community organization in Lunga Lunga Sub County, Kwale.
- Mwazaro BMU Self Help Group is a member of Bahari CBO Network that consists of 13 organizations based in Kwale County of Kenya

- Mmangrove restoration initiatives
- Milkfish farming
- Mwazaro is headed by a Chairman and an executive committee.
- The group that is internally organized into 25-member business units

INSTALLATION: PARTNERSHIPS TO BUILD LOCAL ENGINEERING CAPACITY



From the first Measurement to the first Experiment

- Engineers Midega and Auka taking the first measurement
- Laying the foundation of for the dryers

- SolCoolDry Hub ready for launch
- KIRDI Food Scienstiists drying mangoes

SolCoolDry Research, Innovation and Business Hub

SolCoolDry as a Research, Innovation and Business Hub

- Ice for fish preservation and handling
- Fish drying and packaging
- Outdoor delicacies Parlour
- Online Marketing Portal and Website

- Onsite Research, Training and Educational Tourism Platform
- Blue Economy Promotion Portal: fish, seaweed farming
- Leveraging Local Innovations and Resources: coconut, fruits, root crops

SolCoolDry System as an ice producer, fish drier and plug-in hub for adaptable solar-powered innovations, value addition concepts and expoiting of Blue Economy opportunities

SolCoolDry Ice Production

- Solar powered ice production for the preservation of fish and other loal fresh produce

Ice Production Maximum Capacity

Optimise ice production: daily (500kg), monthly (15,000 kg)

SolCoolDry Fish Dryng

Fish drying

Drying process documentation

- The SolCoolDry Hub is located in an area with access to fish landing sites of Gazi, Bati, Shimoni, Kijiweni, Kibuyuni, Vanga and Jazini.

- Fish drying will be central in helping the fishers from these fish landing sites to dry their fish.

- **The SolCoolDry Hub will model three sets of fish drying offers:**

(i) Fish Handling (cleaning, boiling, drying, packaging) services

(ii) Daily drying Leasing of fish drying space

Contractual Drying of Agro Produce

Sweetpotato cubes drying

Squid/ngisi drying

- Agro-produce: problems of post-harvest spoilage and lack of value addition.
- SolCoolDry hub will offer drying and packaging services to these Agro Produce.

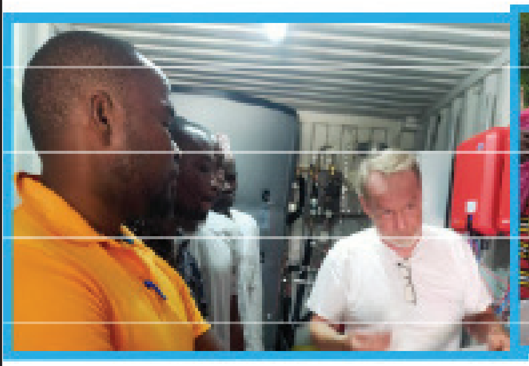
- **SolCoolDry intervention:**

(i) Agro-produce Handling (sorting, cleaning, boiling, drying, packaging) services

(ii) Daily Drying Leasing: Agro-produce drying space chargeable per tray

(iii) SolCoolDry Bulk Agro Produce Drying for marketing at the Hub

SolCoolDry Hub as a Research, Training and Education Tourism Platform



- Adaptation for dissemination to rural off-grid communities.
- Platform for studying, optimizing and adapting the system for local fabrication.
- Training platform on good production practices, HACCP system, post-harvest handling and value addition.
- Education tourism : schools, colleges, universities and technical institutions .

SolCoolDry

Solar Drying
Solar Cooling

Research, Innovation & Business Hub

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

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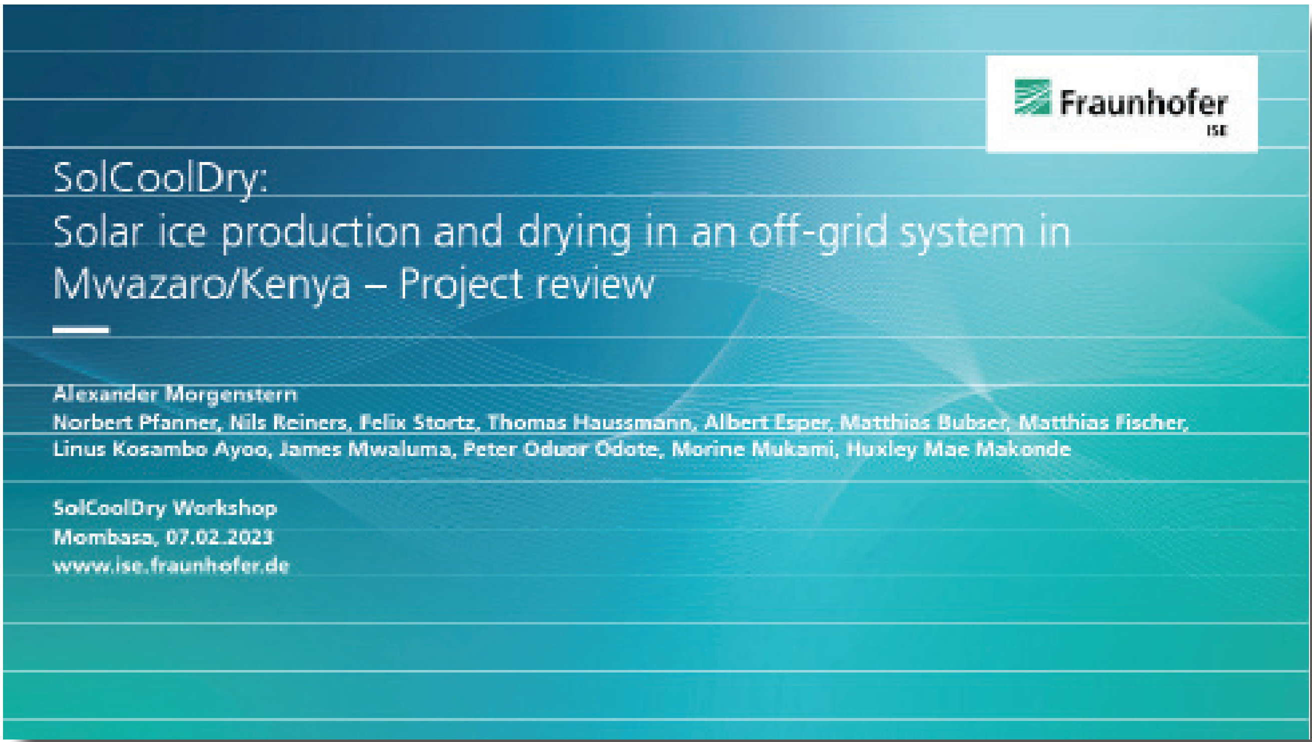
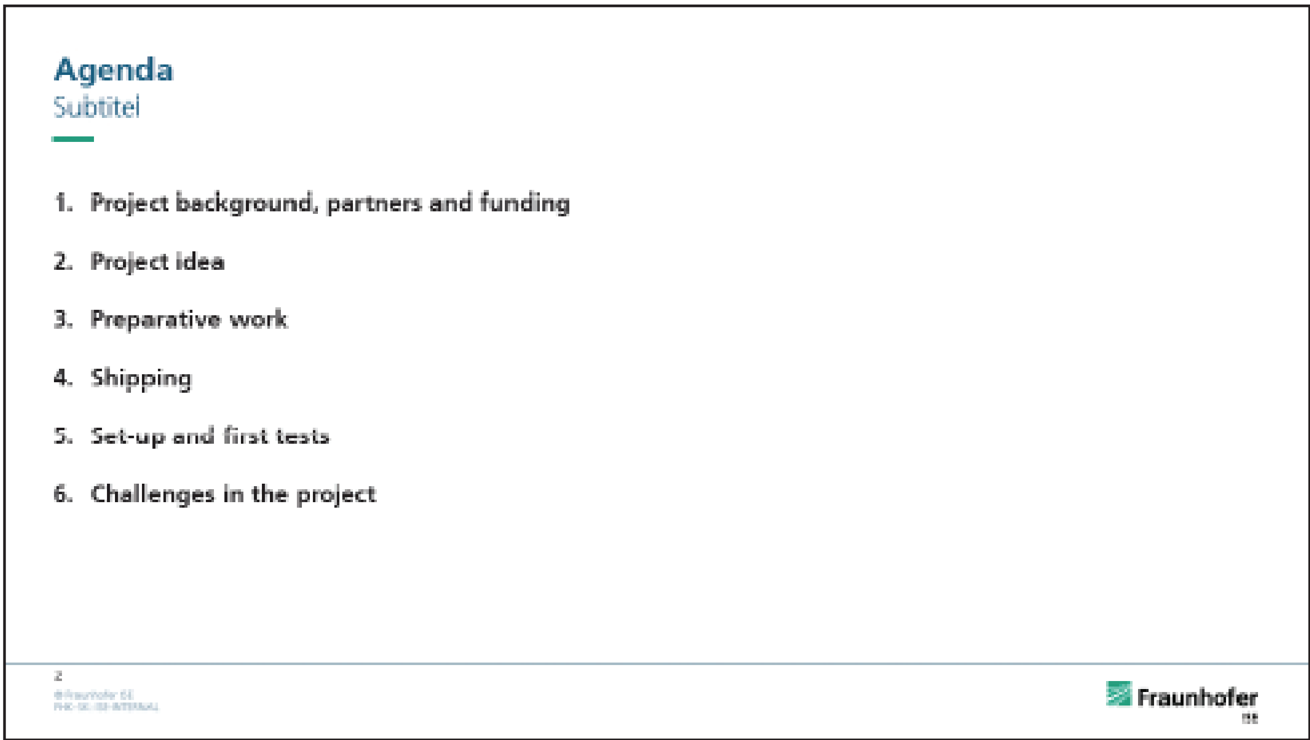
INNOTECH

Thank you!

Session 1, Presentation 2





Background, partners and funding

Background/Intention

- Agriculture and fishery are important sectors of employment and the main drivers of the economy in Kenya
- High post-harvest losses impede economic development and cause health problems
- The reduction of losses may be accomplished by a combination of progress in technical, infrastructural and policy support, as well as awareness, market access and knowledge

Project start

- Funding by the German Federal Office for Agriculture and Food
- Project start in 2019 with the partners

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INNOTECH

3

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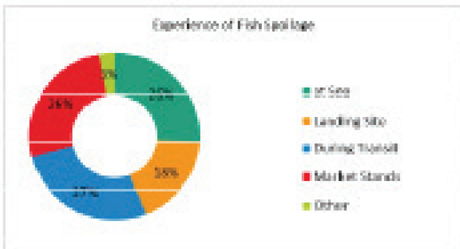
Project idea and system design

History

- First idea: cooling and drying of mangos – highly attractive for foreign customers and consumers
- Focus at fish because of higher nutritional value for the local communities
  - Cold storage and dryer for fish
- Baseline survey by the partners in Kenya after project start and adaptation of the aim to the local requirements
  - Conservation of fish from harvest to market and additional drying capacity
  - Solar autonomous operation for application in rural areas



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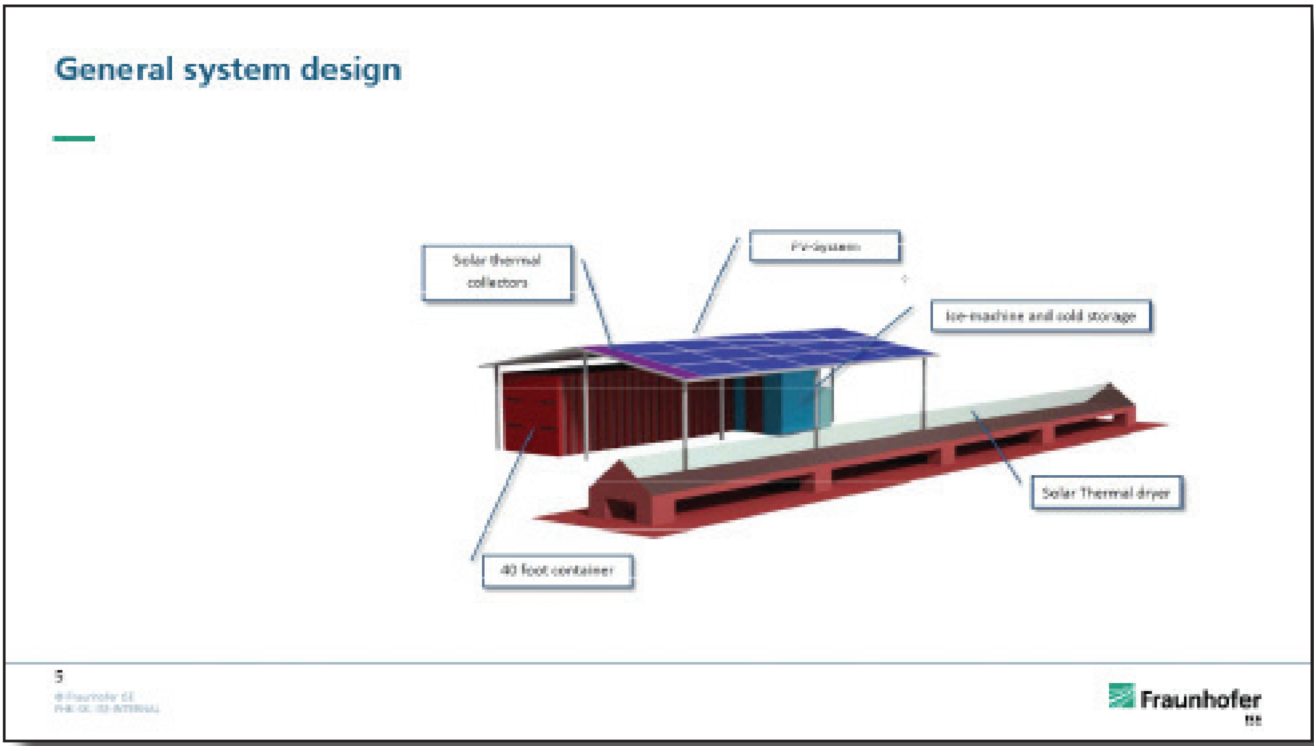
General system design
Solar thermal collectors
PV-System
Ice-machine and cold storage
Solar Thermal dryer
40 foot container
5
Fraunhofer


Solar thermal drying system design
Two solar tunnel dryer
Solar autonomous operation
One with additional heating suport
Thermal system
12 m² flat plate collectors
2000 l heat storage
PV-System
Solar thermal collectors
Ice-machine and ice storage
Solar thermal dryer
40 foot container
6
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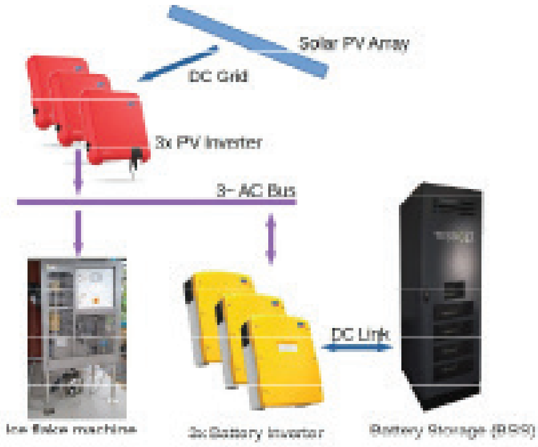
PV Off-Grid Power Supply System – Overview

- PV and battery system
  - Installed PV capacity: 15 kWp
  - Battery capacity (LiFePo): 19.2 kWh
  - AC-power nominal: 13.8 kW
  - AC-power peak: 36 kW
  - 3-phase grid



7

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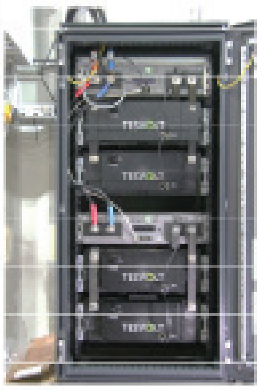
Off-Grid Power Supply System

- Power supply system
  - PV-Inverters (red)
  - Battery-Inverters (grey/yellow)
  - Battery rack with battery management system



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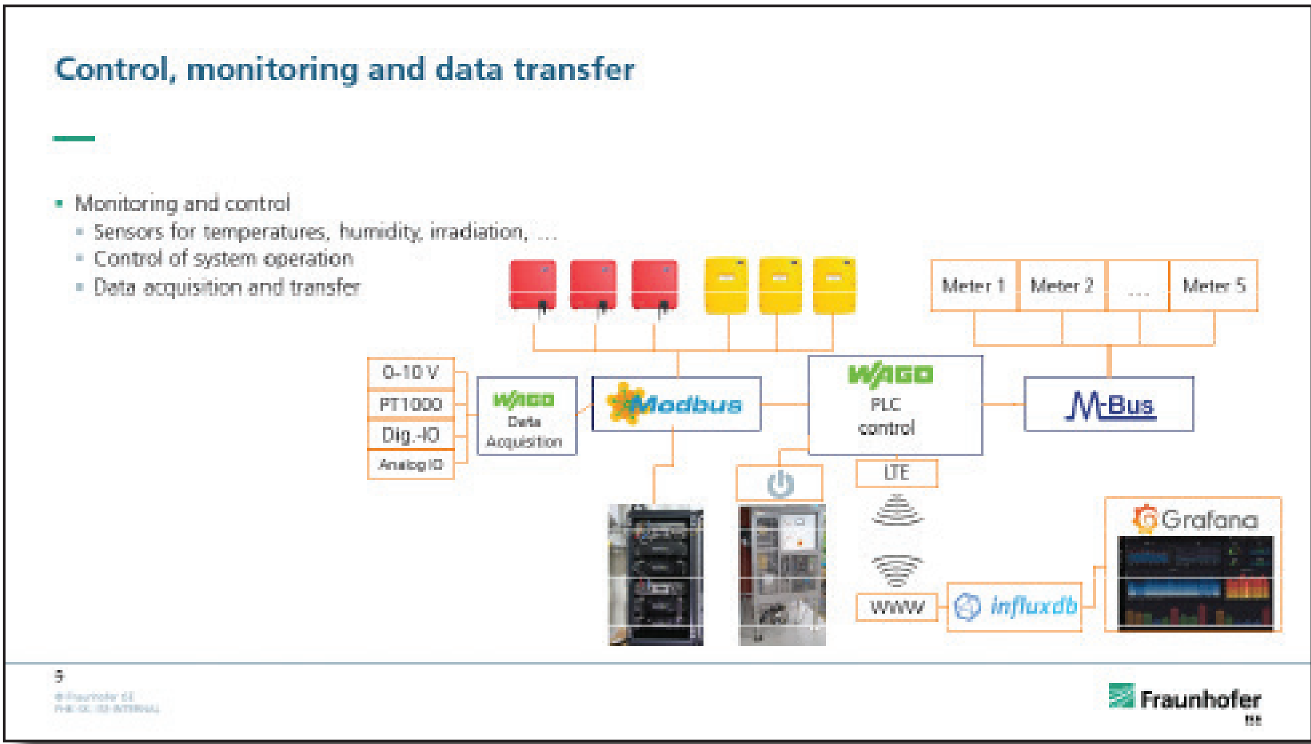
Control, monitoring and data transfer
Monitoring and control
Sensors for temperatures, humidity, irradiation, ...
Control of system operation
Data acquisition and transfer
Meter 1
Meter 2
...
Meter 5
0-10 V
PT1000
Dig.-IO
Analog IO
WAGO
Data Acquisition
Modbus
WAGO
PLC control
M-Bus
LTE
WWW
influxdb
Grafana
9
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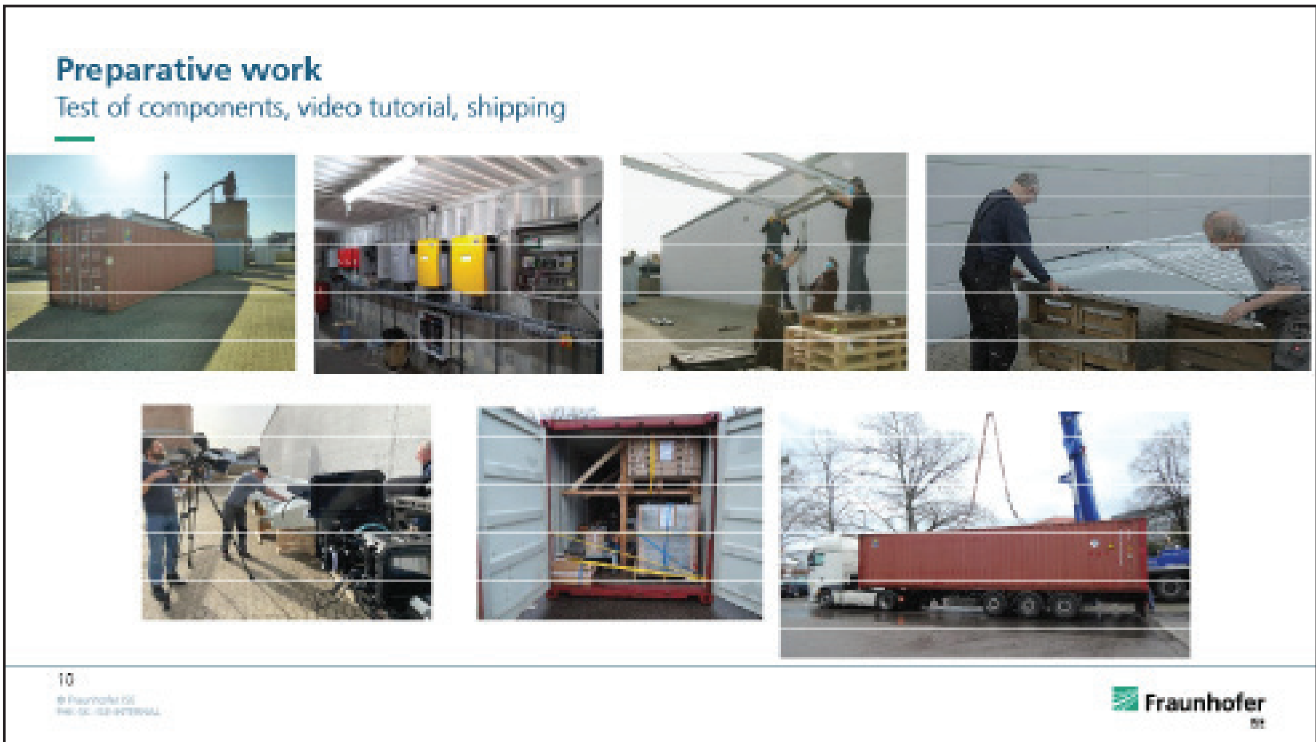
Preparative work
Test of components, video tutorial, shipping
10
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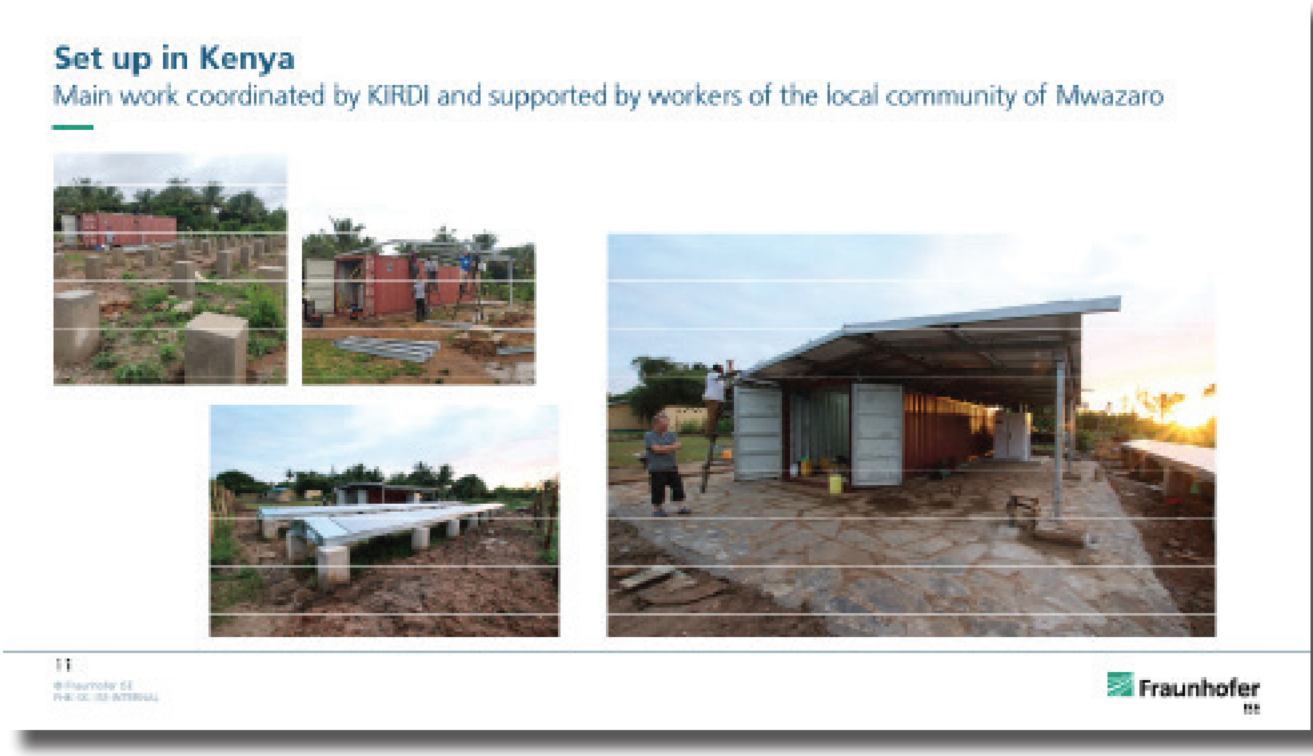
Set up in Kenya
Main work coordinated by KIRDI and supported by workers of the local community of Mwazaro
11
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Finalized system installation
12
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Set up an first tests
Ice production and drying of seaweed
13
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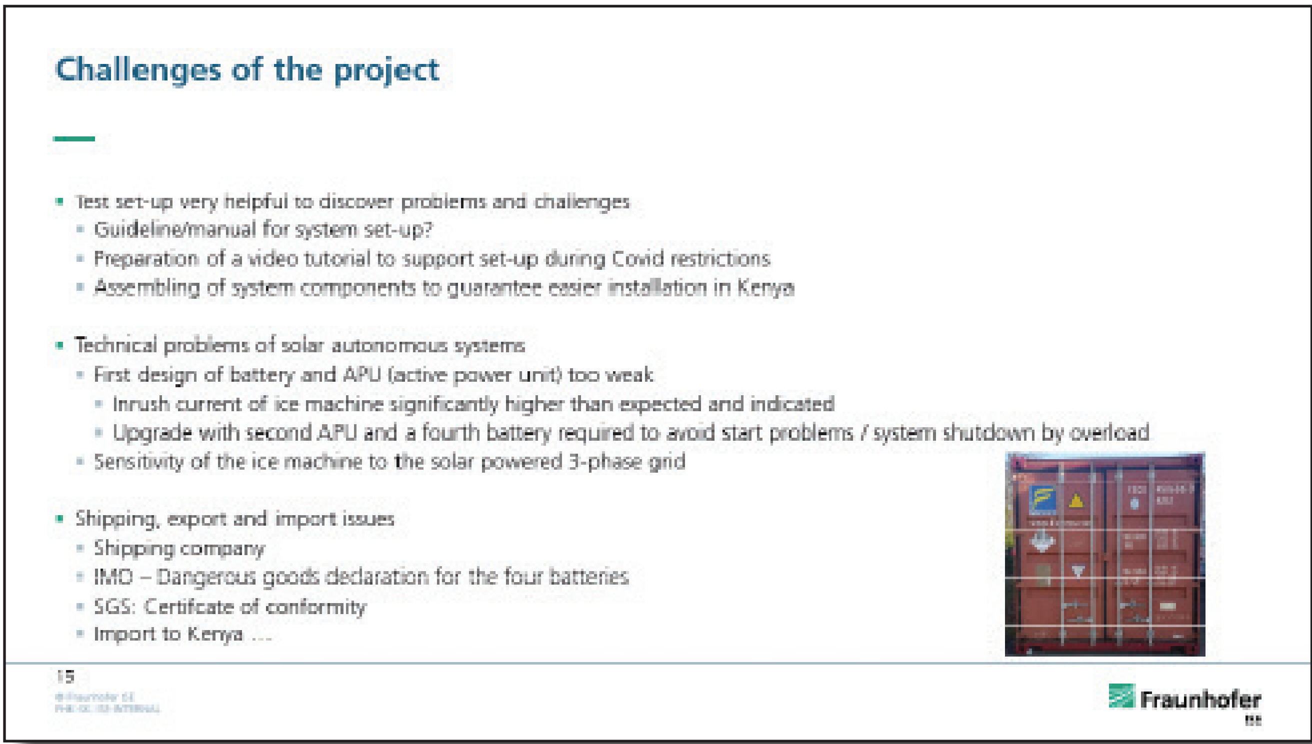
Permanent use of the system since late summer 2022
Drying of different goods and ice production
Ray
Rosella
14
Fraunhofer


Challenges of the project
Test set-up very helpful to discover problems and challenges
Guideline/manual for system set-up?
Preparation of a video tutorial to support set-up during Covid restrictions
Assembling of system components to guarantee easier installation in Kenya
Technical problems of solar autonomous systems
First design of battery and APU (active power unit) too weak
Inrush current of ice machine significantly higher than expected and indicated
Upgrade with second APU and a fourth battery required to avoid start problems / system shutdown by overload
Sensitivity of the ice machine to the solar powered 3-phase grid
Shipping, export and import issues
Shipping company
IMO – Dangerous goods declaration for the four batteries
SGS: Certifcate of conformity
Import to Kenya ...
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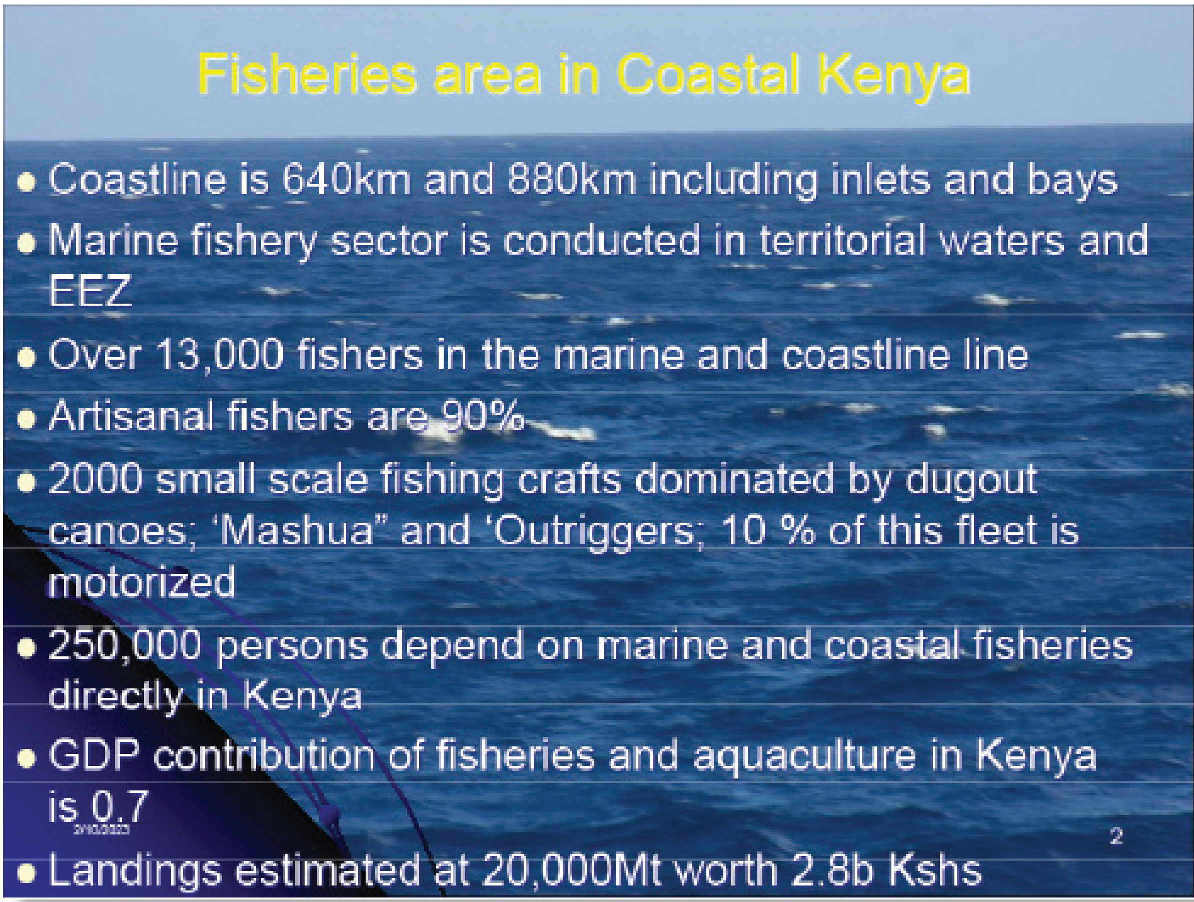
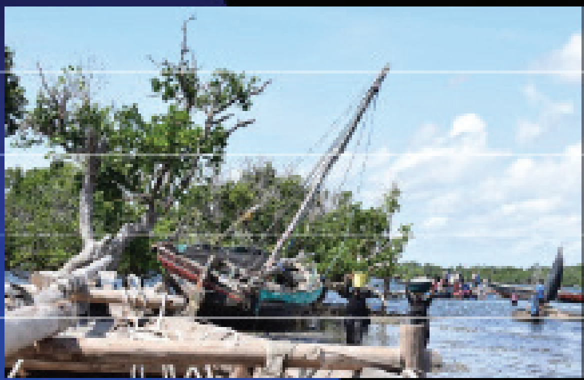
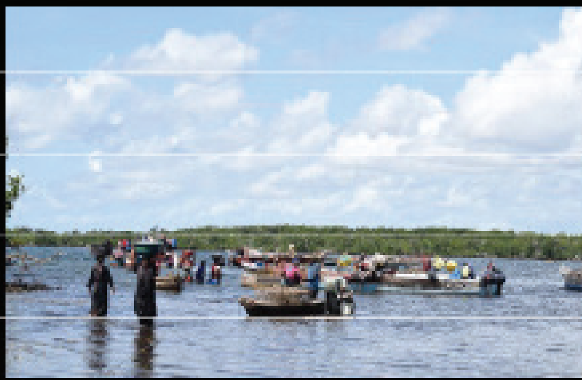
Session 1, Presentation 3



Typical landing time





Species landed in coastal Kenyan waters

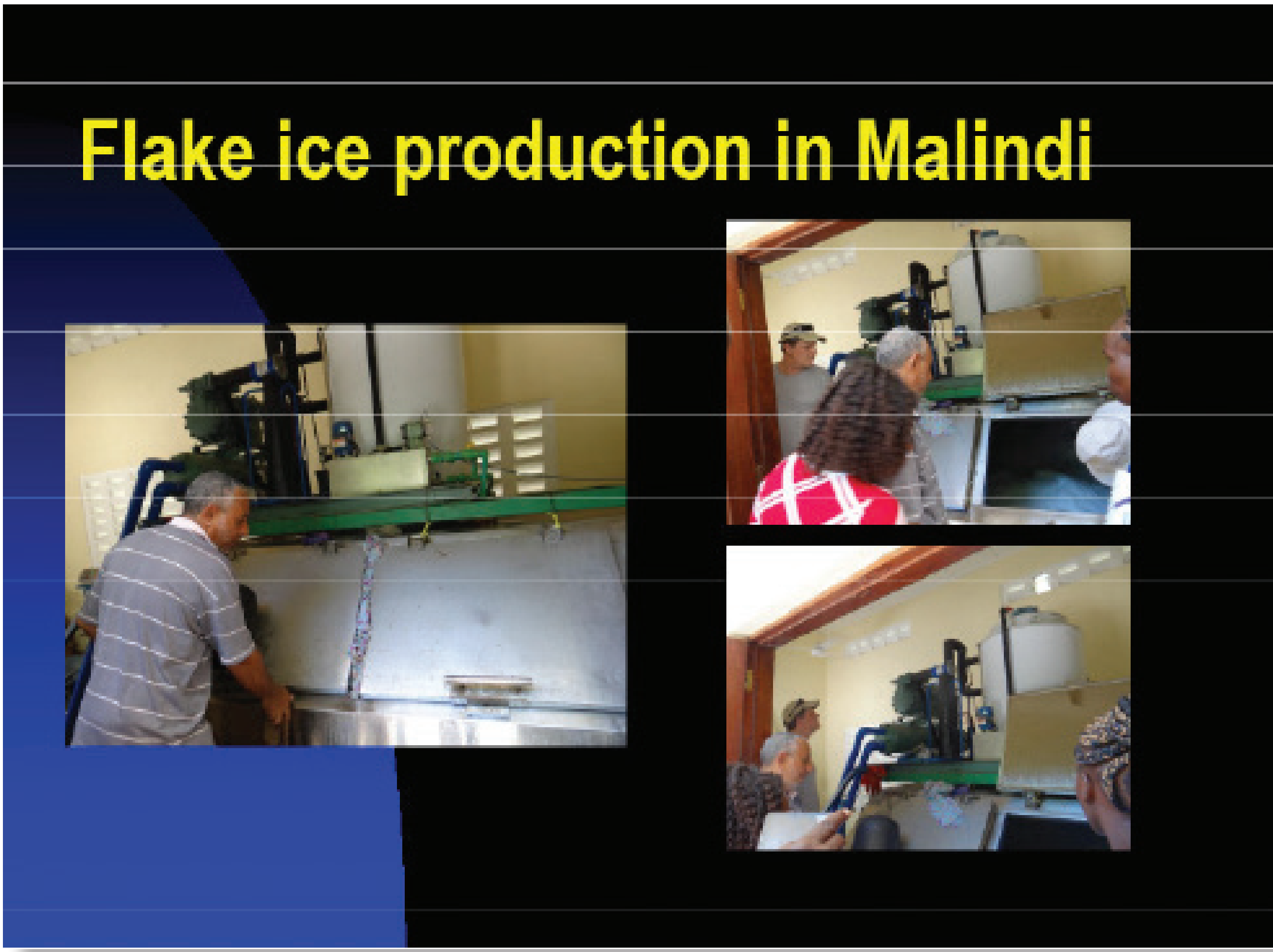
- The demersal fishes have been contributing most of the catch (49.8%),
- followed by pelagic (26%),
- crustaceans (11 %),
- octopus (3.8%),
- sharks and rays (3.3%),
- sardines (3.0%),
- squids (2.0%),
- beche-de-mers (0.7%) and
- oysters (0.3%) in that order.

2/10/2023 4

Spoilage, quality and interventions

- Fish spoils immediately it is out of water
- Main players in coastal fishery with 90% landings are the artisanal fishermen
- There are about 197 fish landing sites along the coastal region from Kiunga to Vanga
- Their landings are important to supply products in the cold chain
- They have few options as their landings spoil during bumper harvest
- The options they have is to reach or have cooling facilities or other preservation methods

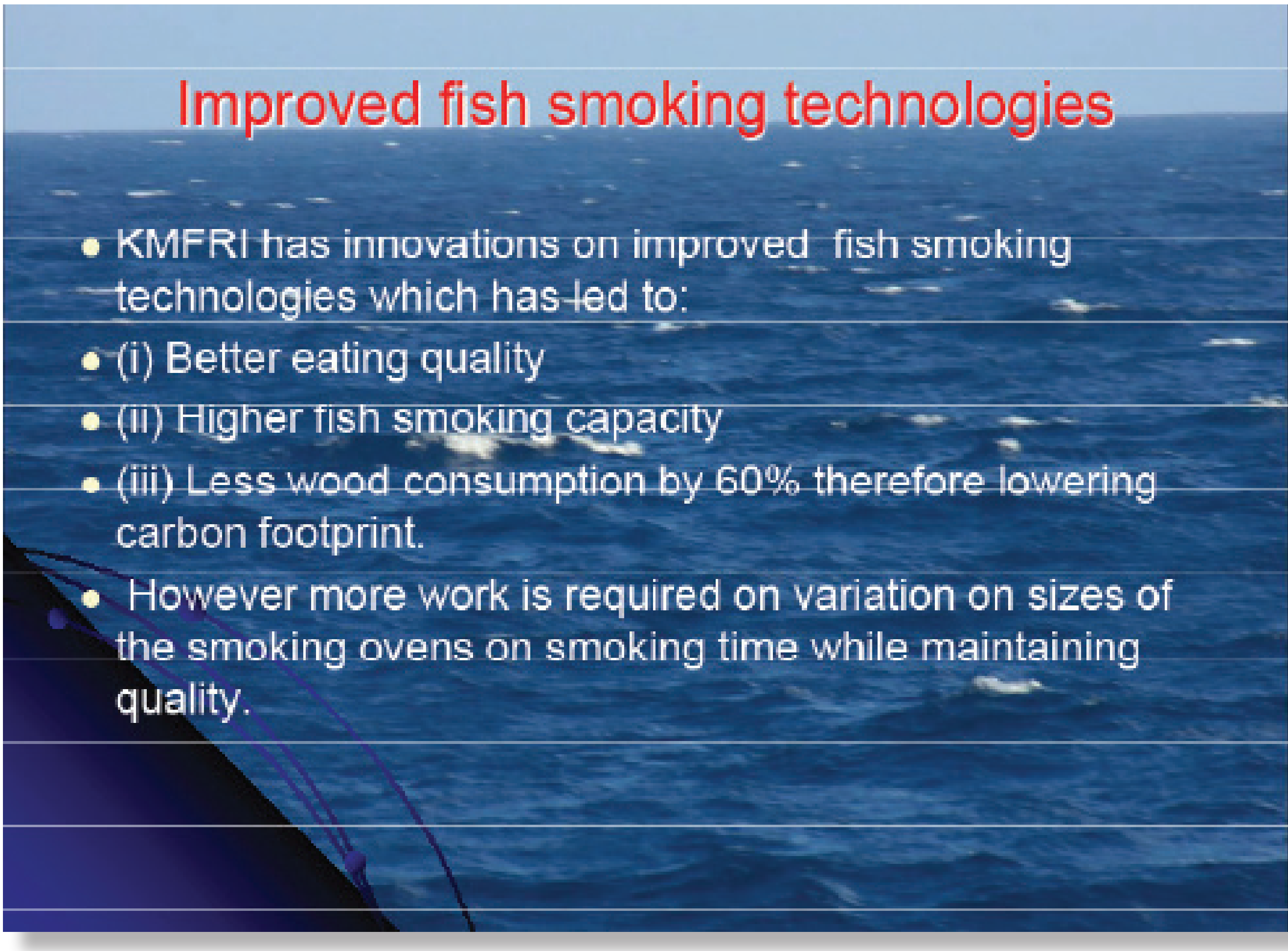
THE COLD CHAIN


Flake ice production in Malindi


DRY CHAIN TECHNOLOGIES
1. Smoked fish dry chain
2. Fried fish chain
3. Dried fish chain

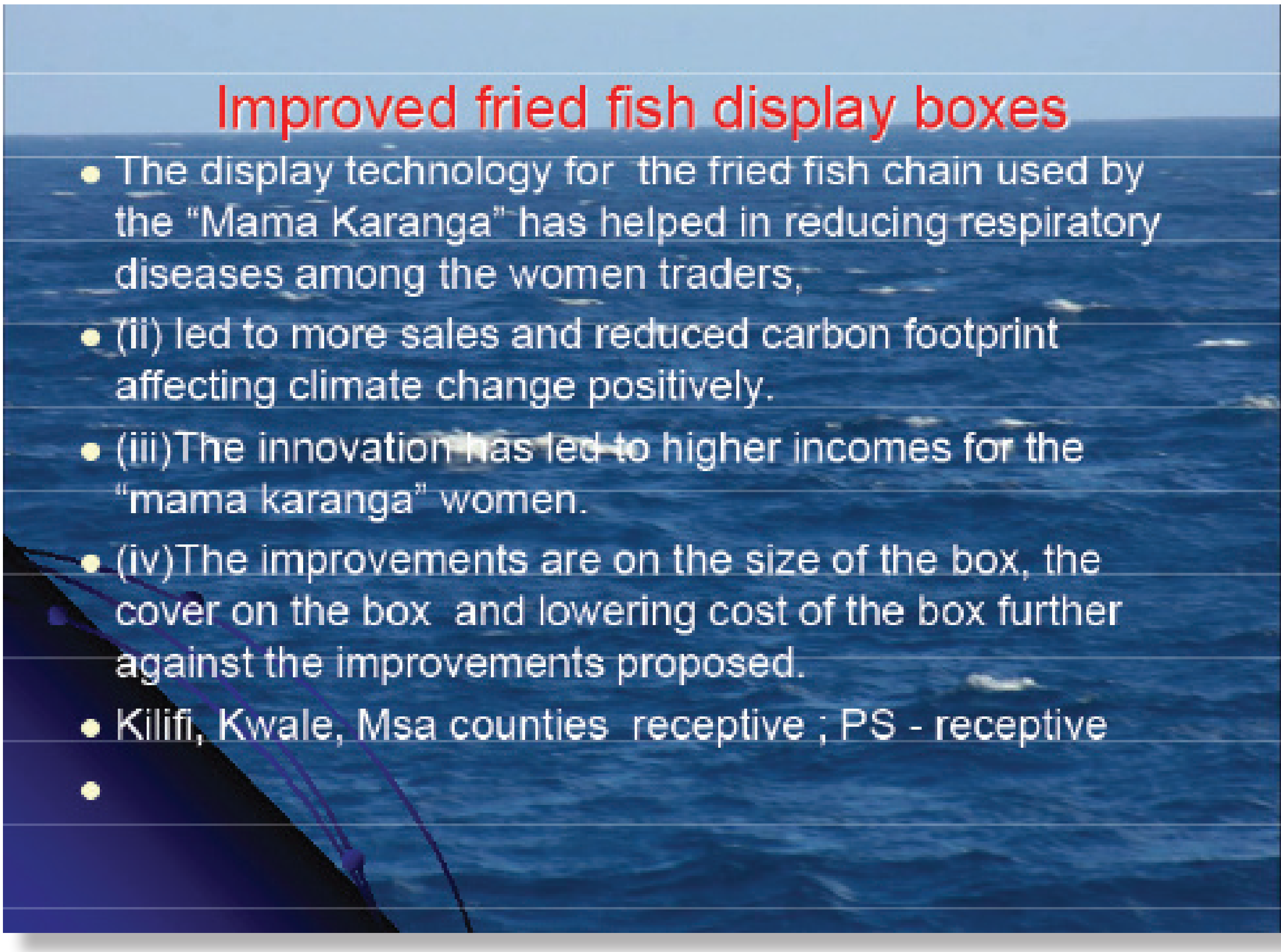

DRY CHAIN TECHNOLOGIES
1. Smoked fish dry chain
2. Fried fish chain
3. Dried fish chain

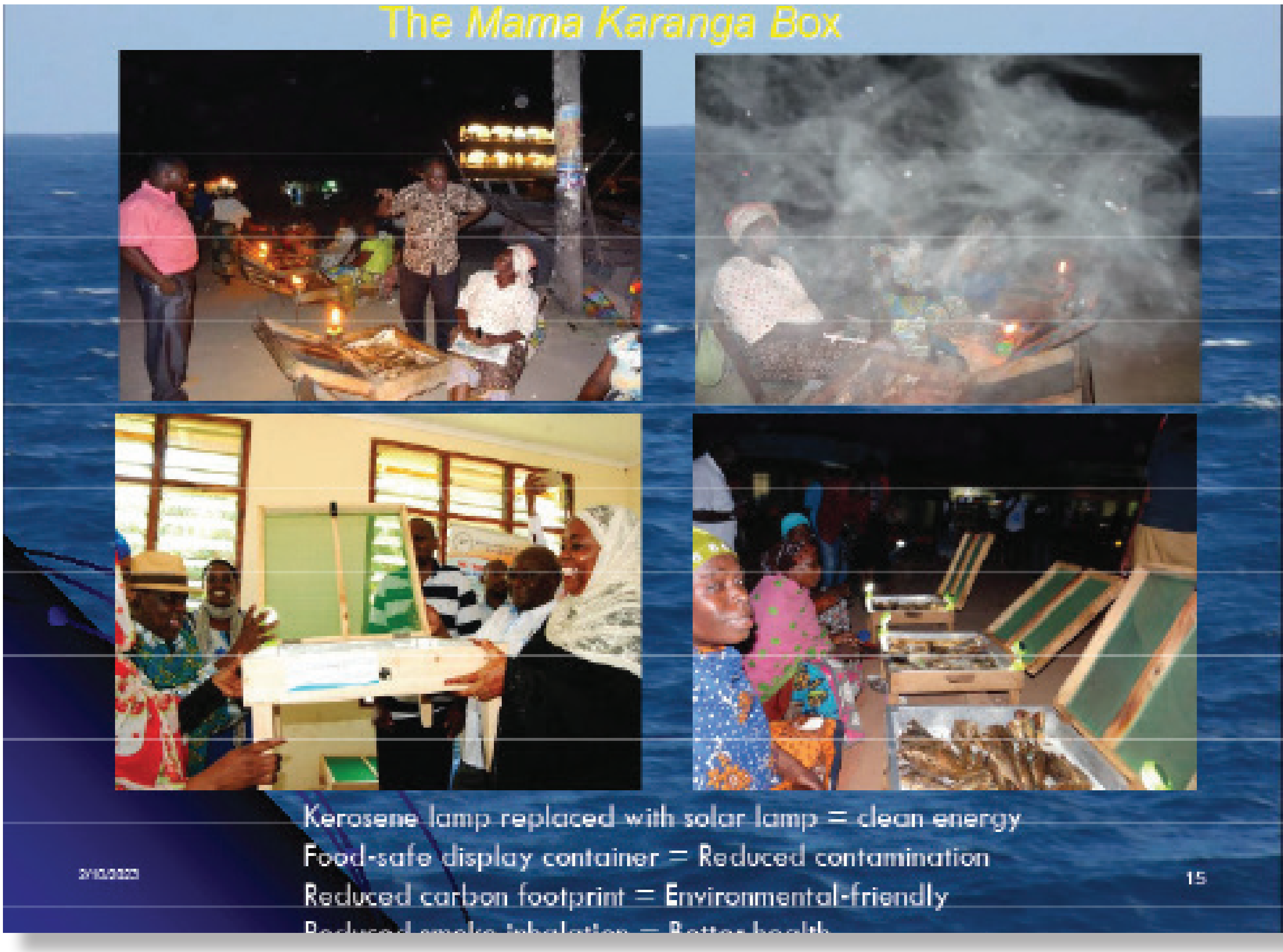

Traditional Fish Smoking Ovens in Lake Kenyatta and Moa
2/10/2023

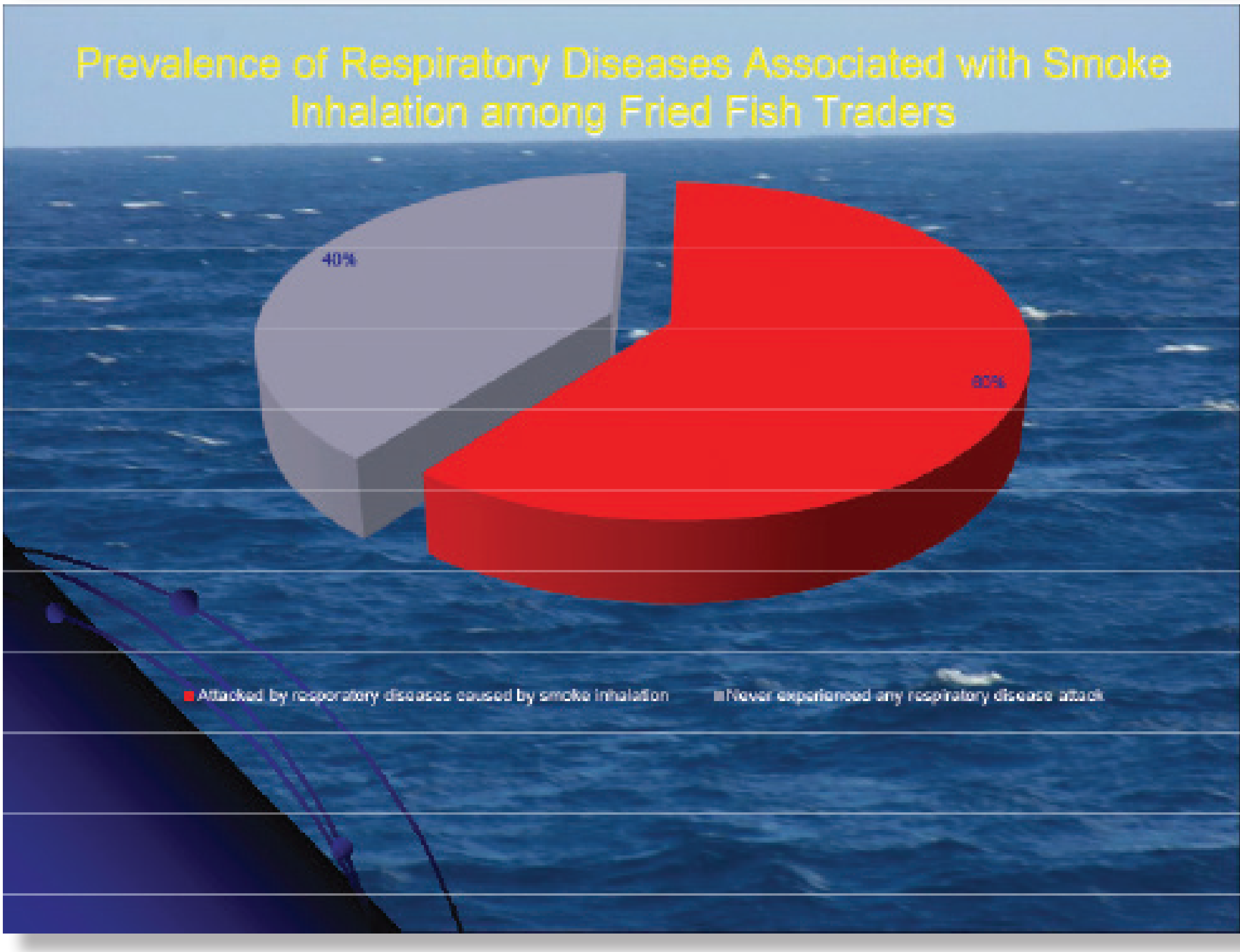

Improved fish smoking technologies
KMFRI has innovations on improved fish smoking technologies which has led to:
(i) Better eating quality
(ii) Higher fish smoking capacity
(iii) Less wood consumption by 60% therefore lowering carbon footprint.
However more work is required on variation on sizes of the smoking ovens on smoking time while maintaining quality.


Improved fish smoking ovens
12

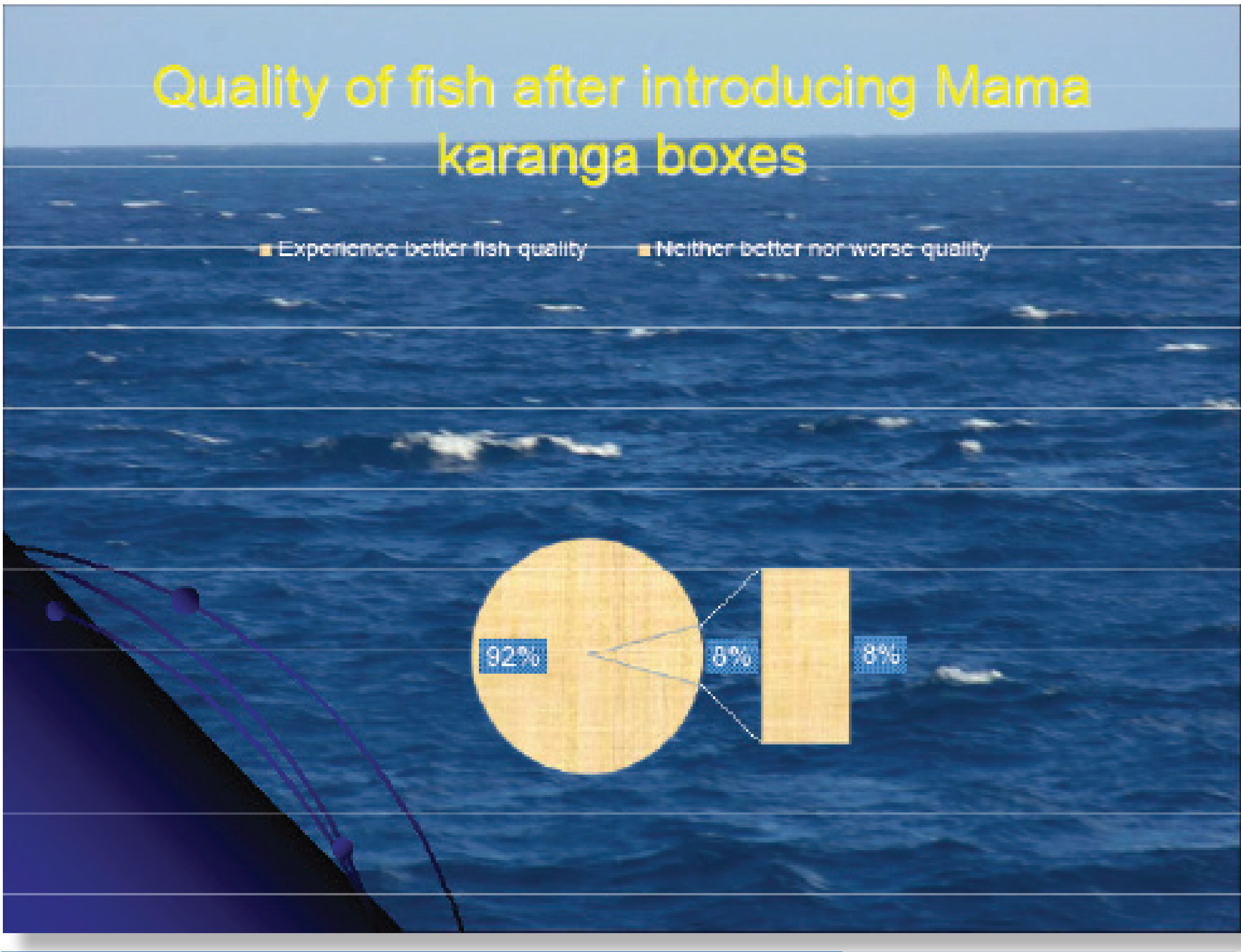

Fried fish chain-The "Mama karanga"

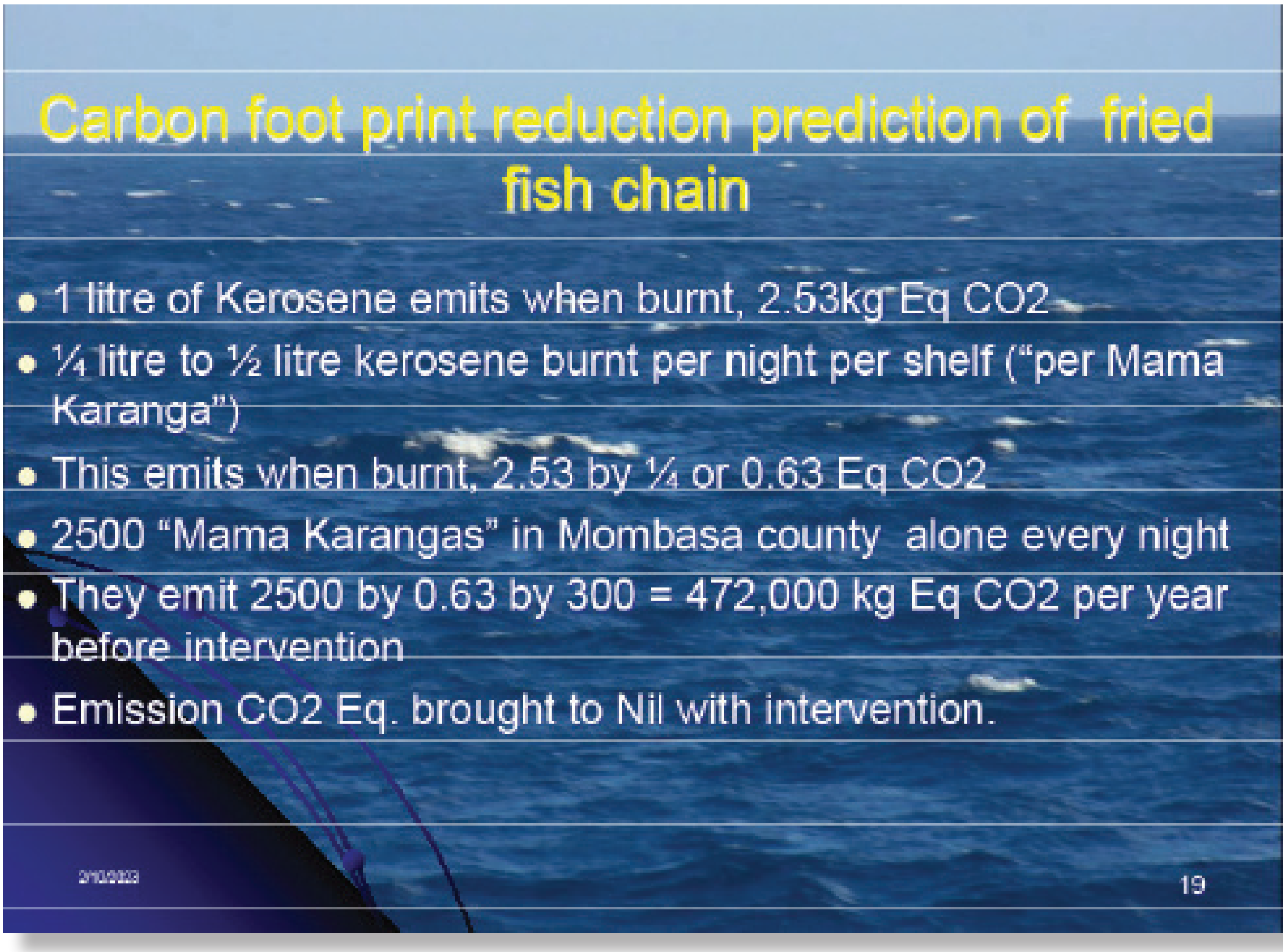

Improved fried fish display boxes
• The display technology for the fried fish chain used by the "Mama Karanga" has helped in reducing respiratory diseases among the women traders,
• (ii) led to more sales and reduced carbon footprint affecting climate change positively.
• (iii)The innovation has led to higher incomes for the "mama karanga" women.
• (iv)The improvements are on the size of the box, the cover on the box and lowering cost of the box further against the improvements proposed.
• Kilifi, Kwale, Msa counties receptive ; PS - receptive
•

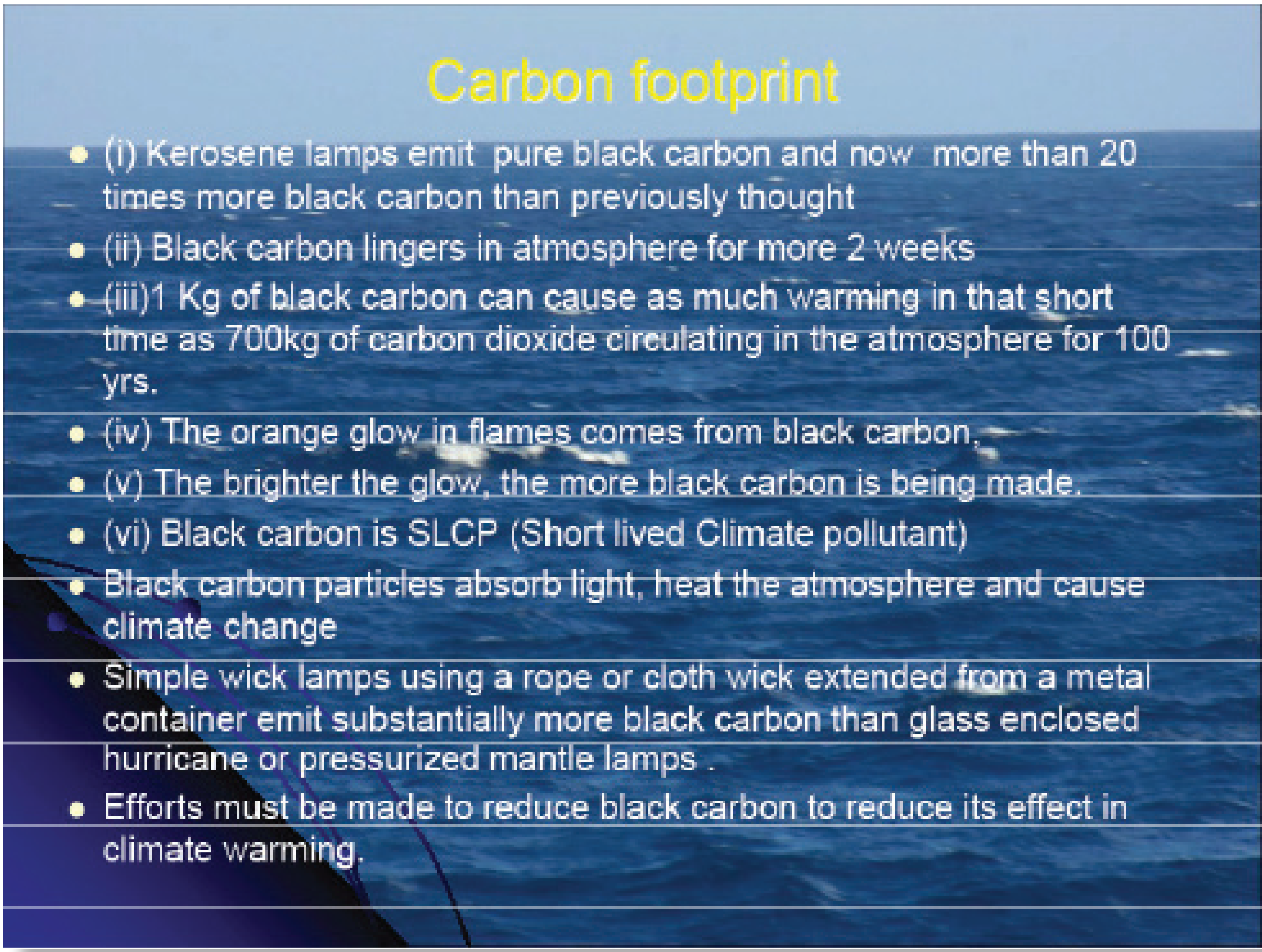

The Mama Karanga Box
Kerosene lamp replaced with solar lamp = clean energy
Food-safe display container = Reduced contamination
Reduced carbon footprint = Environmental-friendly
15


Prevalence of Respiratory Diseases Associated with Smoke Inhalation among Fried Fish Traders
40%
60%
Attacked by resporatory diseases caused by smoke inhalation
Never experienced any respiratory disease attack


Improved traffic for higher sales
% Traffic flow of customers
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
84%
8%
8%
Increased
Constant
Has not noticed anything
% Traffic flow of customers

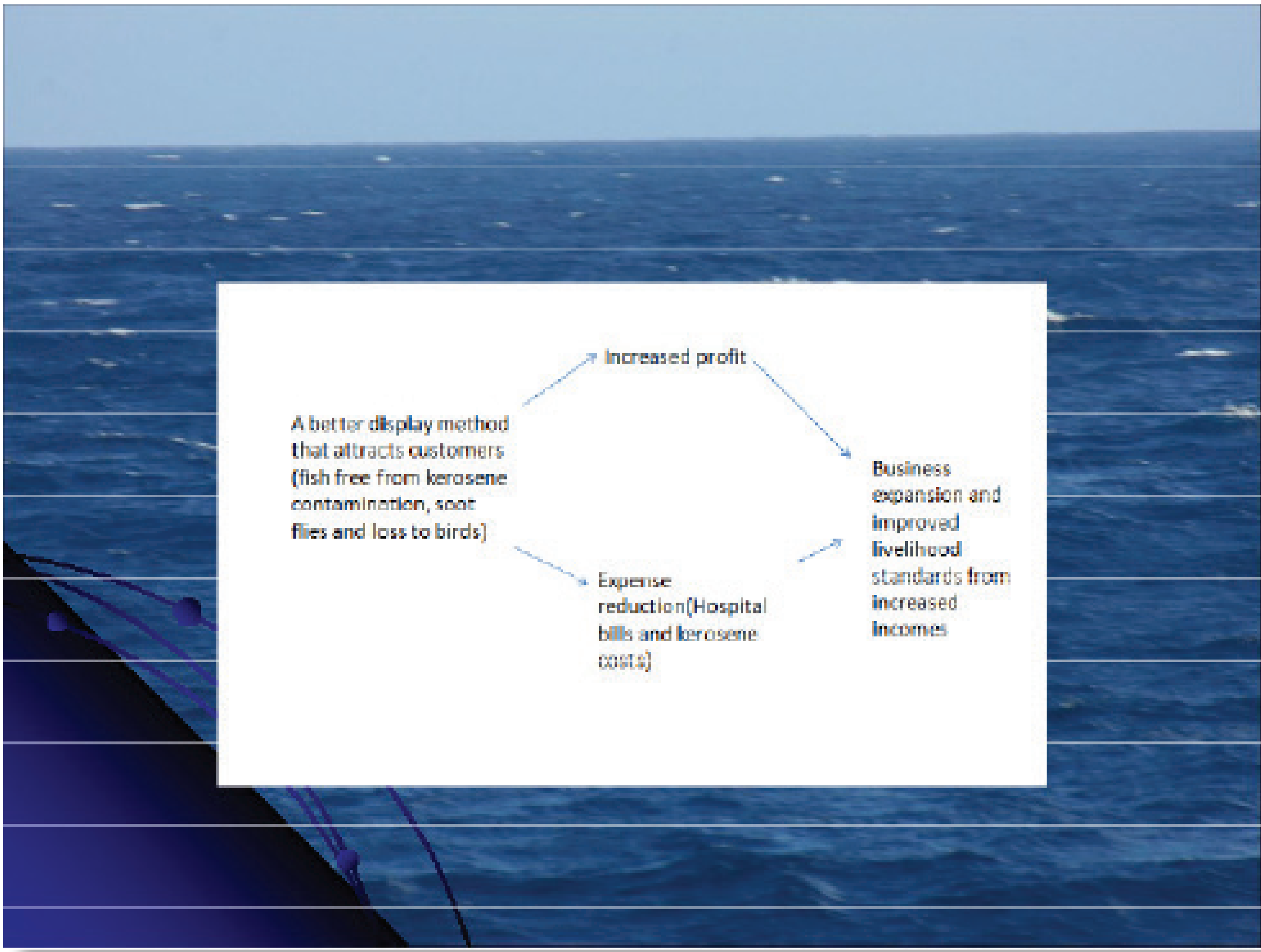

Quality of fish after introducing Mama karanga boxes
Experience better fish quality
Neither better nor worse quality
92%
8%
8%

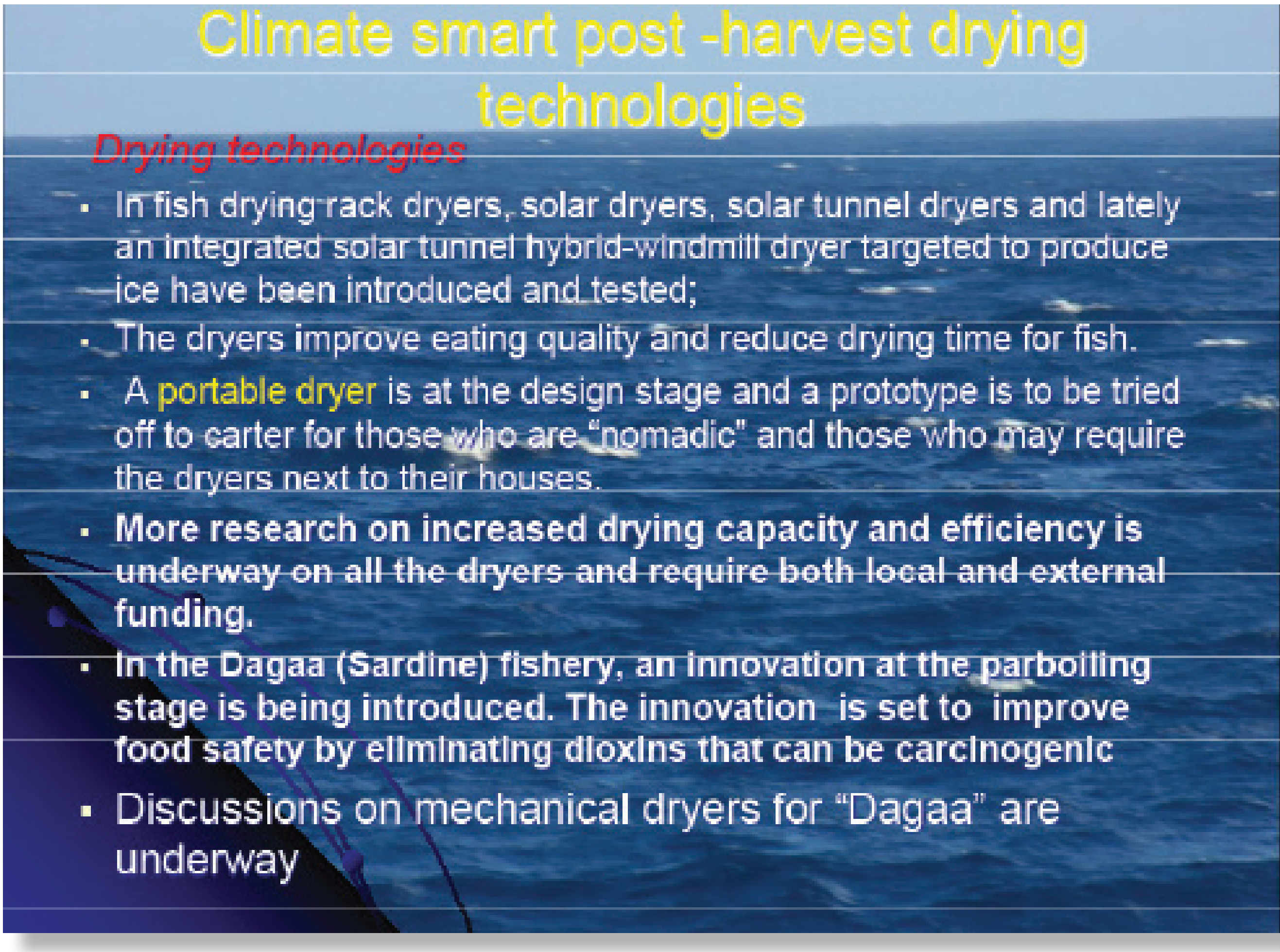

Carbon foot print reduction prediction of fried fish chain
1 litre of Kerosene emits when burnt, 2.53kg Eq CO2
¼ litre to ½ litre kerosene burnt per night per shelf ("per Mama Karanga")
This emits when burnt, 2.53 by ¼ or 0.63 Eq CO2
2500 "Mama Karangas" in Mombasa county alone every night
They emit 2500 by 0.63 by 300 = 472,000 kg Eq CO2 per year before intervention
Emission CO2 Eq. brought to Nil with intervention.
19

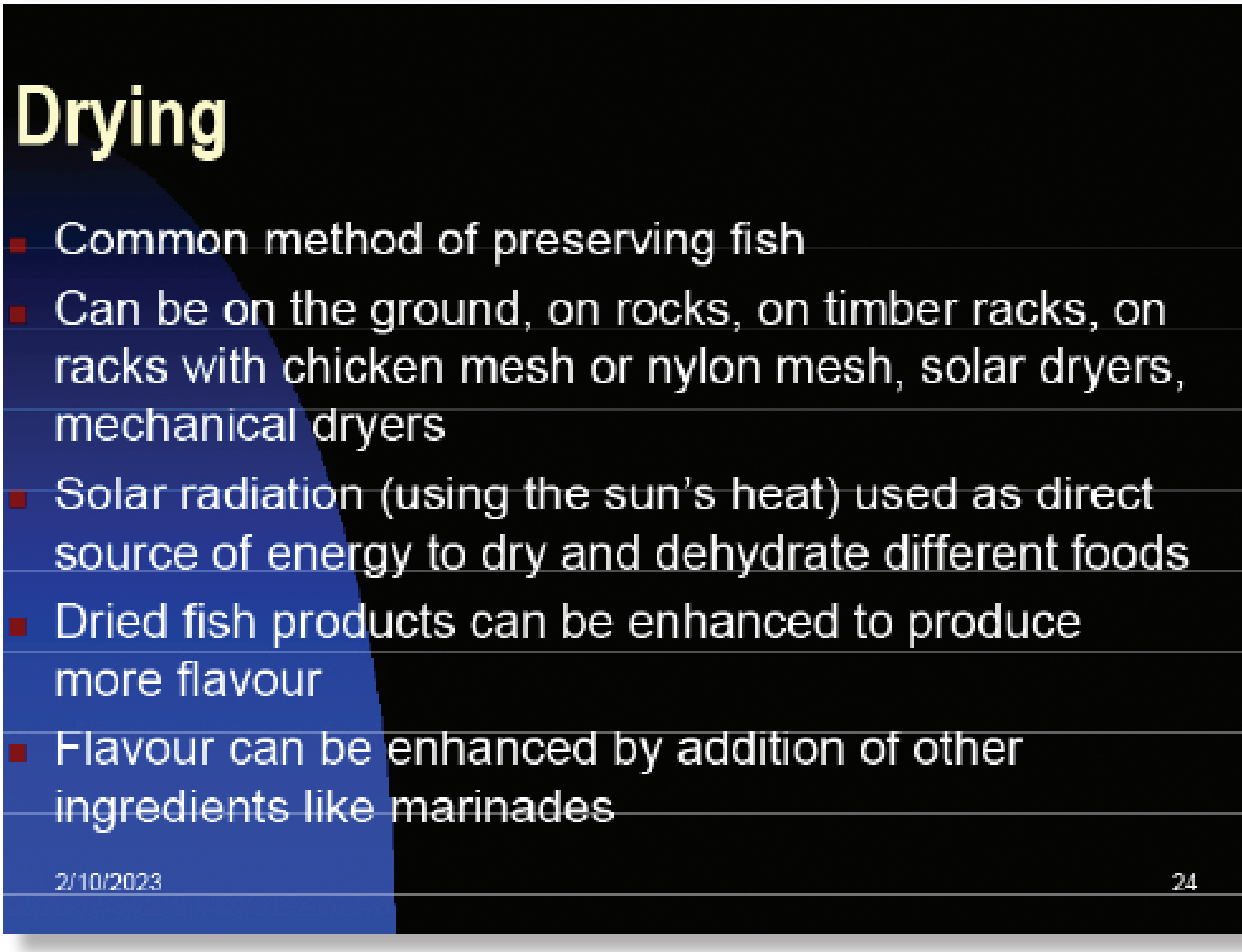

Carbon footprint
(i) Kerosene lamps emit pure black carbon and now more than 20 times more black carbon than previously thought
(ii) Black carbon lingers in atmosphere for more 2 weeks
(iii)1 Kg of black carbon can cause as much warming in that short time as 700kg of carbon dioxide circulating in the atmosphere for 100 yrs.
(iv) The orange glow in flames comes from black carbon.
(v) The brighter the glow, the more black carbon is being made.
(vi) Black carbon is SLCP (Short lived Climate pollutant)
Black carbon particles absorb light, heat the atmosphere and cause climate change
Simple wick lamps using a rope or cloth wick extended from a metal container emit substantially more black carbon than glass enclosed hurricane or pressurized mantle lamps .
Efforts must be made to reduce black carbon to reduce its effect in climate warming.

Summary on actual impacts of the Mama karanga box (Assumptions-
1.The women work 300 days in a year
2.The number of customers is retained throughout the year

Area	Effect	Cost reduction	Estimated cost per year	Price of Mama Karanga box
Health: Respiratory diseases	Previously prevalent but reduced among users of the "Mama karanga" box	2 visits per month to the clinics costing 1500/= for respiratory diseases' medication including children reduced to nil	18000 per year	12000 to 15000/=; Lifespan 5 years
Quantity and quality loss due to paraffin contamination	Fish no longer discarded or sold at lower prices	An average of 2 kilograms lost per day translating to a loss of 700/=	600 kilograms translating to 43200/=	
Customer traffic and stock expansion	increased number of customers thus business expanded from increased profits	Some traders experienced up to an increment of 2 customers due to better fish quality(hygienic conditions)		
Reduced expenses	Cost of buying kerosene no longer incurred	Average daily kerosene cost was 30/=	9000/=	
Carbon emission	reduced black carbon emission into	Reducing its effect on climate warming		




Climate smart post -harvest drying technologies
Drying technologies
In fish drying rack dryers, solar dryers, solar tunnel dryers and lately an integrated solar tunnel hybrid-windmill dryer targeted to produce ice have been introduced and tested;
The dryers improve eating quality and reduce drying time for fish.
A portable dryer is at the design stage and a prototype is to be tried off to carter for those who are "nomadic" and those who may require the dryers next to their houses.
More research on increased drying capacity and efficiency is underway on all the dryers and require both local and external funding.
In the Dagaa (Sardine) fishery, an innovation at the parboiling stage is being introduced. The innovation is set to improve food safety by eliminating dioxins that can be carcinogenic
Discussions on mechanical dryers for "Dagaa" are underway


Drying
Common method of preserving fish
Can be on the ground, on rocks, on timber racks, on racks with chicken mesh or nylon mesh, solar dryers, mechanical dryers
Solar radiation (using the sun's heat) used as direct source of energy to dry and dehydrate different foods
Dried fish products can be enhanced to produce more flavour
Flavour can be enhanced by addition of other ingredients like marinades
2/10/2023
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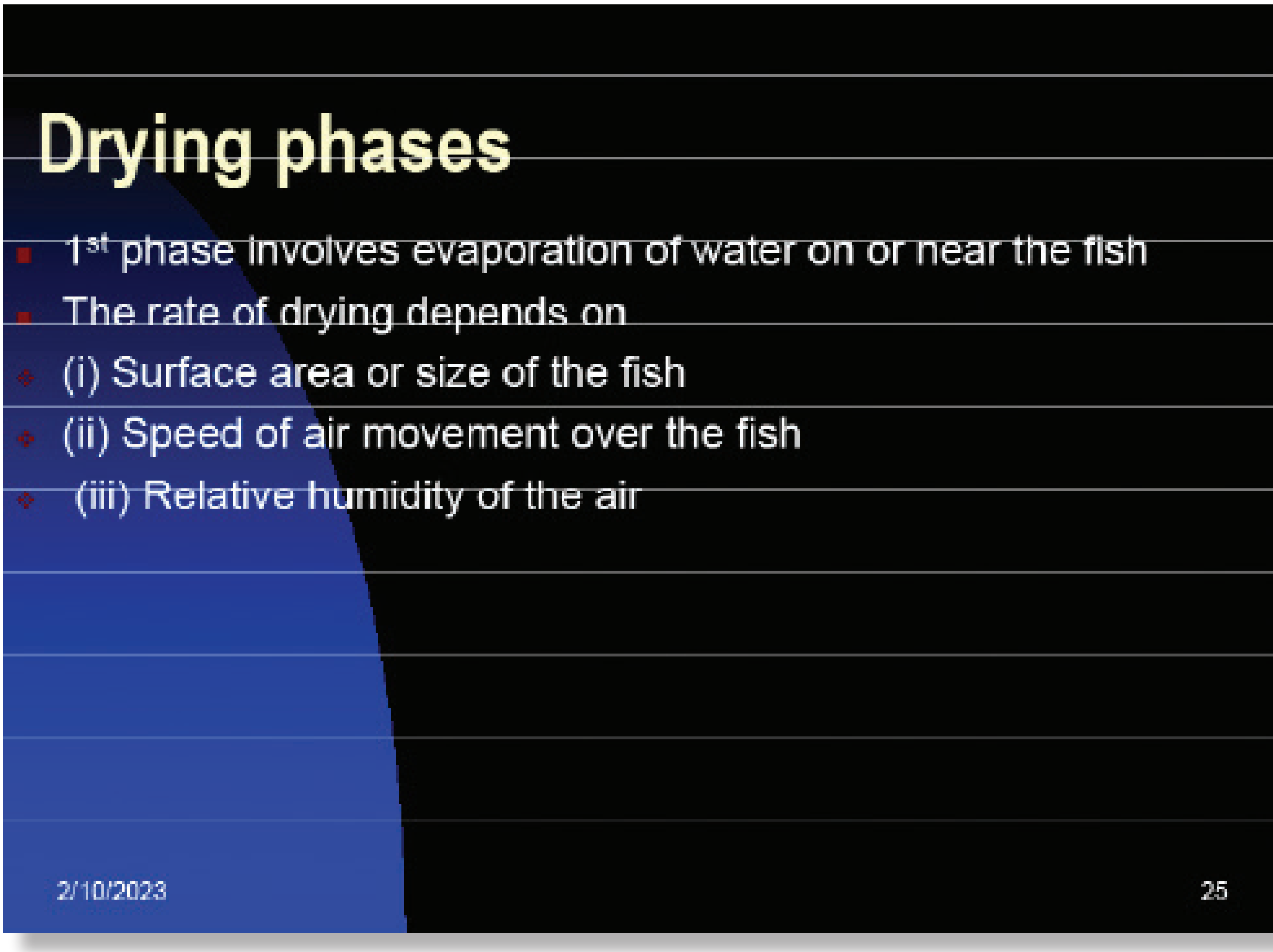
Drying phases
1st phase involves evaporation of water on or near the fish
The rate of drying depends on
(i) Surface area or size of the fish
(ii) Speed of air movement over the fish
(iii) Relative humidity of the air
2/10/2023
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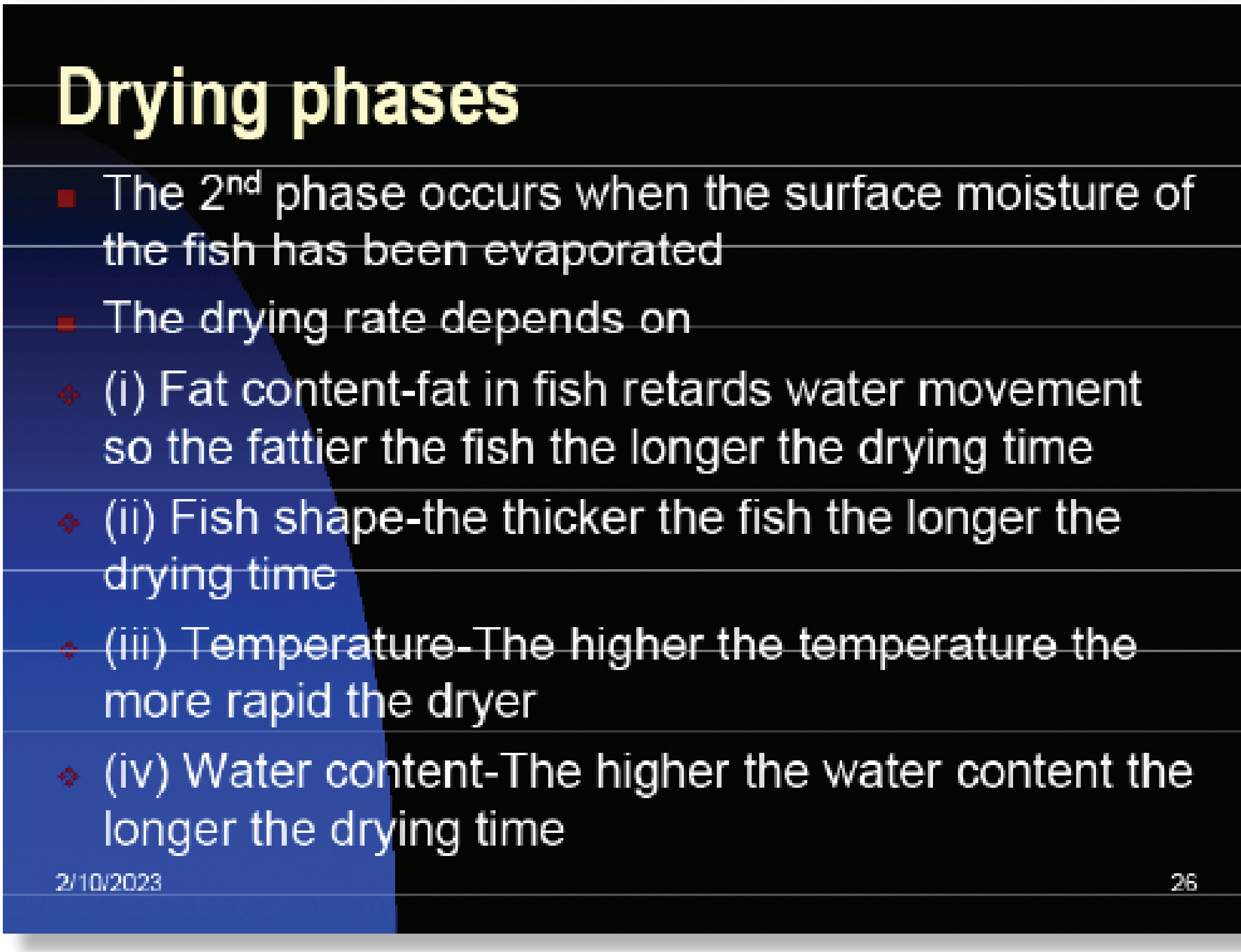
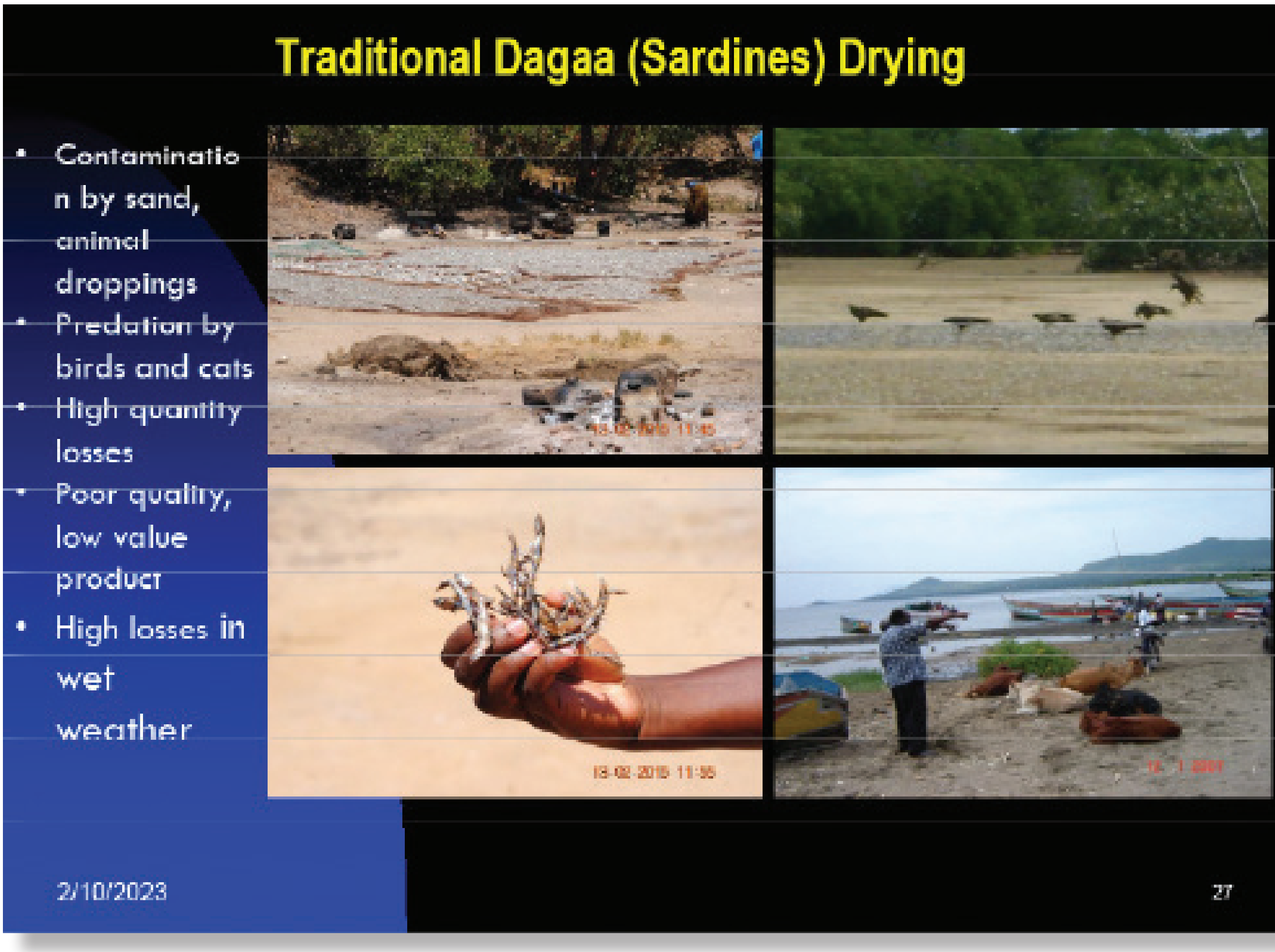
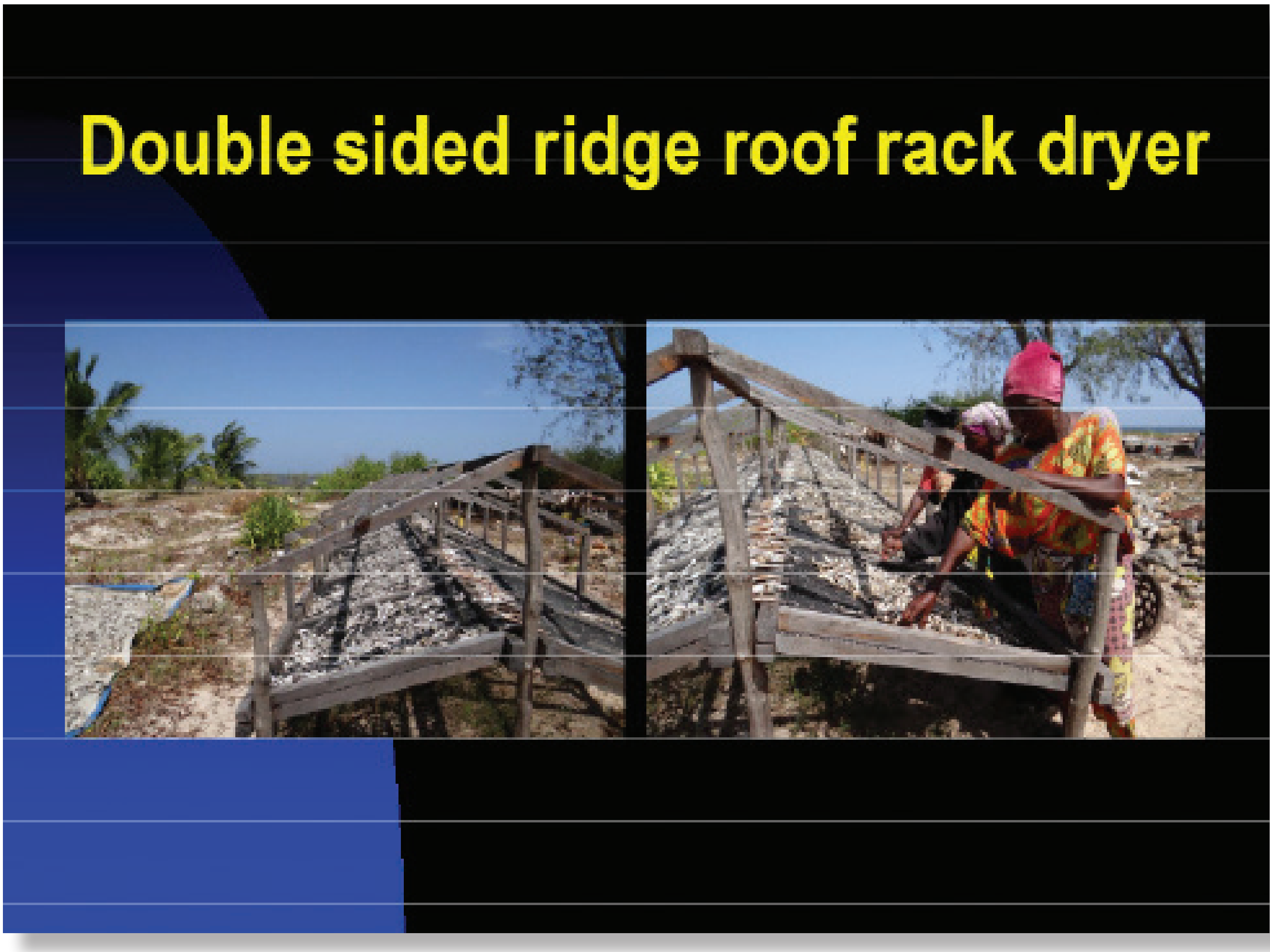
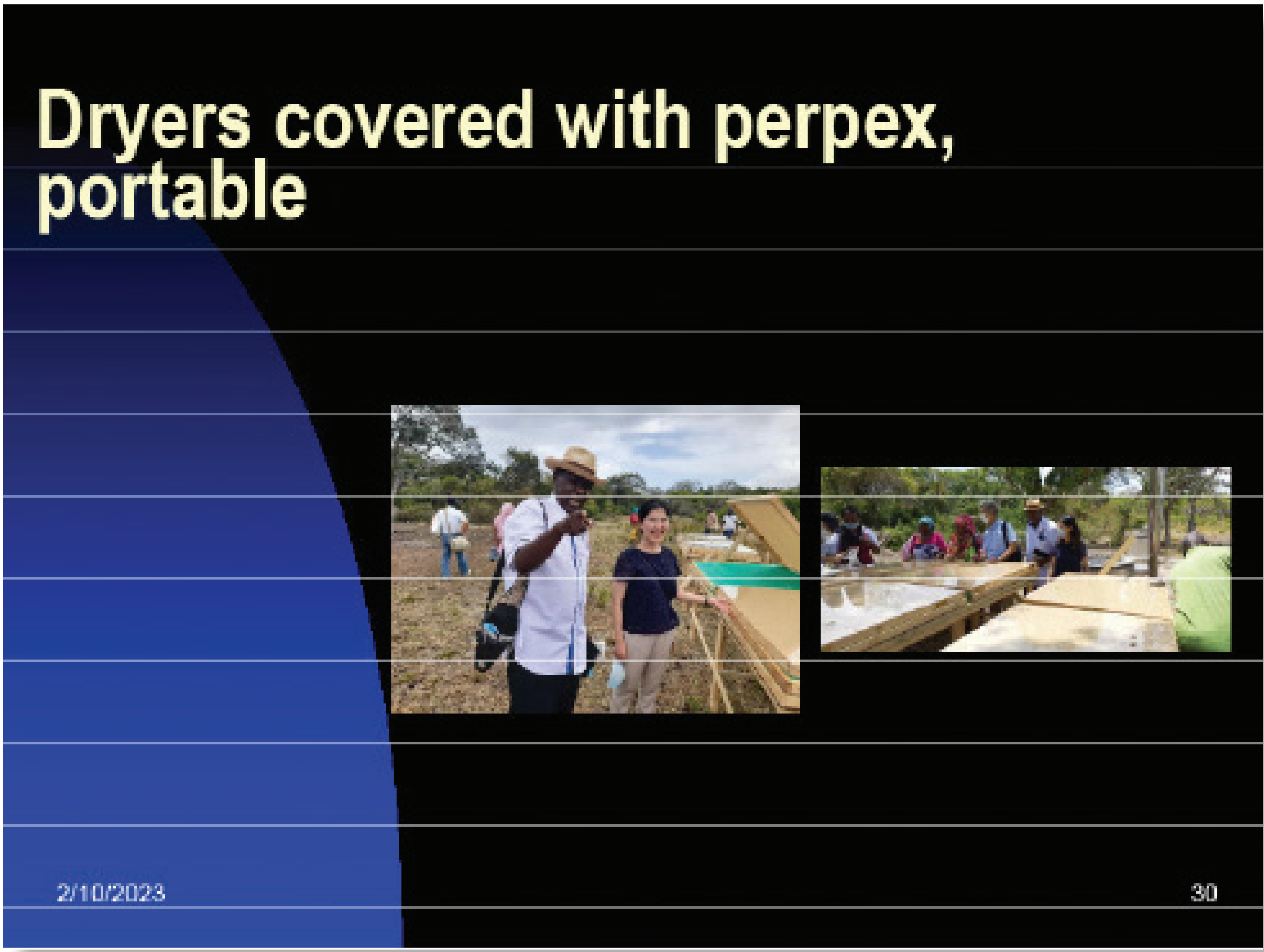
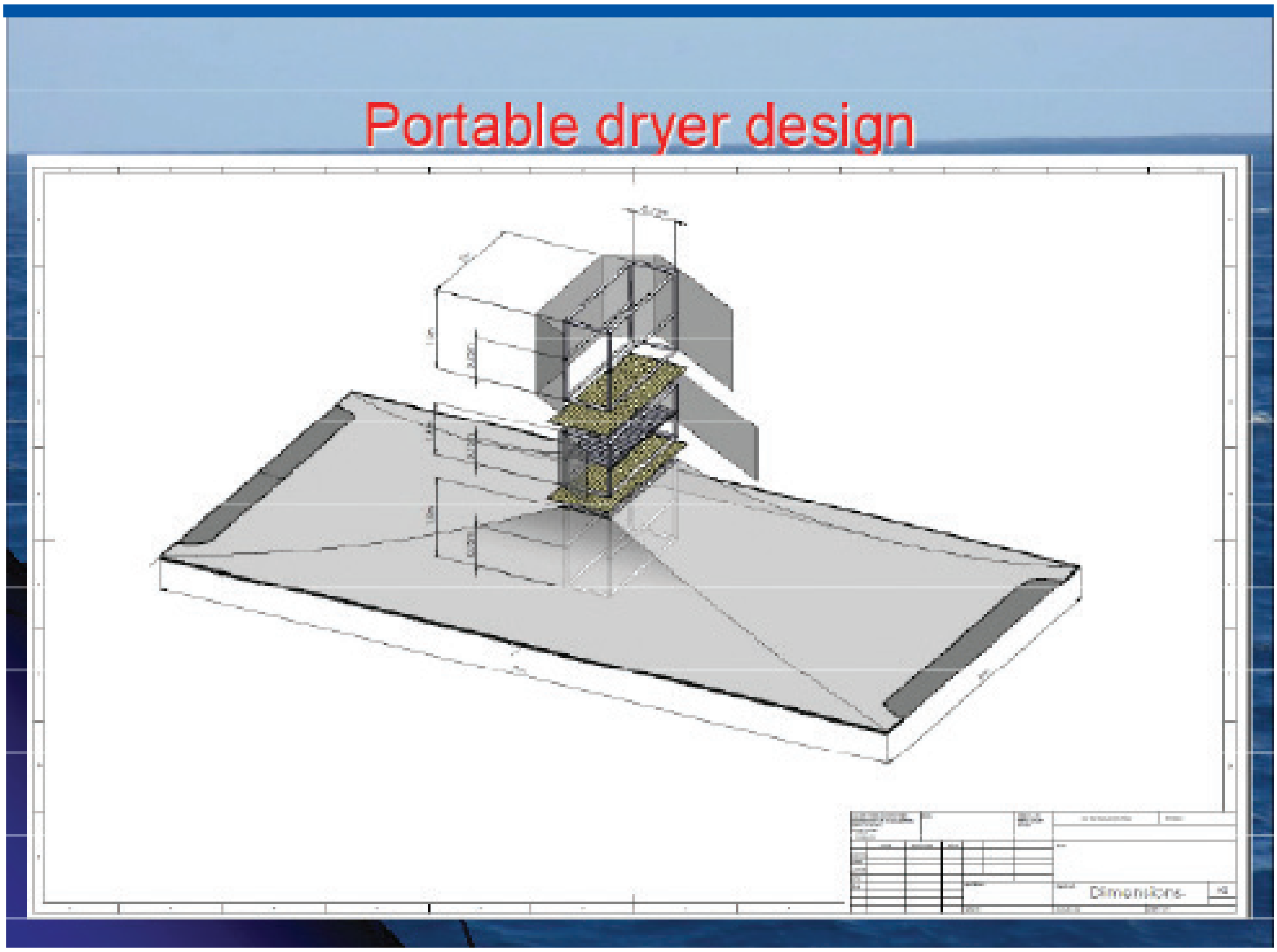

Drying phases
The 2nd phase occurs when the surface moisture of the fish has been evaporated
The drying rate depends on
(i) Fat content-fat in fish retards water movement so the fattier the fish the longer the drying time
(ii) Fish shape-the thicker the fish the longer the drying time
(iii) Temperature-The higher the temperature the more rapid the dryer
(iv) Water content-The higher the water content the longer the drying time
2/10/2023
26

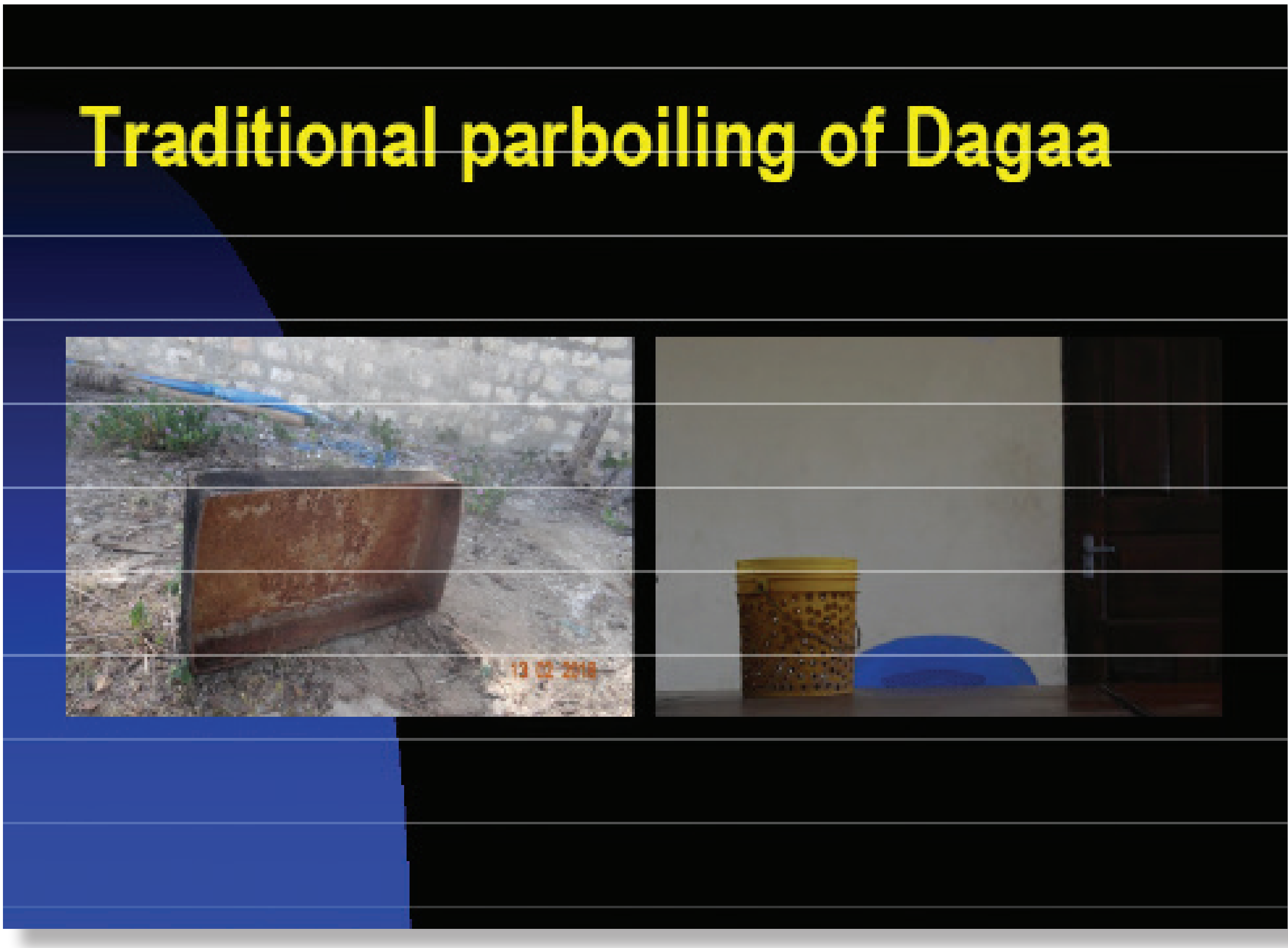

Traditional Dagaa (Sardines) Drying
• Contamination by sand, animal droppings
• Predation by birds and cats
• High quantity losses
• Poor quality, low value product
• High losses in wet weather
2/10/2023
27


Improvements in the dry chain: Drying Racks
✓ Contamination by sand and animal droppings eliminated
✓ UV-stabilized covers
✓ Reduced contamination & sardine breakage = better quality
✓ Reduced quality losses & better quality = Higher profits
2/10/2023
28


Double sided ridge roof rack dryer

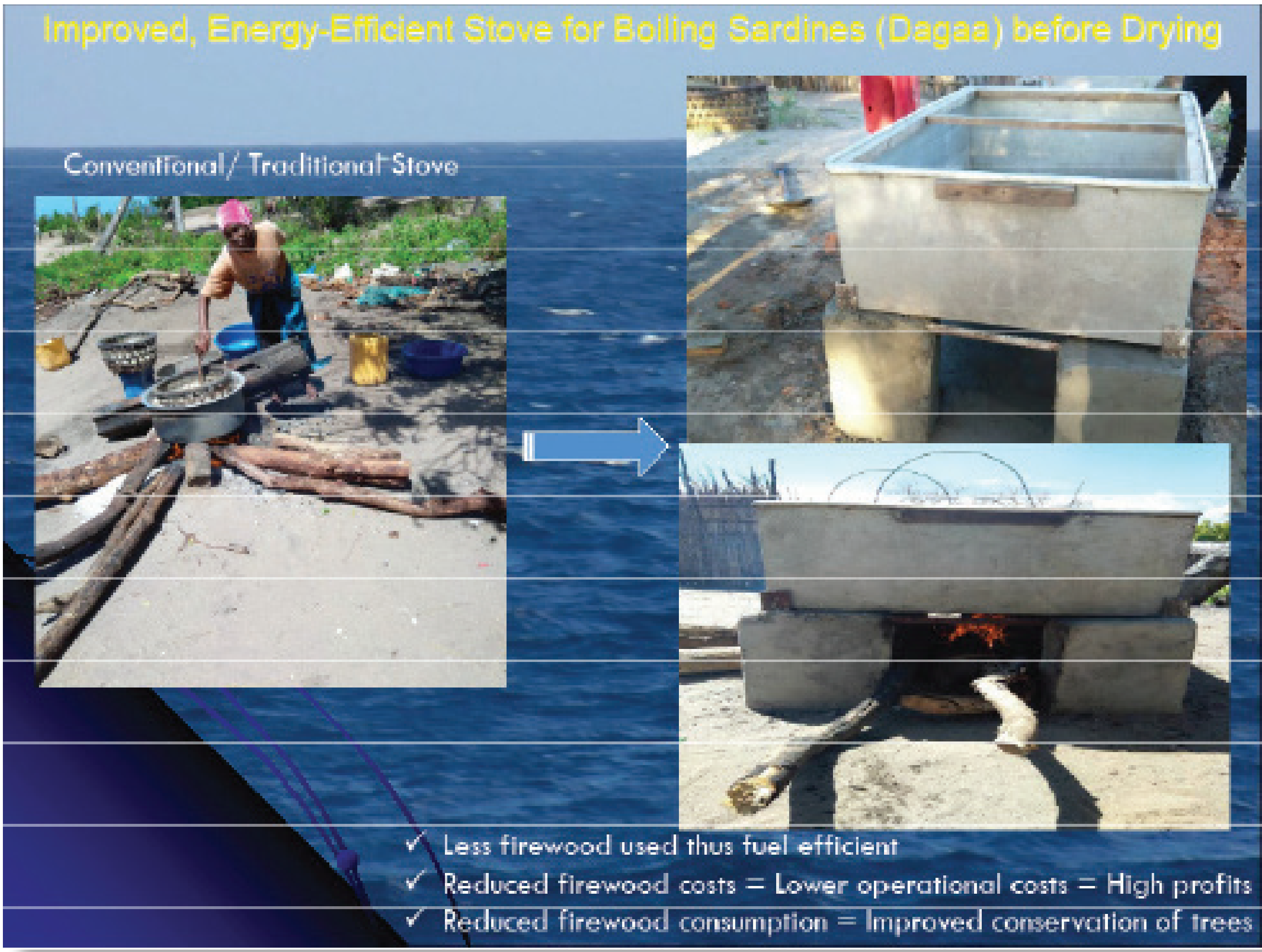

Dryers covered with perpex, portable
2/10/2023
30


Portable dryer design

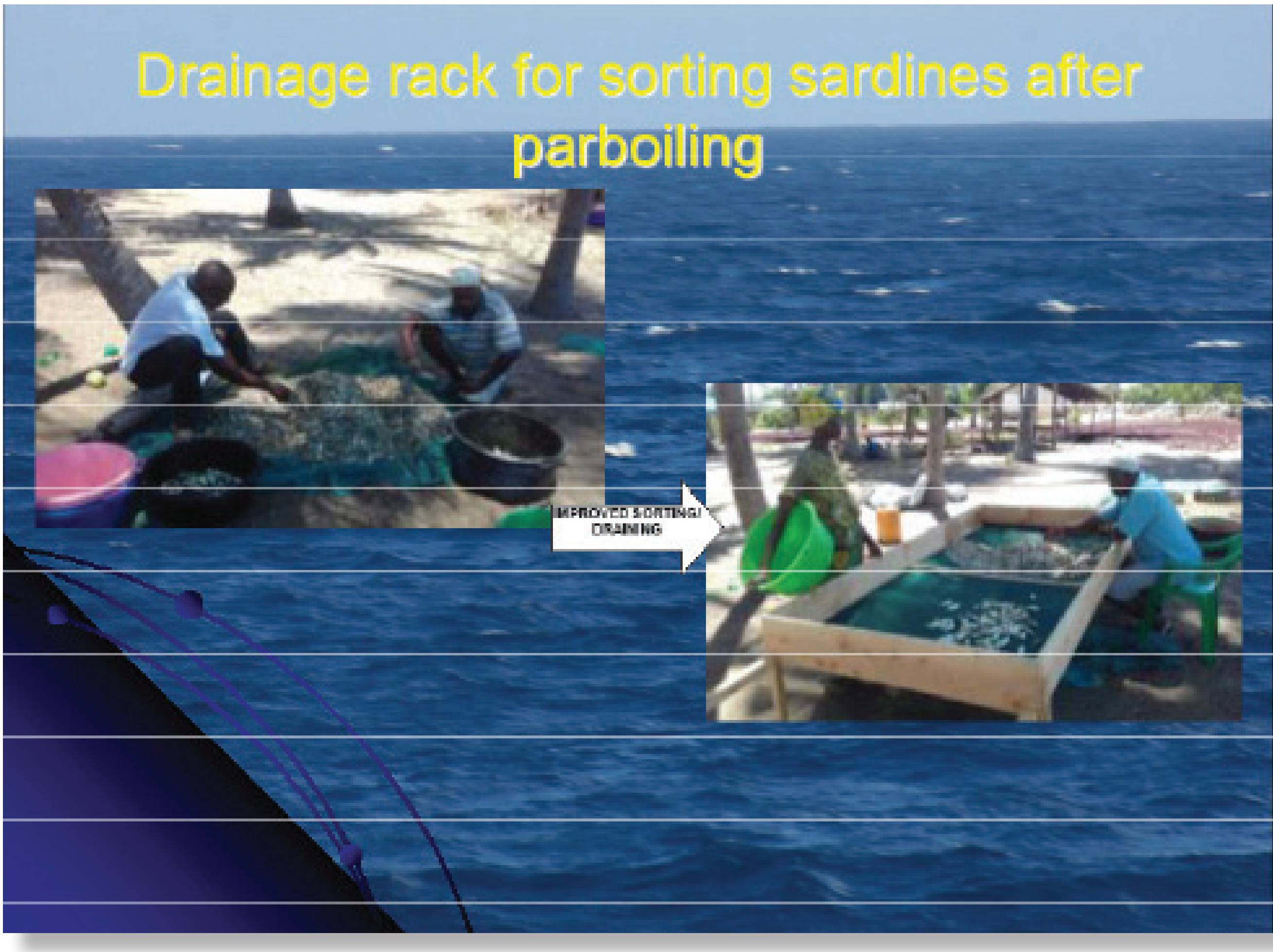

Traditional parboiling of Dagaa


Improved Food-safe Par-Boiling Vessel for Processing Dried Sardines (Dagaa)
Conventional Boiling Apparatus
✓ Carcinogenic dioxins from use of plastic buckets eliminated
✓ Sand and particles clinging on conventional containers eliminated
✓ More sardines processed at a go thus saves time and resources
✓ Food-safe, easy to clean container


Improved boiling containers


Improved, Energy-Efficient Stove for Boiling Sardines (Dagaa) before Drying
Conventional/ Traditional Stove
✓ Less firewood used thus fuel efficient
✓ Reduced firewood costs = Lower operational costs = High profits
✓ Reduced firewood consumption = Improved conservation of trees

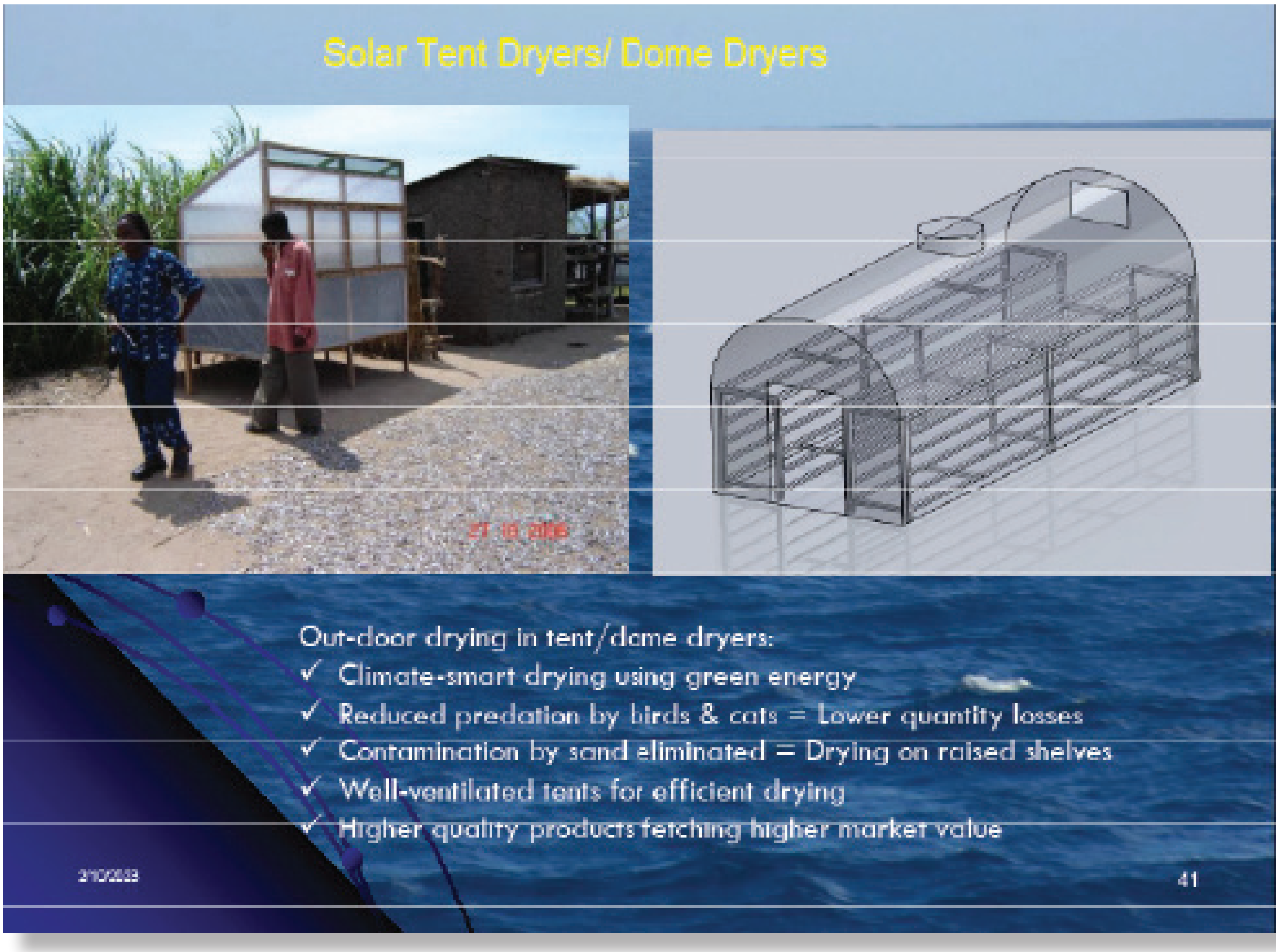

Energy saving boiling vessel for Sardines

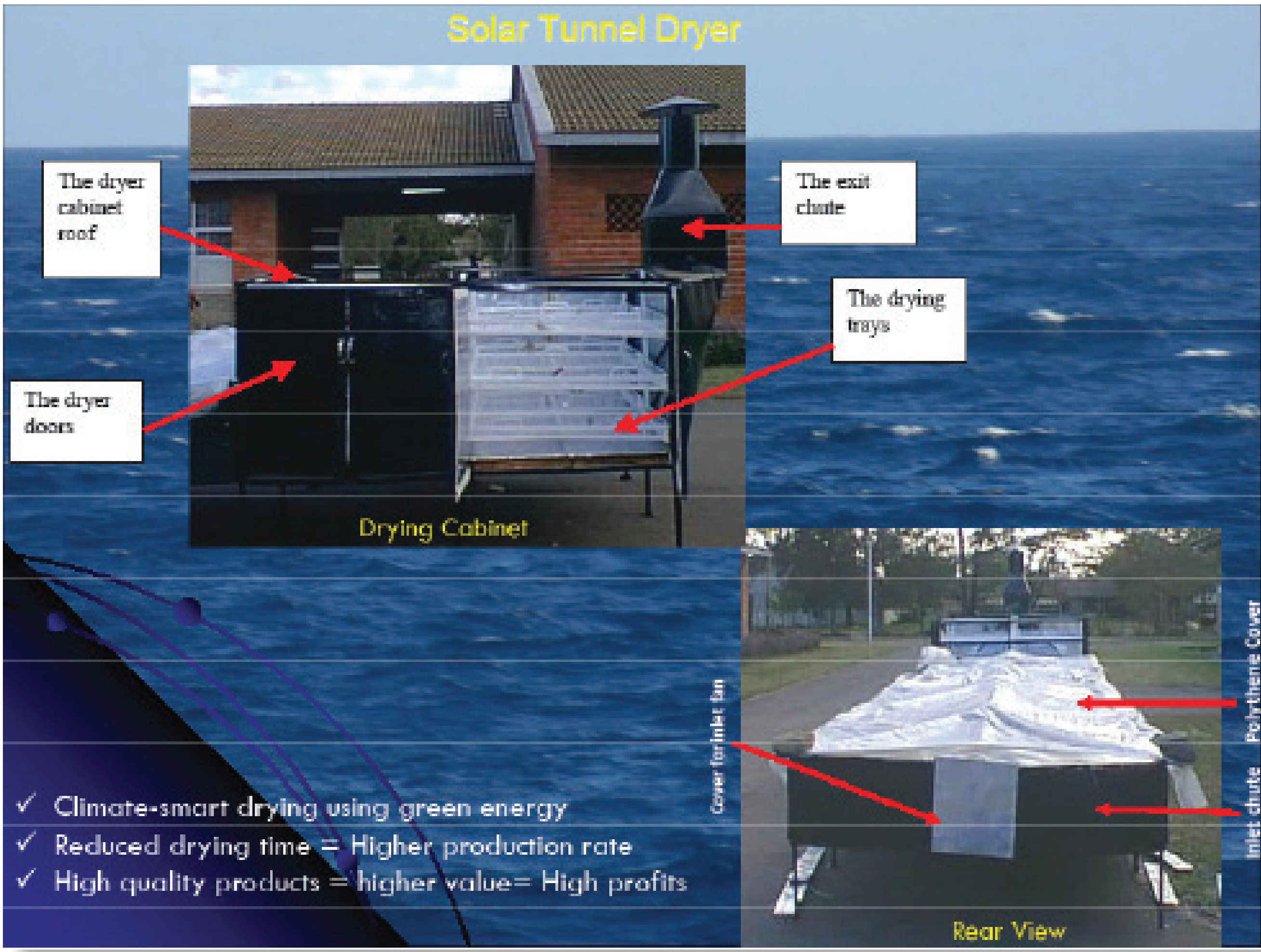

Drainage rack for sorting sardines after parboiling
IMPROVED SORTING/ DRAINING


Drying after sorting

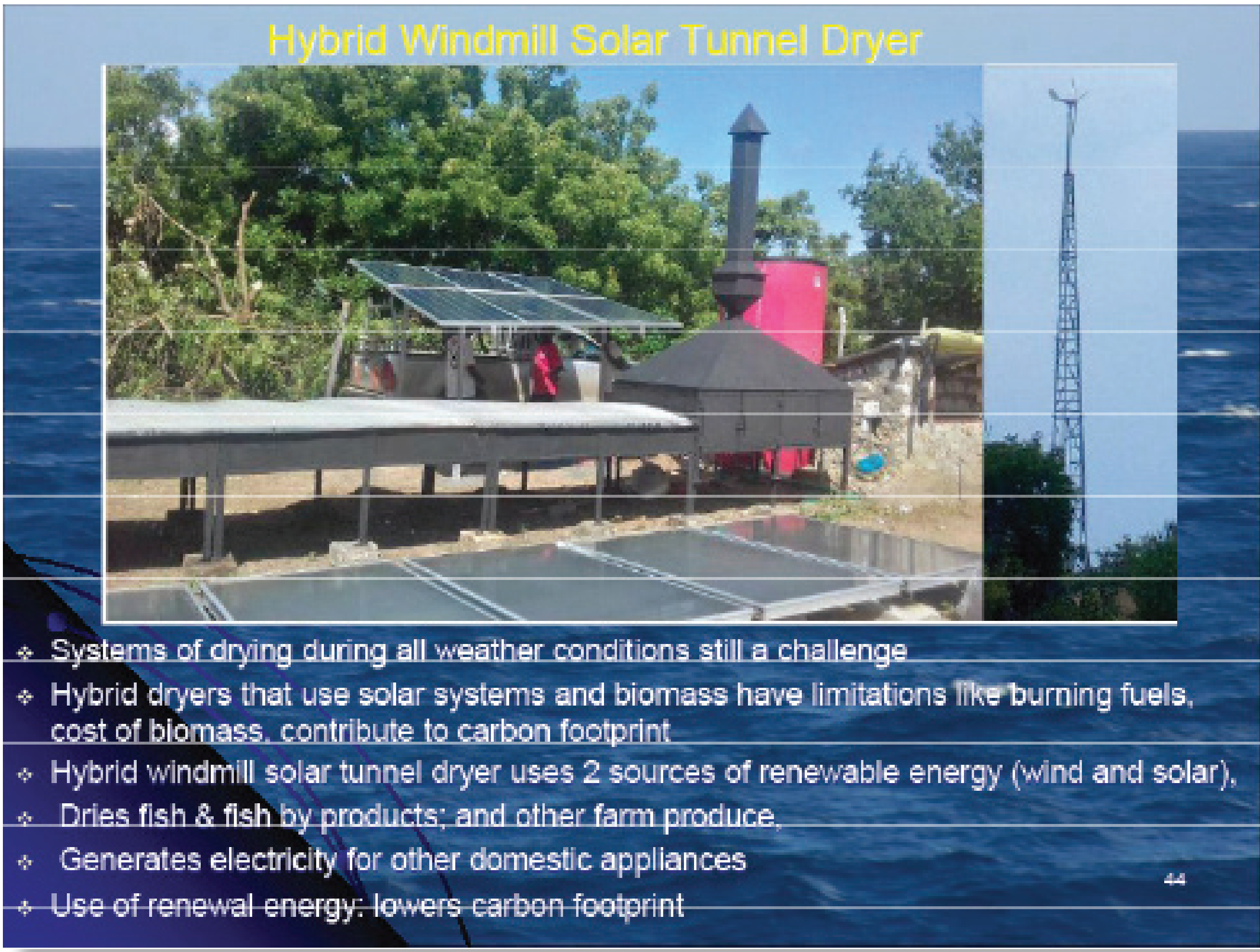

Dried fish products
Solar dried Kimarawali
Solar dried omena

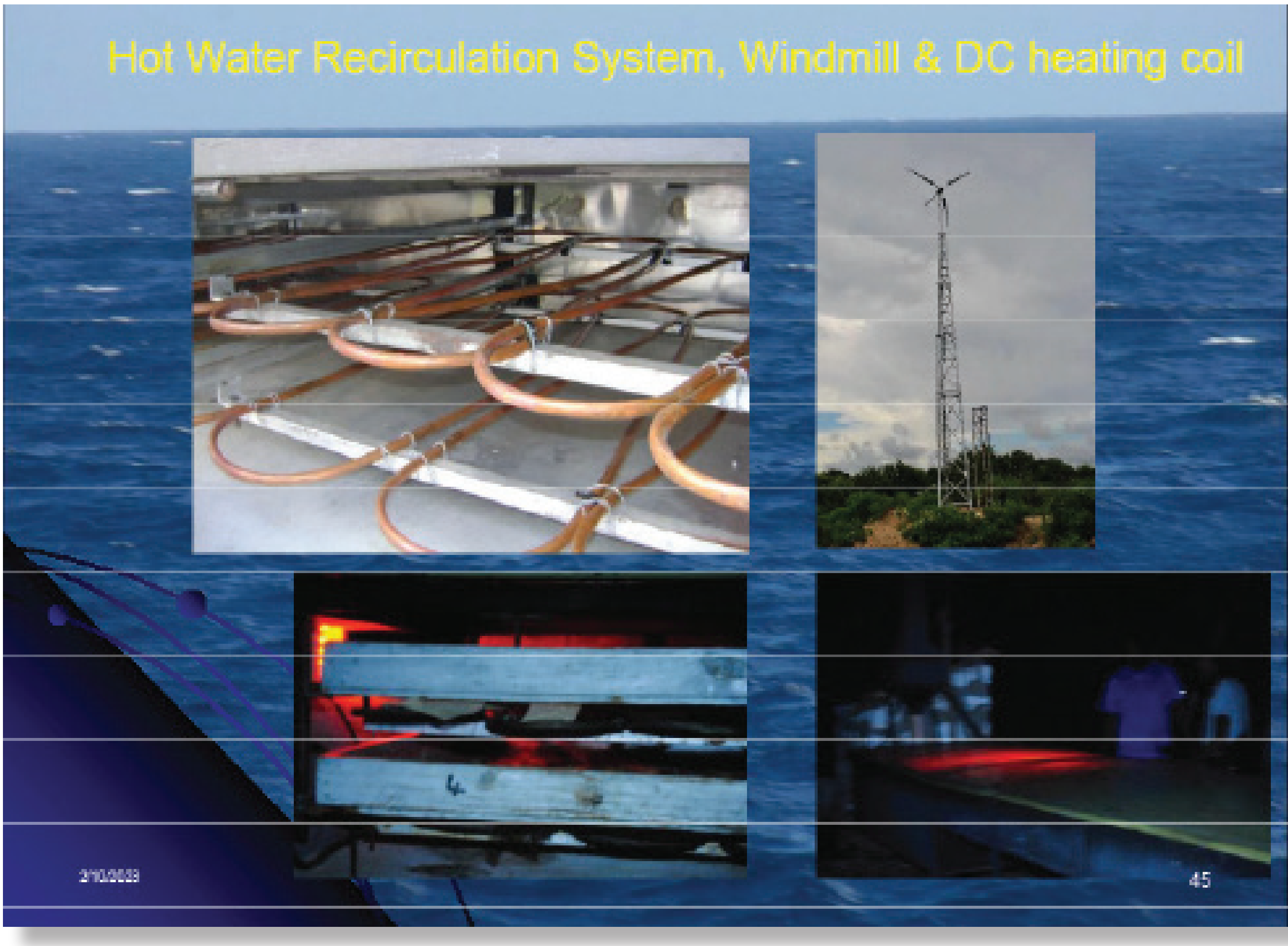

Community training on dried fish value addition to market trials
40


Solar Tent Dryers/ Dome Dryers
Out-door drying in tent/dome dryers:
✓ Climate-smart drying using green energy
✓ Reduced predation by birds & cats = Lower quantity losses
✓ Contamination by sand eliminated = Drying on raised shelves
✓ Well-ventilated tents for efficient drying
✓ Higher quality products fetching higher market value
41

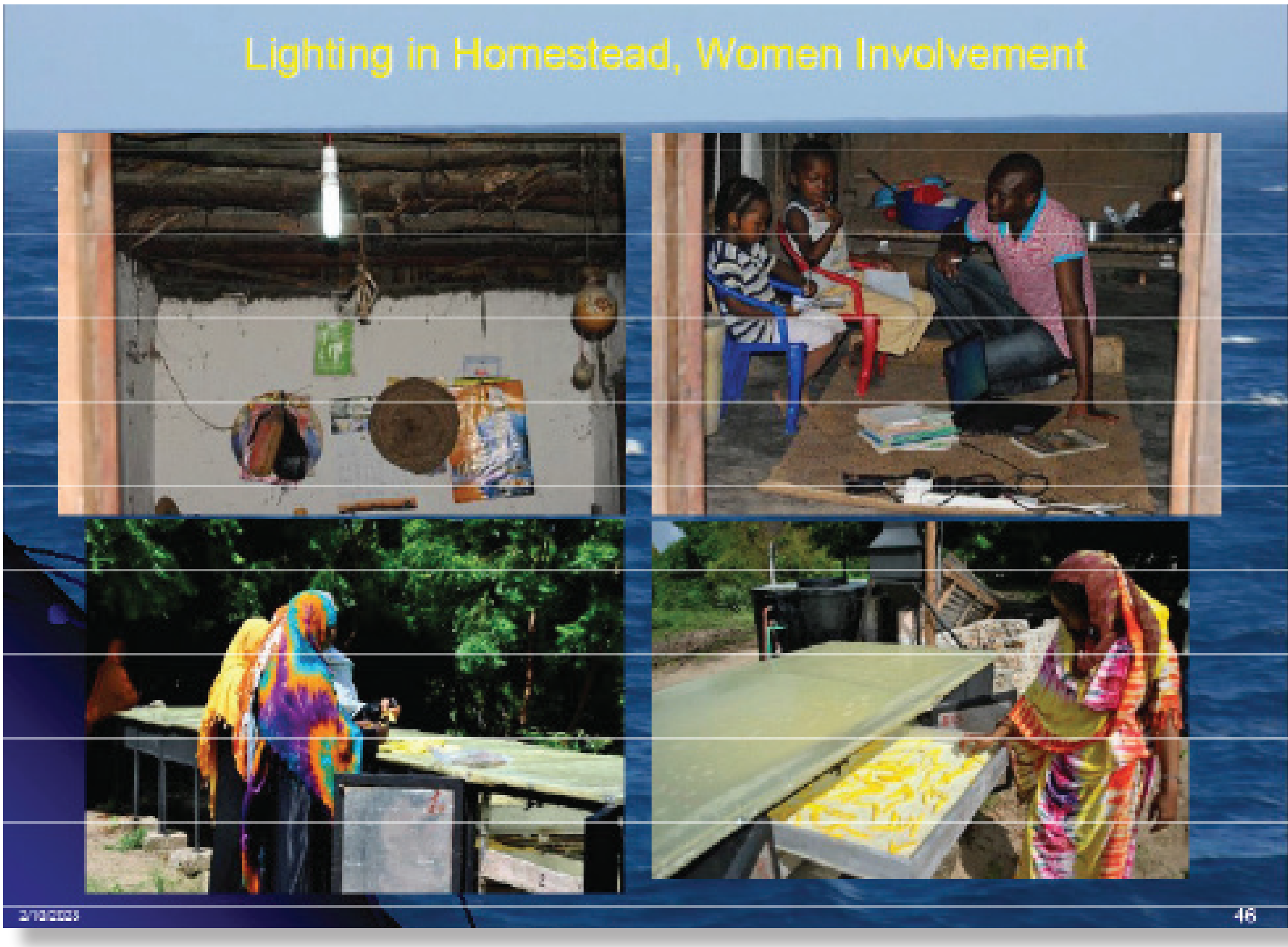

Solar Tunnel Dryer
The dryer cabinet roof
The exit chute
The drying trays
The dryer doors
Drying Cabinet
Cover for inlet fan
Polythene Cover
Inlet chute
Rear View
✓ Climate-smart drying using green energy
✓ Reduced drying time = Higher production rate
✓ High quality products = higher value= High profits


Fish Drying in Solar Tunnel Dryer
✓ Superior quality dried fish
✓ Community members trained on use of innovation

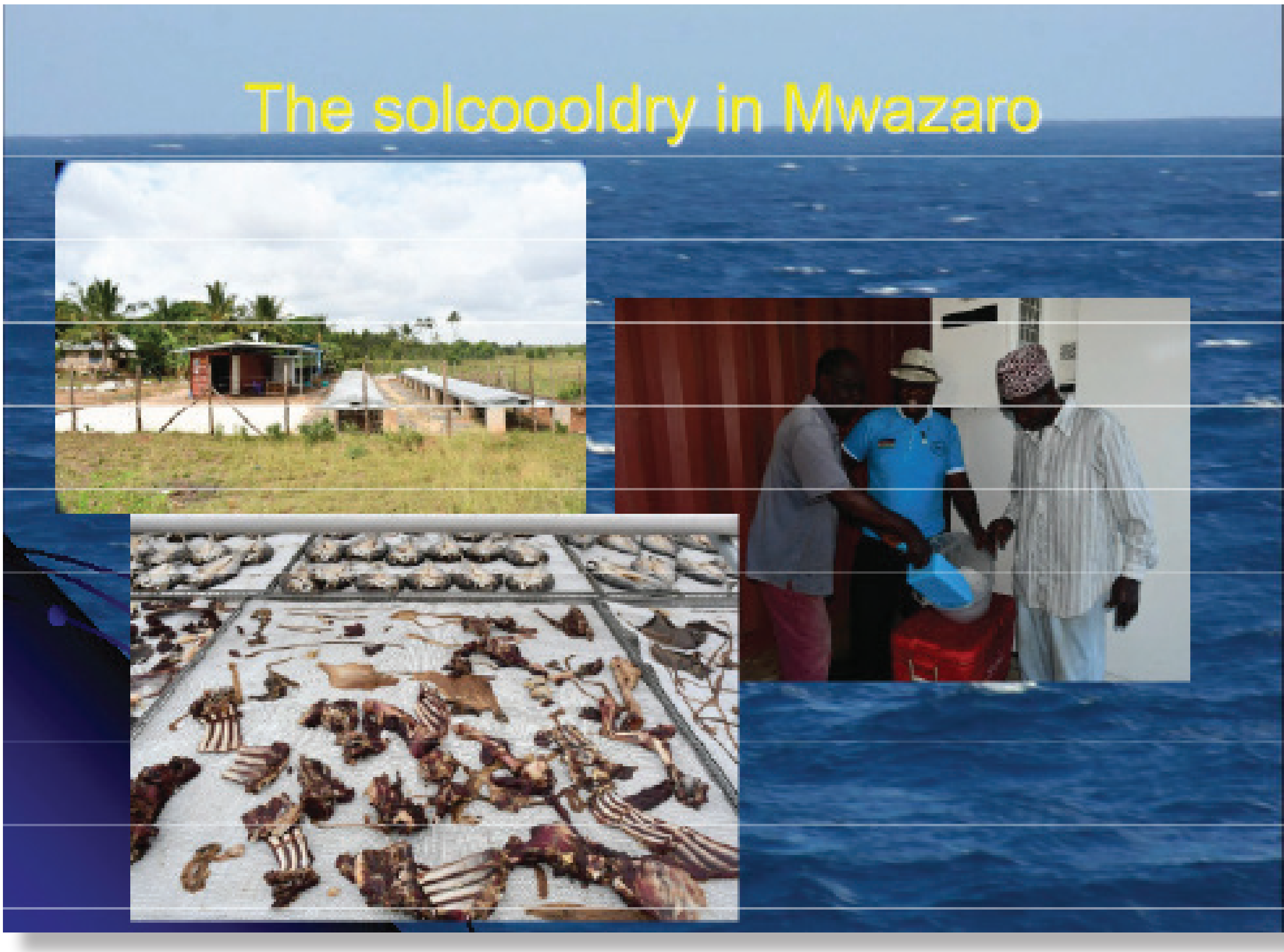

Hybrid Windmill Solar Tunnel Dryer
❖ Systems of drying during all weather conditions still a challenge
❖ Hybrid dryers that use solar systems and biomass have limitations like burning fuels, cost of biomass, contribute to carbon footprint
❖ Hybrid windmill solar tunnel dryer uses 2 sources of renewable energy (wind and solar),
❖ Dries fish & fish by products; and other farm produce,
❖ Generates electricity for other domestic appliances
❖ Use of renewal energy: lowers carbon footprint
44


Hot Water Recirculation System, Windmill & DC heating coil
2/10/2023
45


Training Communities in Drying Other Farm Produce
2/10/2023
Community members drying fruits & vegetables using the innovation
47


Lighting in Homestead, Women Involvement
46


Hybrid Windmill Solar Tunnel Dryer Producing Ice
Hybrid Dryer Ice-Making Unit
Community Members Explore the Ice-Making System


The solcooooldry in Mwazaro


Attention in the dry chain
Innovations require technology uptake by communities or industry
Private sector partnerships for direct sponsorship
Marketing of products and market conditions
Innovations in processing that lower carbon footprint
Expand innovations in drying technology to other farm produce


Attention in the dry chain
Innovations require technology uptake by communities or industry
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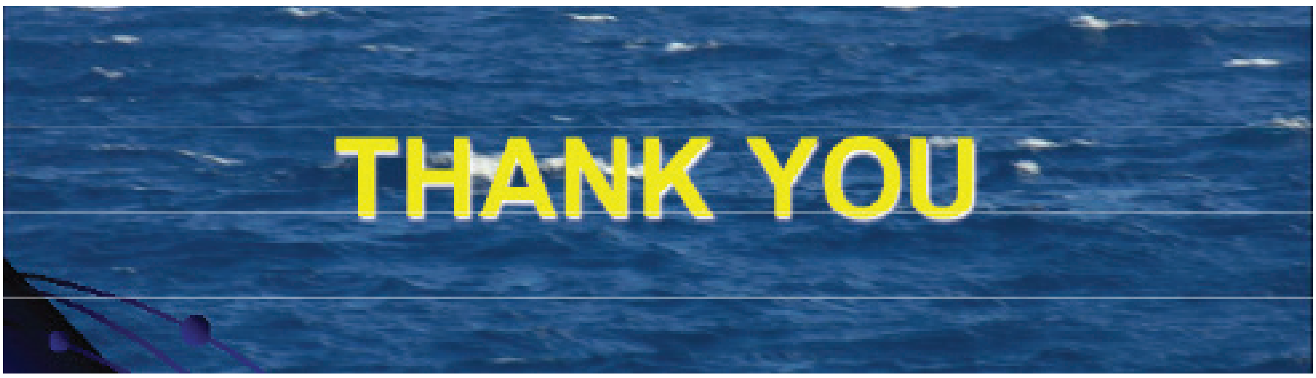
THANK YOU

Session 1, Presentation 4

Cooperating with Universities and Research Institutions

INNOTECH

- University of Hohenheim, Stuttgart
- University of Stuttgart
- University of Kassel
- University of Konstanz
- Karlsruher Institut für Technologie, KIT
- KIT, Royal Institute, The Netherlands
- Uppsala University, Sweden
- SINTEF, Norway
- Makarere University, Uganda
- Sokoine University, Tansania
- Jimma University, Äthiopia
- Pontifical Bolivarian University, Columbia
- Silapakorn University, Thailand
- Mahasarakam University, Thailand
- Chulalongkorn University, Thailand
- Royal Chitralada Projects, Thailand
- Action for Food Production, India
- Renewable Energy Center Mithradham, India
- Egerton University, Kenya
- University of Nairobi, Kenya
- Institute d' Rural Economie, Mali

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06.02. | 3

Cooperating with International Organisations

INNOTECH

- Caritas
- Brot für die Welt
- UNDP
- DEG
- GIZ
- FAO
- USAID
- UNEP
- PIBID
- DAAD
- UNIDO
- Chemonics International, USA
- PADCO, USA
- DANIDA, Denmark
- DWWH, Germany
- Misereor
- Weltkirche Rottenburg
- SWSSCO

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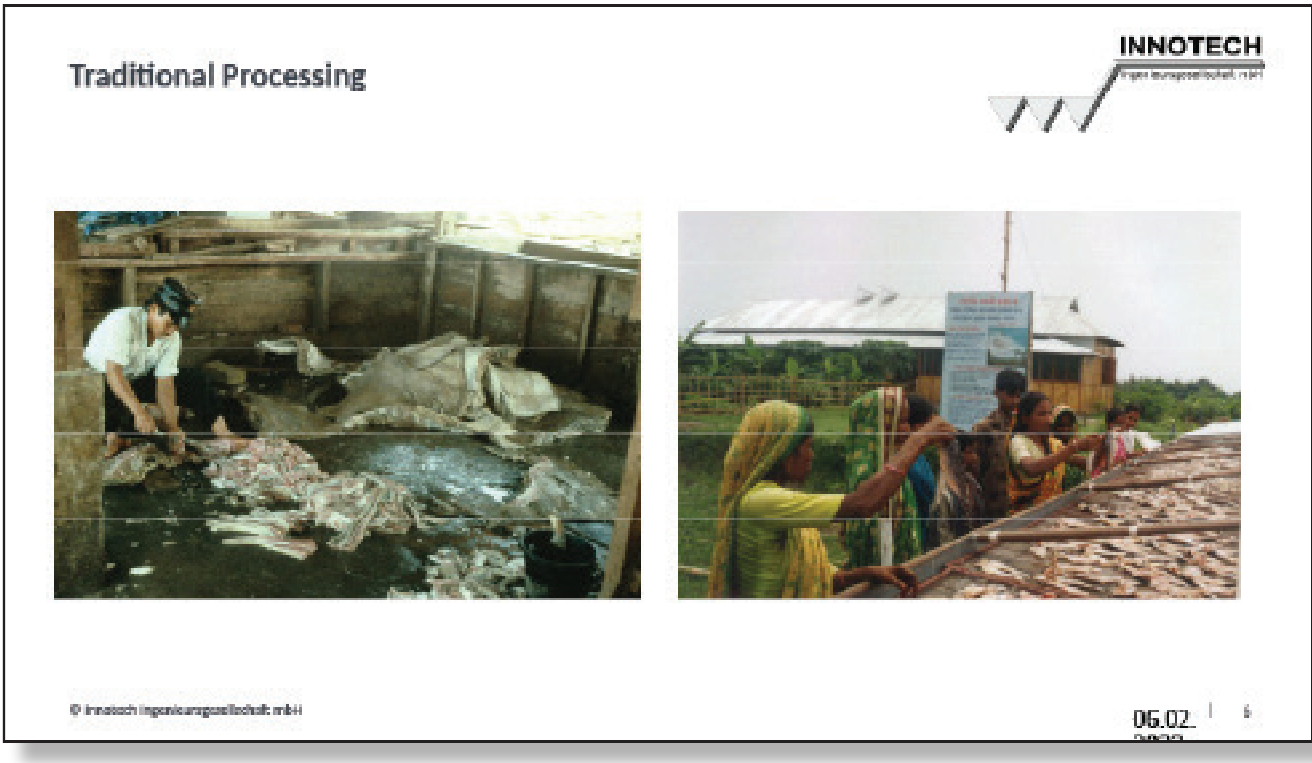
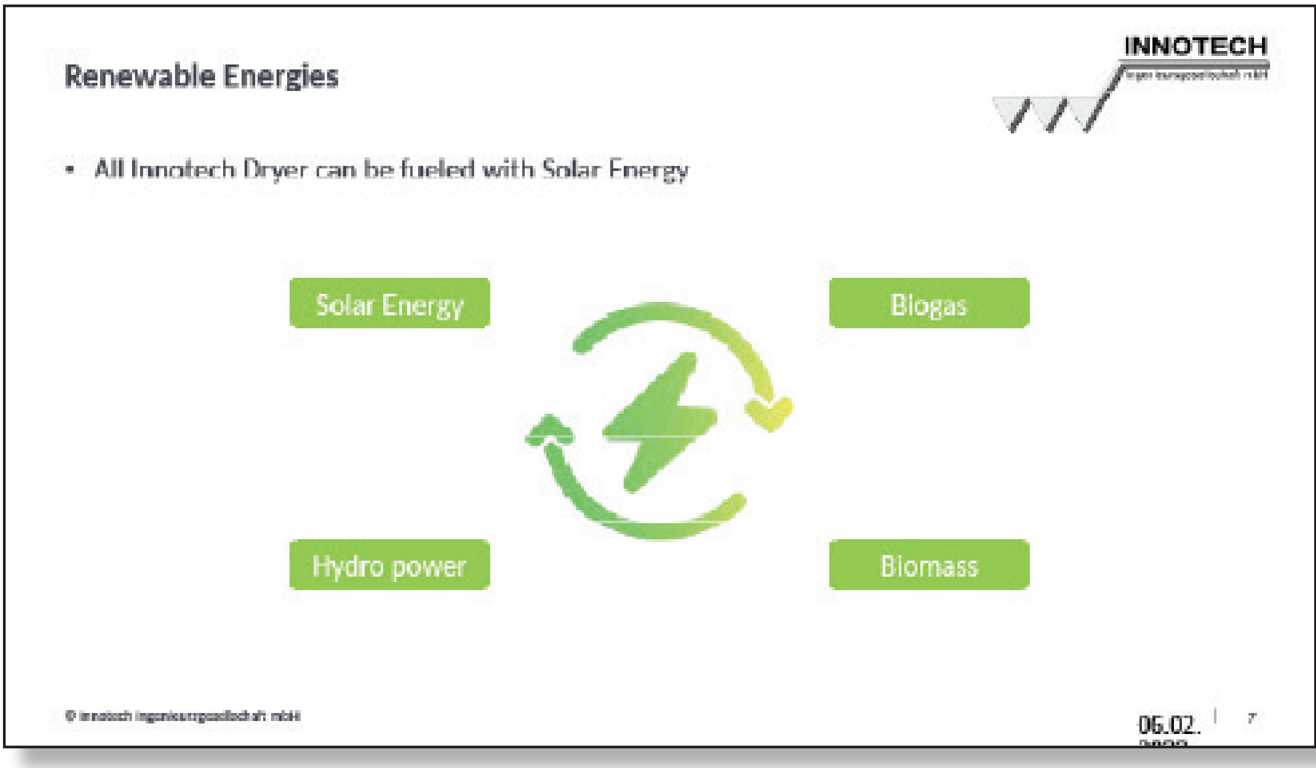
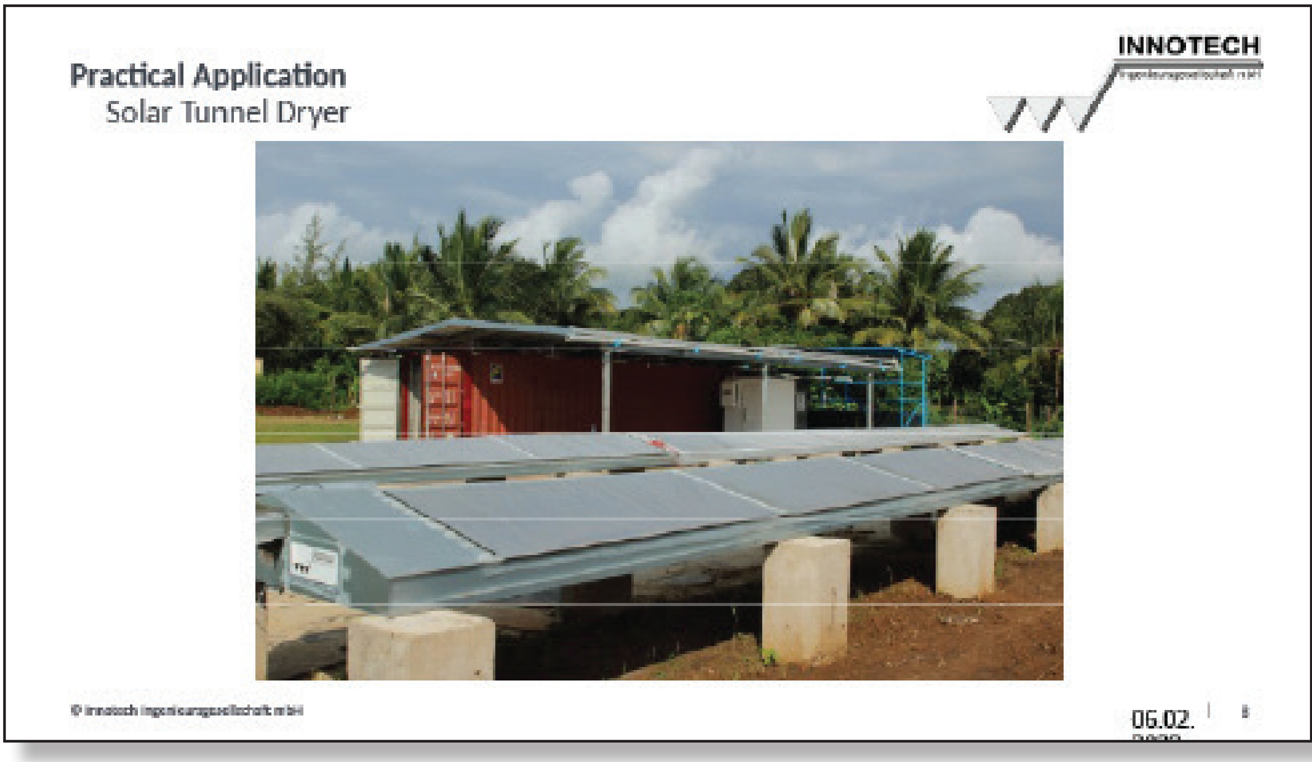
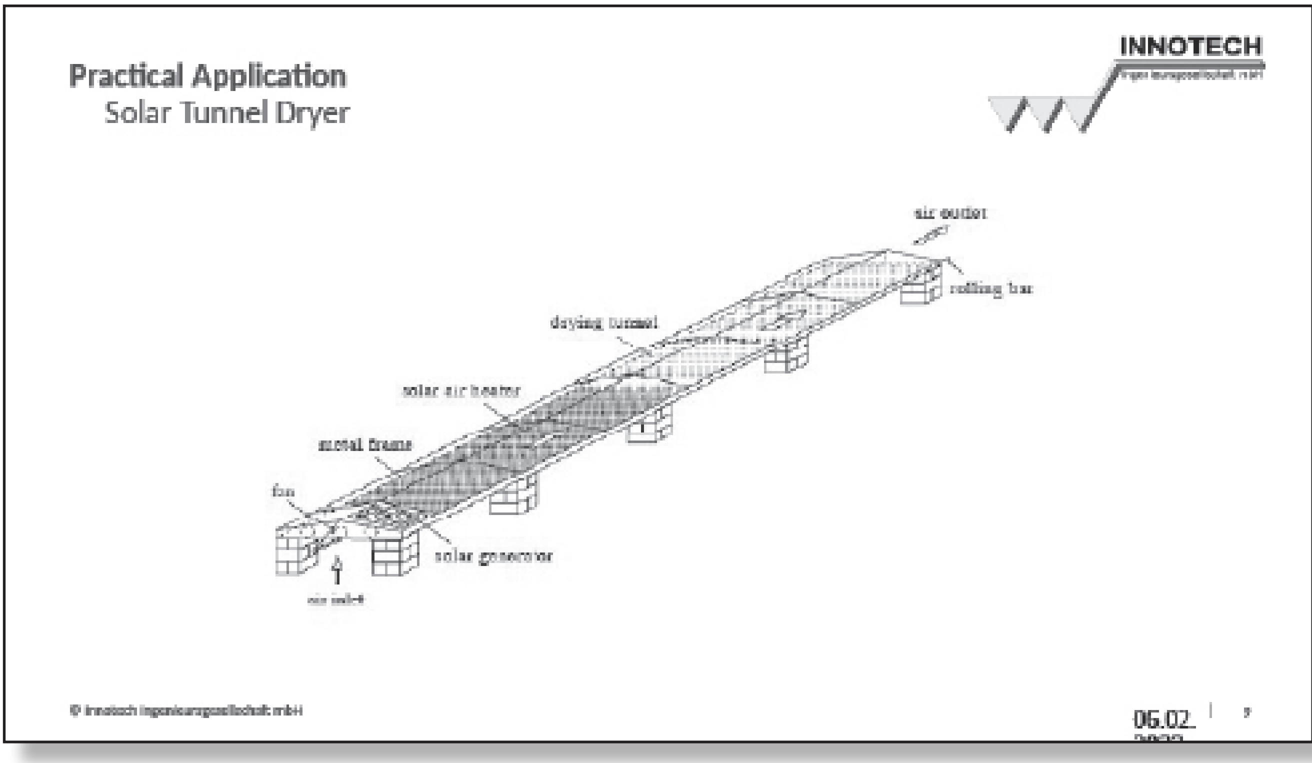
06.02. | 4

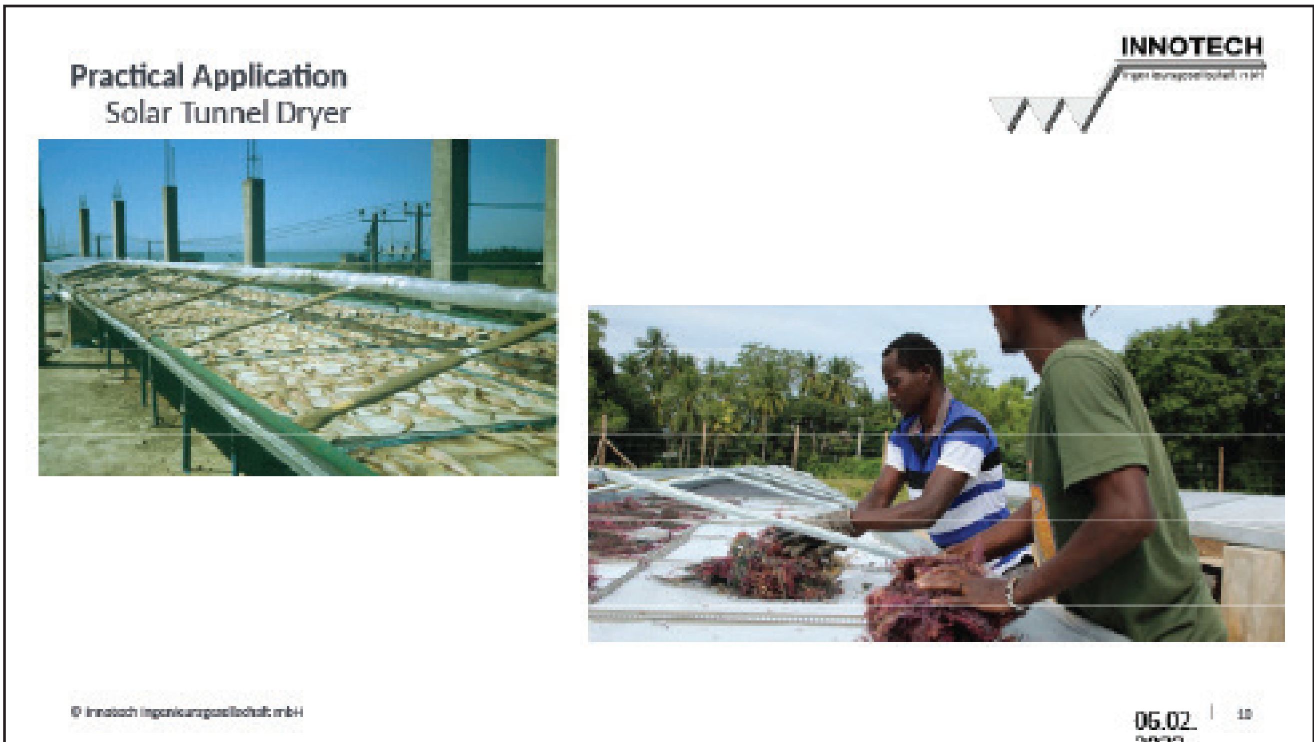

Trockenprodukte
INNOTECH
06.02.

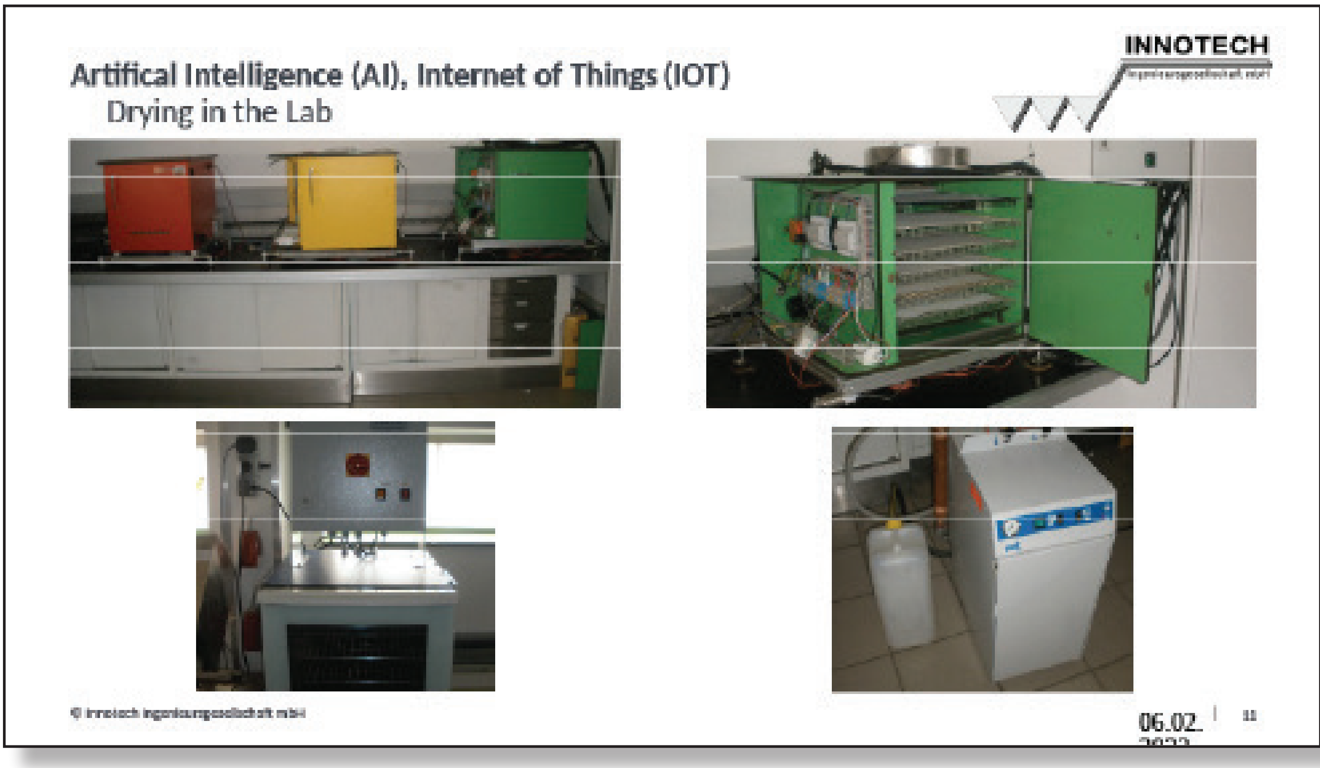

Traditional Processing
INNOTECH
06.02.


Renewable Energies
INNOTECH
• All Innotech Dryer can be fueled with Solar Energy
Solar Energy
Biogas
Hydro power
Biomass
06.02.
7


Practical Application
Solar Tunnel Dryer
INNOTECH
06.02.
8


Practical Application
Solar Tunnel Dryer
INNOTECH
air outlet
rolling bar
drying tunnel
solar air heater
metal frame
fan
solar generator
air inlet
06.02.


Practical Application
Solar Tunnel Dryer
INNOTECH
06.02.


INNOTECH
Artifical Intelligence (AI), Internet of Things (IOT)
Drying in the Lab
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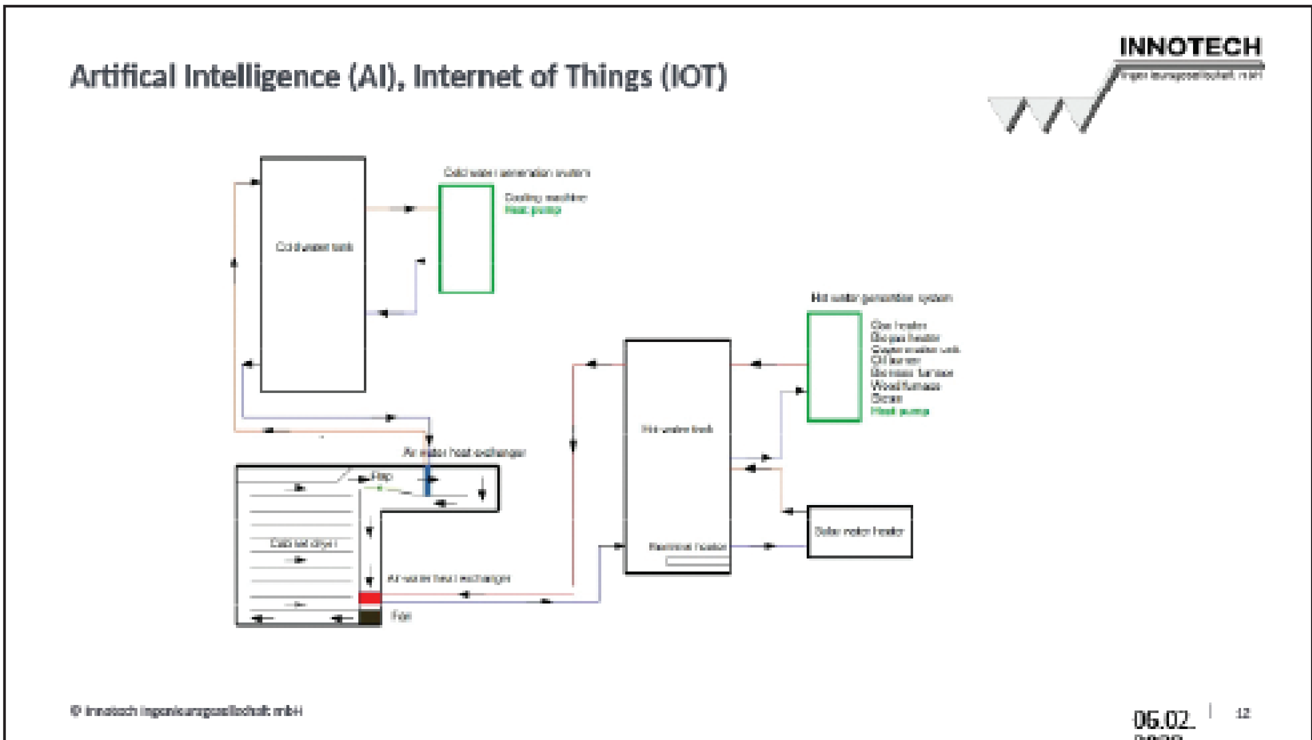
INNOTECH
Artifical Intelligence (AI), Internet of Things (IOT)
Cooling machine
Heat pump
Wood furnace
Heat pump
Flap
Fan
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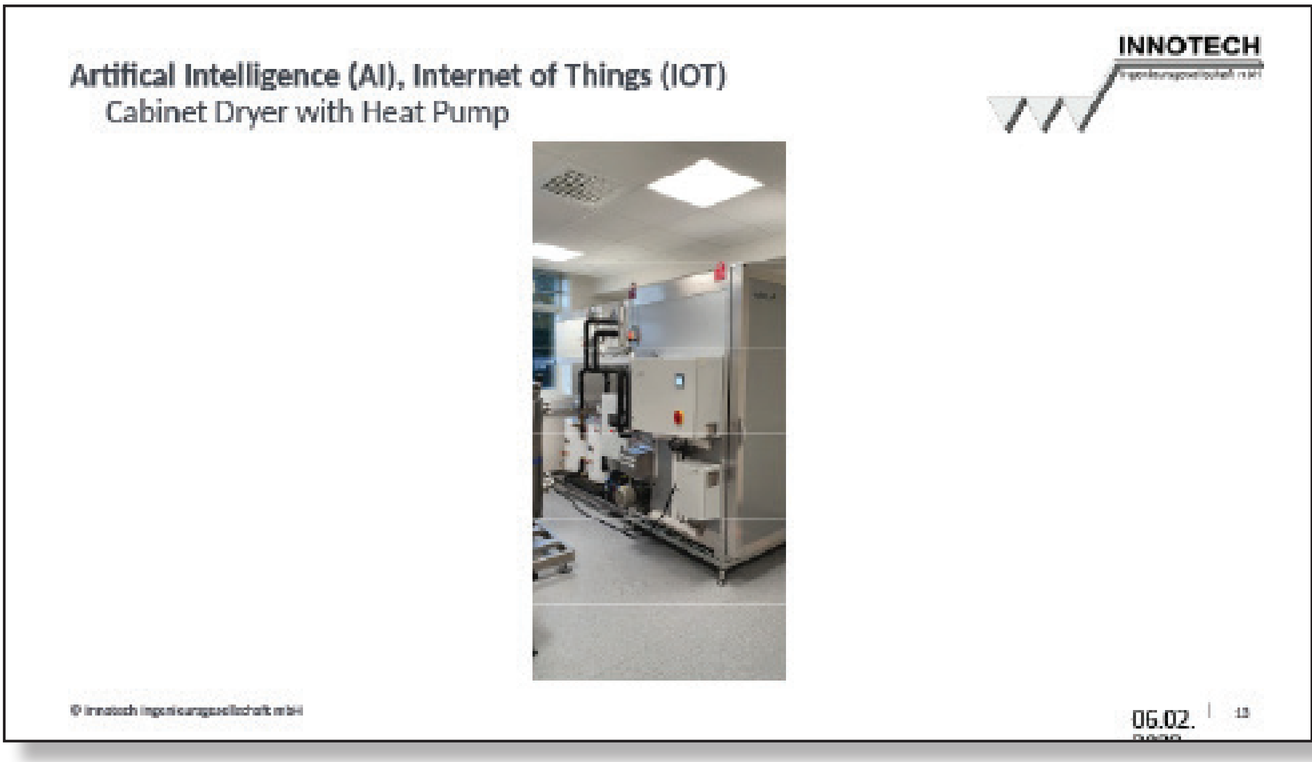
12


Artifical Intelligence (AI), Internet of Things (IOT)
Cabinet Dryer with Heat Pump
INNOTECH
© innotech Ingenieursgesellschaft mbH
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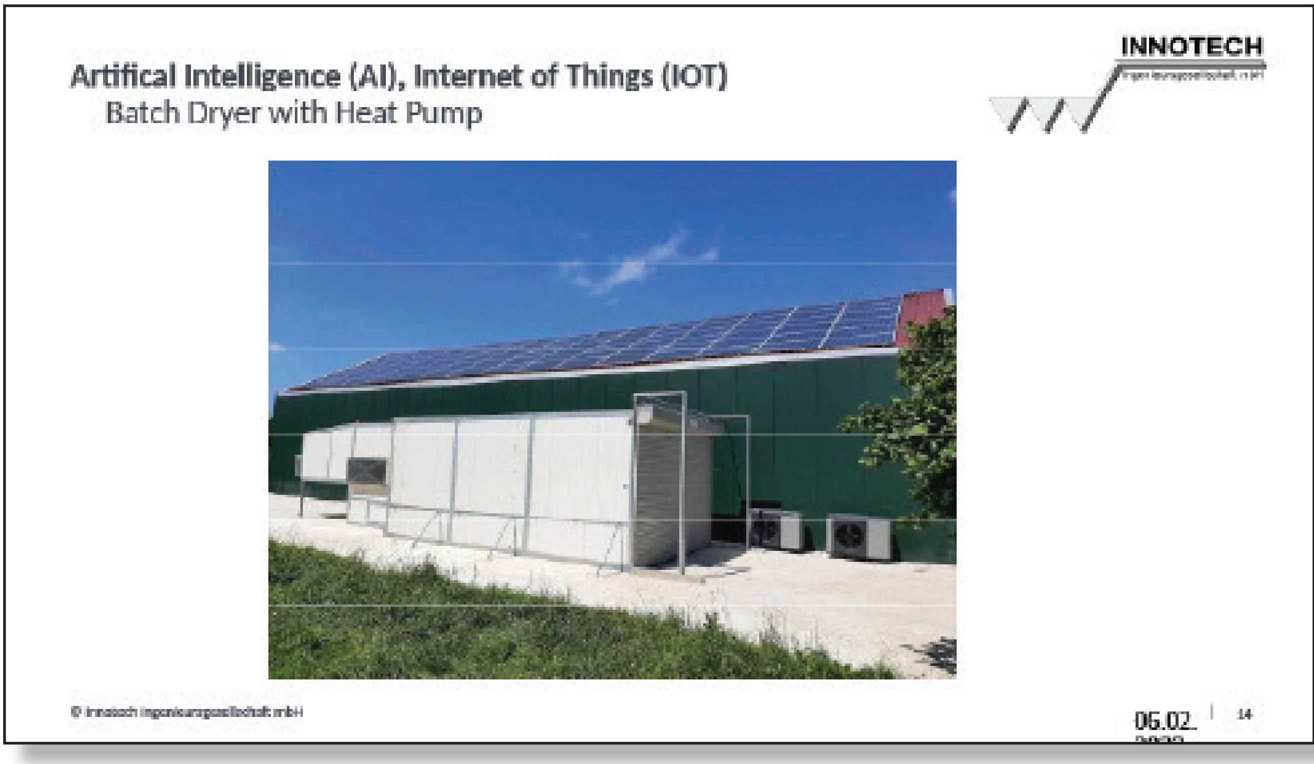
13


Artifical Intelligence (AI), Internet of Things (IOT)
Batch Dryer with Heat Pump
INNOTECH
© innotech Ingenieursgesellschaft mbH
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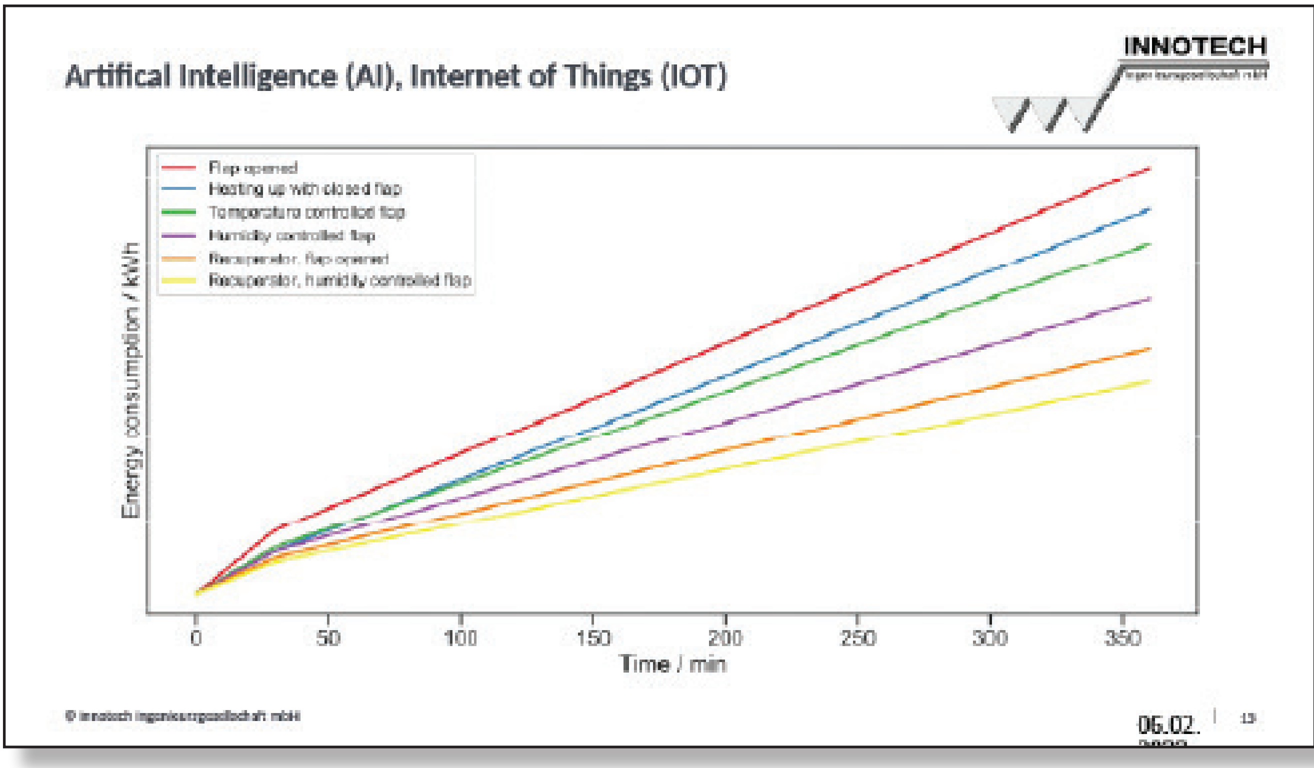
14


Artifical Intelligence (AI), Internet of Things (IOT)
INNOTECH
Flap opened
Heating up with closed flap
Temperature controlled flap
Humidity controlled flap
Recuperator, flap opened
Recuperator, humidity controlled flap
Energy consumption / kWh
0
50
100
150
200
250
300
350
Time / min


Solar Drying
Solar Cooling
SolCoolDry
Research, Innovation & Business Hub
KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE
Fraunhofer
ISE
INNOTECH


INNOTECH
www.innotech-ing.com
Dr.-Ing. Albert Esper
Dr.-Ing. Mathias Fischer
INNOTECH Ingenieursgesellschaft mbH

Session 1, Presentation 5

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

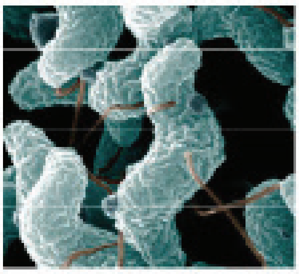
SITUATIONAL ANALYSIS ON ESTABLISHMENT OF HAZARD ANALYSIS AND CRITICAL CONTROL POINTS (HACCP) PLAN FOR SOLCOOLDRY FISH PROCESSING FACILITY AT MWAZARO BEACH MANAGEMENT UNIT SELF-HELP GROUP

Dr. George Wanjala, Dr. Shadrack Makori, Dr. Linus K'osambo M.D.O., Dr.-Ing Clavin Onyango, Ms. Stella Ndungu

PRESENTED AT THE SOLCOOLDRY WORKSHOP TECHNOLOGY DAY AND OFFICIAL LAUNCH – KEMFRI, MOMBASA ON 7-8TH FEBRUARY 2023

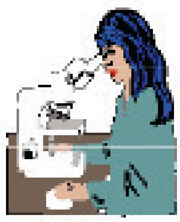
1

INTRODUCTION



Hazard Analysis Critical Control Point:

- Systematic approach to the identification, assessment and control of hazards in food operations.



2

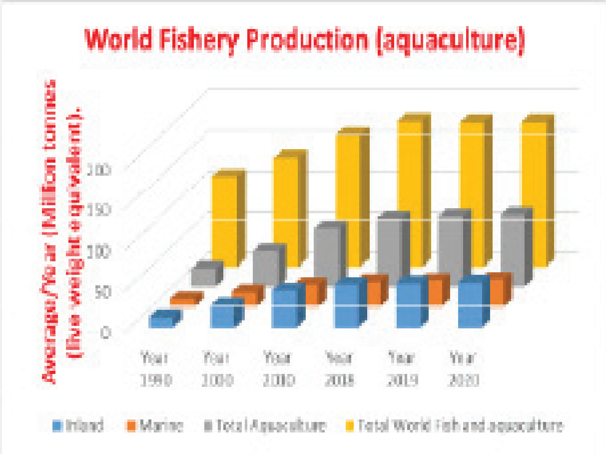
HACCP

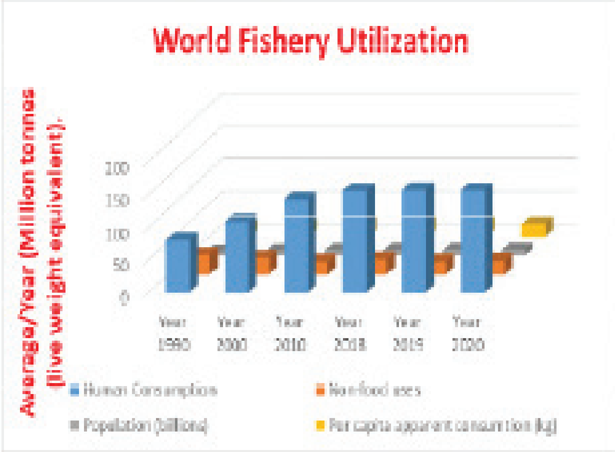
Principle	Activity
1. Hazard analysis	List all potential hazards and suitable control measures
2. CCPs	Determine the points in the process where hazards must be controlled
3. Critical limits	Define the safety limits that must be achieved for each CCP to ensure that the products are safe
4. Monitoring	Establish a system to demonstrate that the CCPs are being controlled within the appropriate critical limit
5. Corrective actions	Actions to be taken when the results of monitoring indicate that a CCP is not under control
6. Verification procedures	Evaluate that the HACCP system is working effectively
7. Documentation	Document all procedures and keep adequate records

Prerequisite programs (PRPs)

Components	Activity
1. Design of premises and equipment	Location and layout of premises and rooms
2. Control of operations	Time, temp, hazards, packaging, hygienic control of water
3. Plant maintenance and cleaning	Equipment and building, pest control and waste management
4. Personal hygiene	Protective clothing, hand-washing, general behaviour, health
5. Transportation	Hygiene of vehicles, temperature control, prevent food damage
6. Product information and consumer awareness	labelling, traceability, storage, use
7. Training	To make personnel aware of their roles and individual responsibilities for food control

The State of World Fisheries and Aquaculture

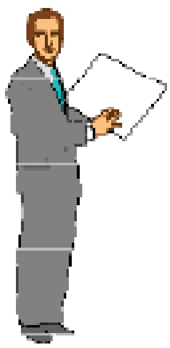




https://www.fao.org/publications/sofia/2022/en/ (Accessed: February 6, 2023).

METHODOLOGY

- ❑ **Descriptive qualitative research.**
- ❑ **Encompassing primary and secondary data sources.**
- ❑ **Similarly, structured interview techniques were used for data collection.**



6

LANDING SITES

- Kibuyuni
- Kijiweni
- Bati
- Gazi
- Shimoni

7

Fish sourcing, handling and processing at the Kibuyuni Fish Landing Site

Fish landing site at Kibuyuni

Open sun dryng of fish

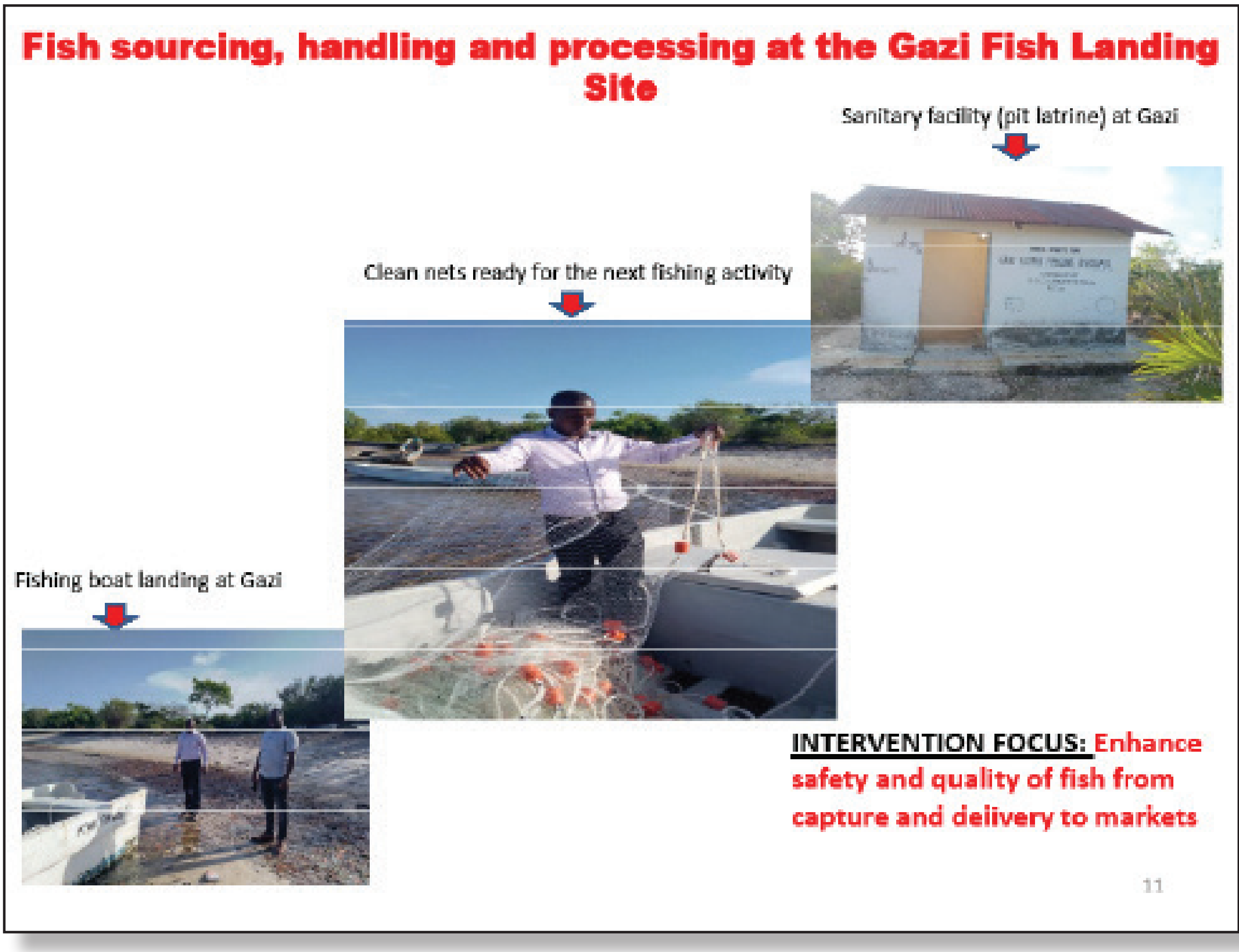
Blanching of fish at Kibuyuni site

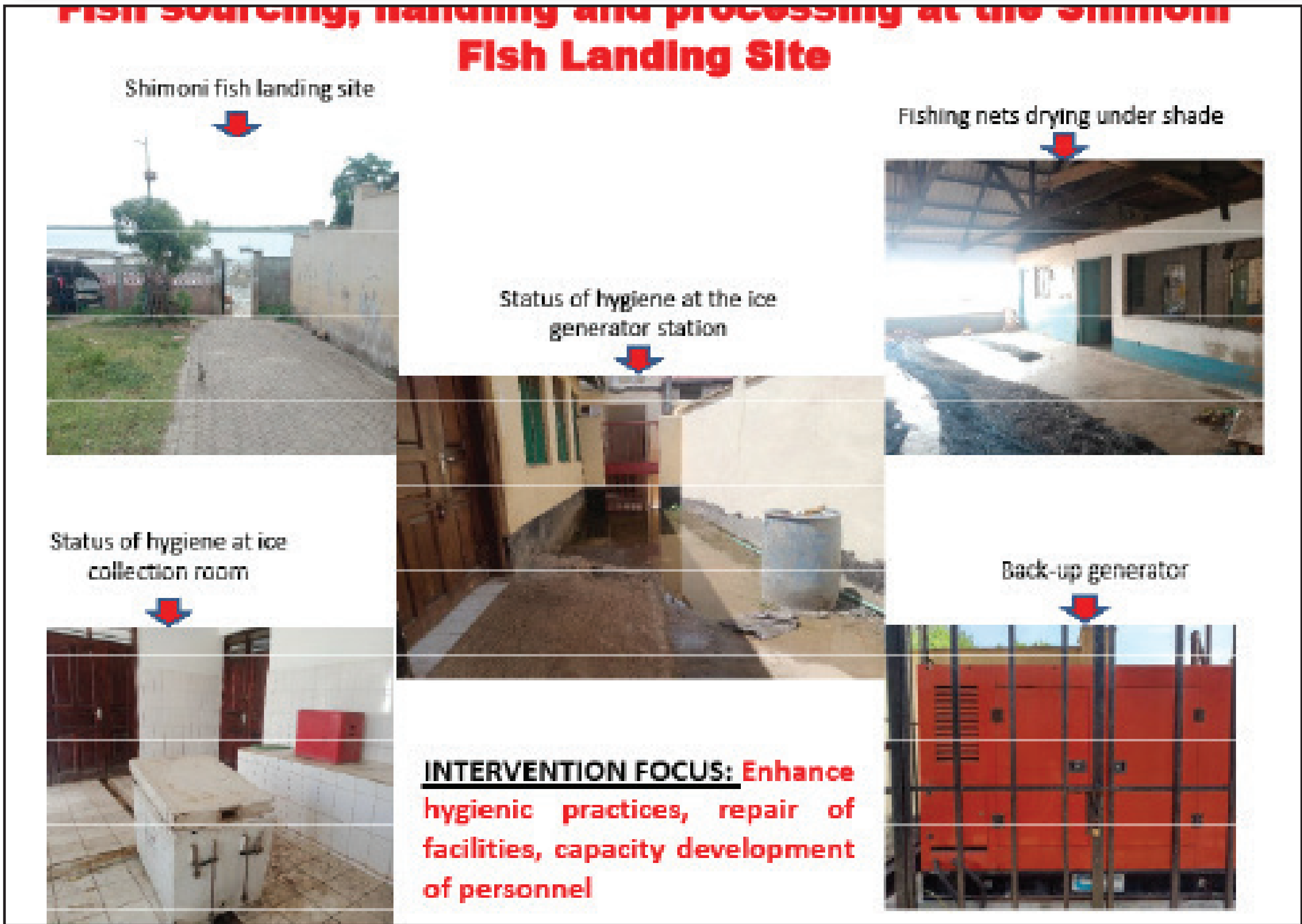
Fresh fish storage and use of open crates for delivery to the market

INTERVENTION FOCUS: Enhance safety and quality of fish from capture, at landing site and delivery to markets


Fish sourcing, handling and processing at the Kijiweni Fish Landing Site
Kijiweni fish landing site
Fish rack/shade for temporary holding
Squid, shark and ray fish at the Kijiweni temporary shade
Boardwalk for ferrying fish to the landing site
Mangrove shoots on path to the boardwalk
INTERVENTION FOCUS: Enhance safety and quality of fish from capture and delivery to markets


Fish sourcing, handling and processing at the Bati Fish Landing Site
Bati fish landing site
Clear ocean horizon at Bati fish landing site
Raised rack for drying at Bati fish landing site
INTERVENTION FOCUS: Enhance safety and quality of fish from capture and delivery to markets


Fish sourcing, handling and processing at the Gazi Fish Landing Site
Sanitary facility (pit latrine) at Gazi
Clean nets ready for the next fishing activity
Fishing boat landing at Gazi
INTERVENTION FOCUS: Enhance safety and quality of fish from capture and delivery to markets
11


Fish Landing Site
Shimoni fish landing site
Fishing nets drying under shade
Status of hygiene at the ice generator station
Status of hygiene at ice collection room
Back-up generator
INTERVENTION FOCUS: Enhance hygienic practices, repair of facilities, capacity development of personnel

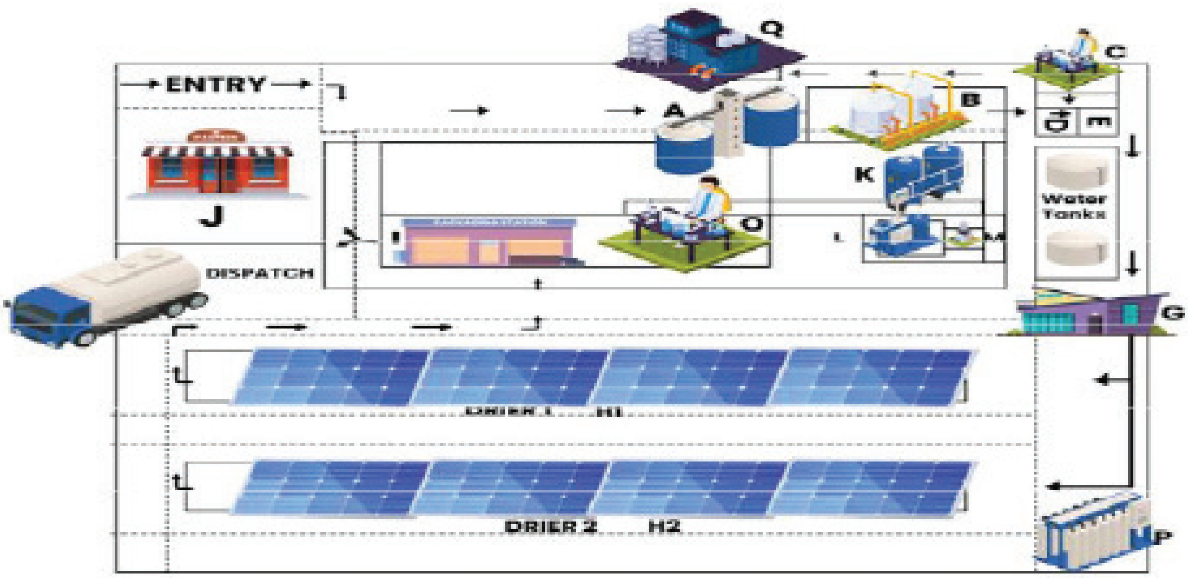
STUDY FINDINGS

- Significant threats exist to food safety in fish handling and processing, from the farm (ocean) to the fork.
- Most landing areas lack basic facilities but where they exist, they are in a deplorable state.
- Personnel (fishermen) and traders exhibited lack basic knowledge on food safety.

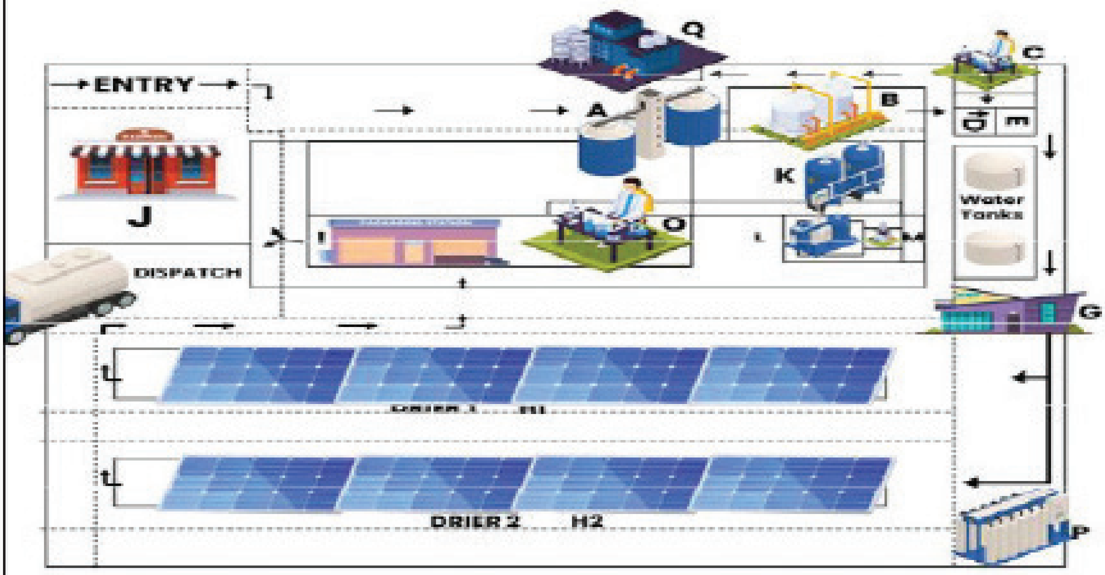
Establishing and implementing a functional food safety system that assures quality and safe fish and fish products is timely.

The development and implementation of the Mwazaro BMU SOLCOOLDRY HACCP is the solution – extended and replicated

INTERVENTION AT THE MWAZARO BMU



TERVENTION AT THE MWAZARO BMU



PARTNERS AND COLLABORATORS

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Thank You

16

Session 2, Presentation 1

KIRDI
Your Industrial Technology Partner...

KENYA VISION 2030

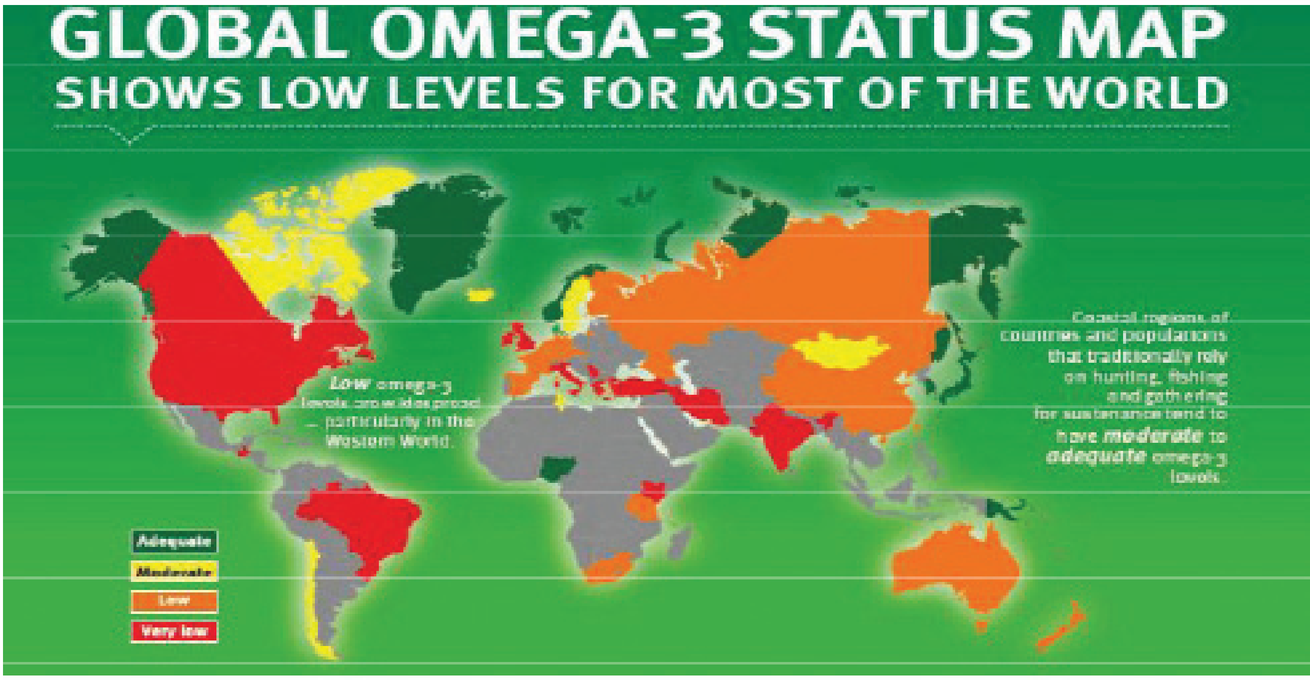
KIRDI Fostering Industrial Research in the Blue Economy: - Opportunities and Perspectives in the New Horizon

Dr. Linus K'osambo M.D.O.
Senior Research Scientist - KIRDI

BACKGROUND:
ECONOMIC POTENTIAL AND NUTRITION

Introduction – Blue Economy Frontier

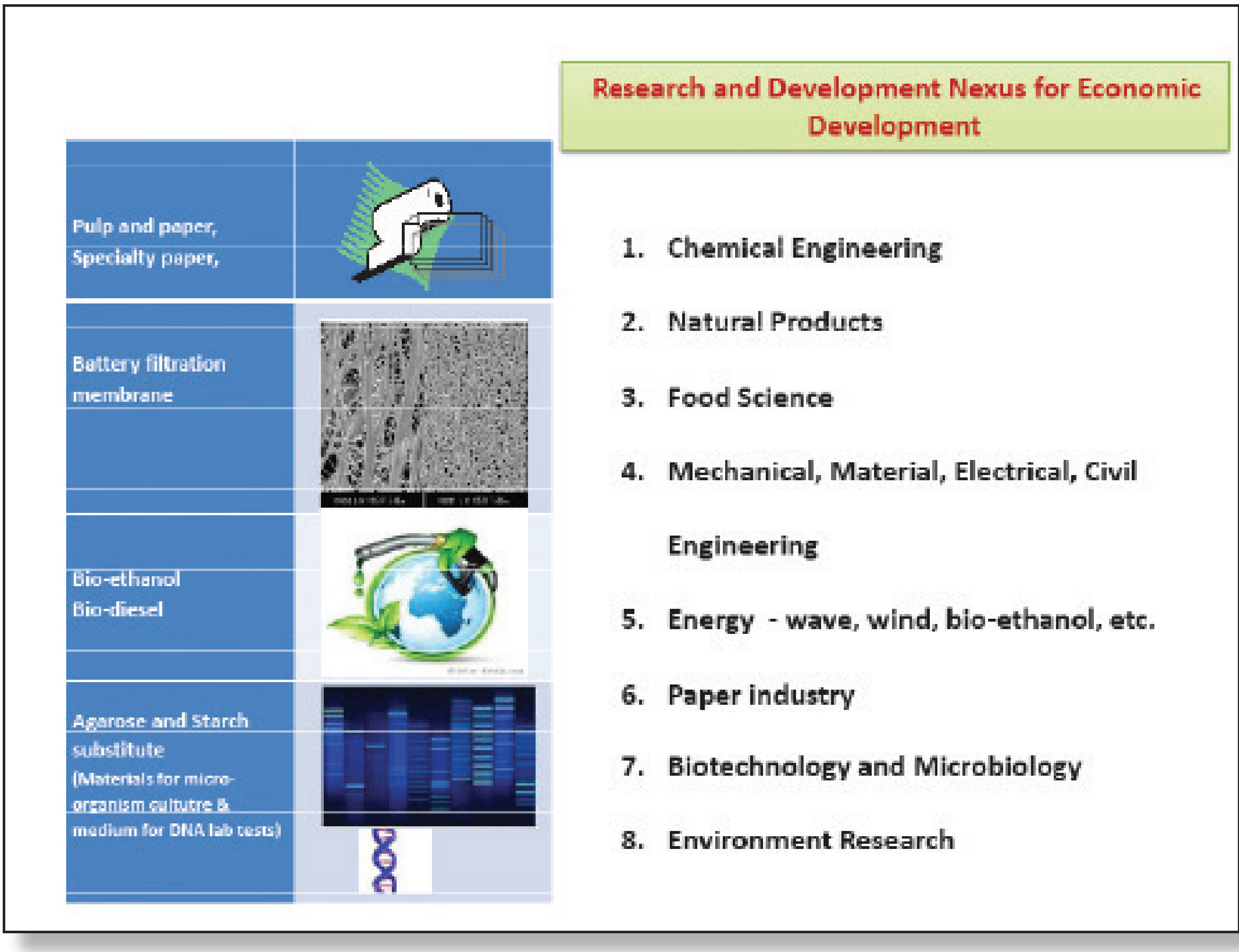
- Kenya: fish production deficit - over $11.4 million imports
- The situation will get worse:
  - ✓ rising population
  - ✓ dwindling fish in Lakes Victoria and Naivasha
- Indian Ocean Exclusive Economic Zone (EEZ) largely unexploited
- EEZ potential: 300,000 tonnes/year valued at about Sh75 billion.
- Blue Economy in EEZ = new investment and economic frontier

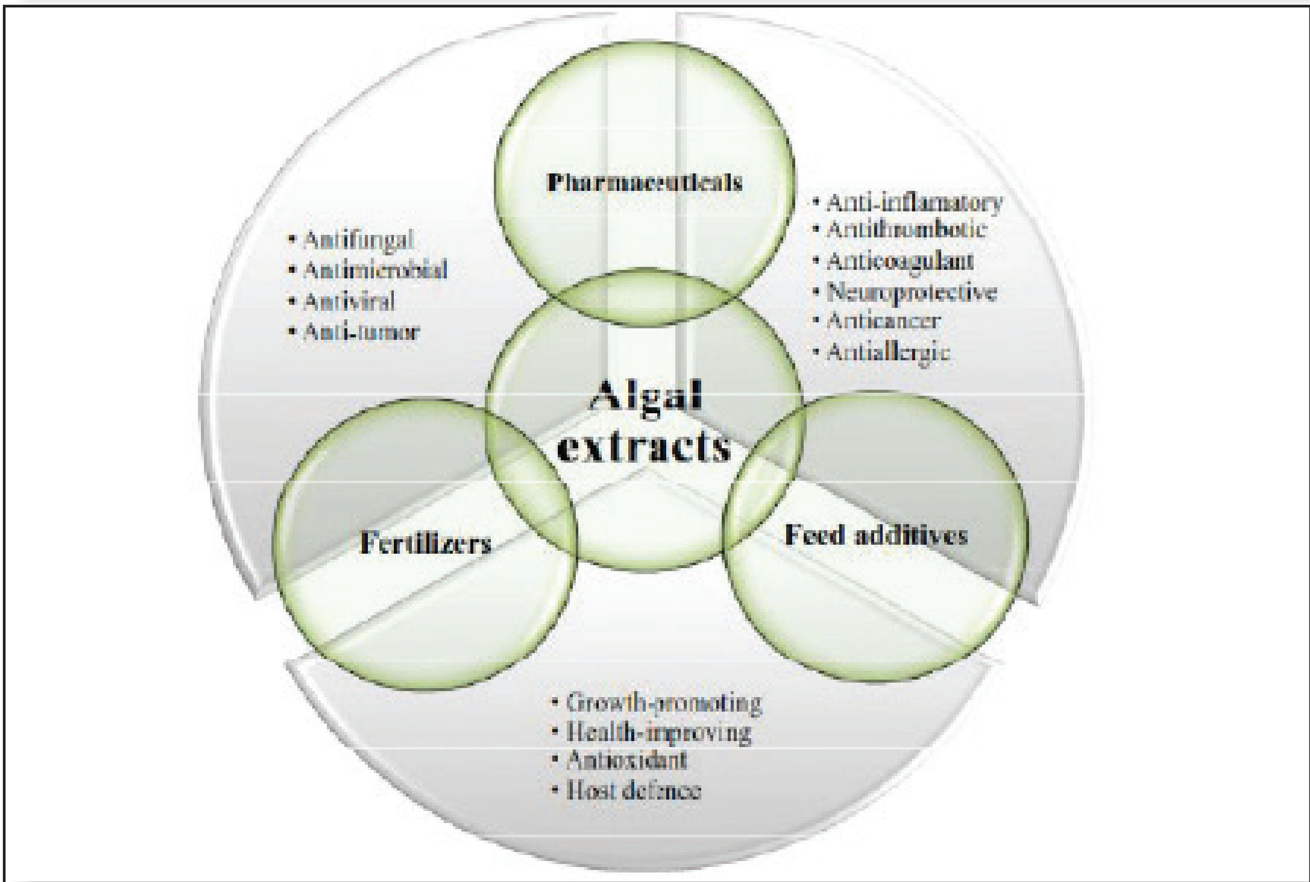


Kenya - Per Capita Consumption = 4.5 kg; Africa = 10 kg, Global = 20 kg.

Production deficit of 225,500 MT to reach African average

OPPORTUITIES IN THE BLUE ECONOMY





Food, Medicinal, Pharmacological and Industrial Uses of Seaweeds

- Seaweeds as food
- Beauty enhancer :– algotherapy - e.g., Ascophyllum nodosum
- Medicinal and pharmacological :- *Sargassum wightii*
- Antimicrobial and antifungal:- extracts of *Gracilaria corticata*
- Anti-inflammatory :- methanol extracts of the seaweeds *Undaria pinnatifida* and Ulva linza
- Anticancer agents :- brown algae *Fucus spp* - against colorectal and breast cancers

Pharmacological and Industrial Uses of Seaweeds

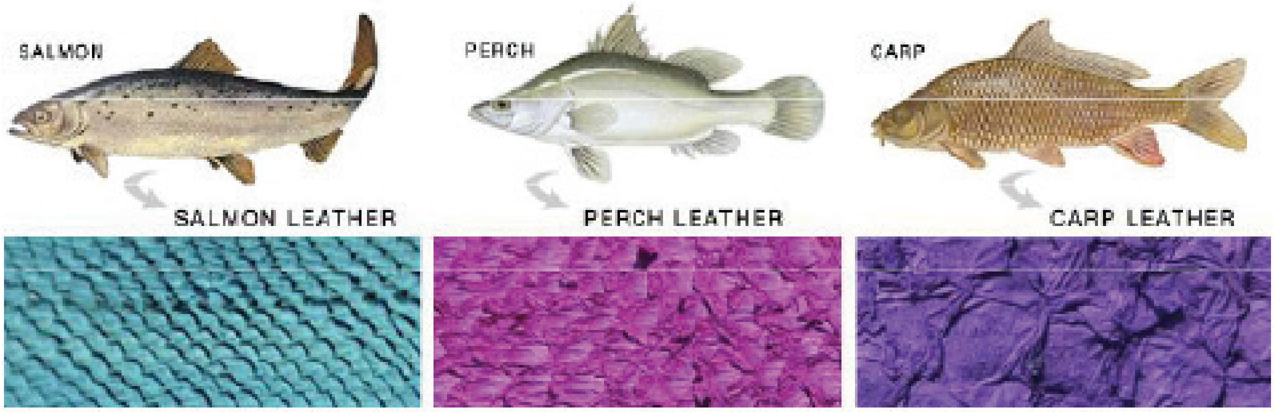
- Antidiabetic activity: - aqueous extract of *Ulva fasciata*
- Antiviral activity :- antiviral sulfated polysaccharides
- Antibiotic - fatty acids, bromophenols, tannins, phloroglucinol, terpenoids and halogenated compounds
- Industrial use – Agar, Alginates, carrageenans
- Renewable energy supplier
- Seaweed used as organic manure


OPPORTUNITIES AND FUTURE PROSPECTS
Industrial Research Opportunities
Site selection – Suitability mapping
Infrastructure development
Diversification and domestication of farmed species
Affordablen feeds
Environmental Management
Development Opportunities
Cage farming of fin fish in deep sea
Hatcheries, feed production , value addition and other value chain needs


Under-exploited Economic Importance of seaweeds
Cosmetics – other valued added products
OXY
AFY

MATERIALS SCIENCE - FISH LEATHER

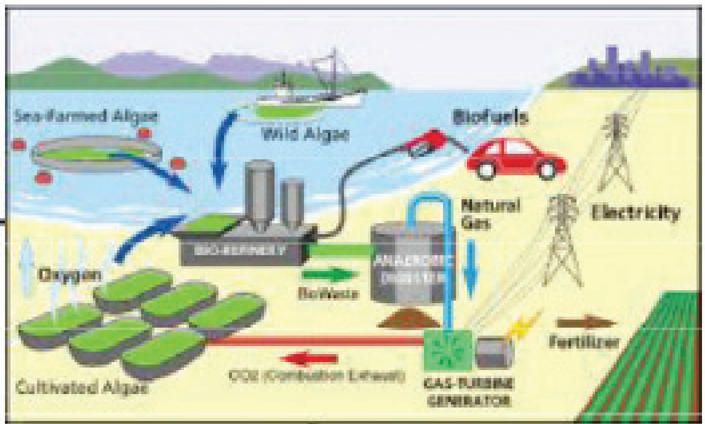
Fish Leather - expanded fishing industry

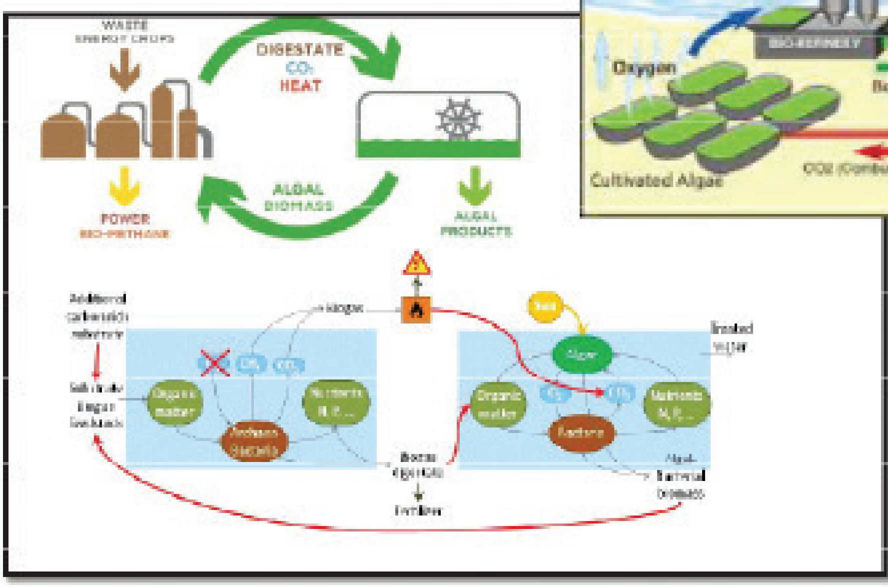


OPPORTUNITIES IN ENERGY

Algae can power and fertilize

Schematics on possible utilization of algae





ENGINEERING OPPORTUNITIES

Marine Cages Design

Marine fabrication and installation

Marine Cages Commercialization, Maintenance and improvement

KIRDI IN BLUE ECONOMY

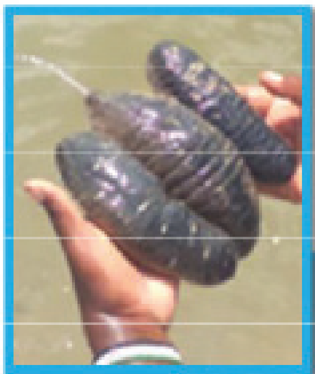

Design of Marine Cages for IMTA of Seaweed and Fish Farming
Two main species: Kappaphycus alvarezii (cottonii) and Eucheuma denticulatum (spinosum)
Marine Cage fabricated by KIRDI
Seaweeds can be farmed around or in cages


IMTA Designs: Seaweeds, Lobsters and Fish
High value lobsters can fetch – KES 3,500 @
Higher productivity of seaweeds in IMTA system
Seaweeds used to feed fish

KIRDI contrinuted in the Establishment of Kibuyuni Seaweed Processing Facility

- Seaweed Soap production and training of Kibuyuni Seaweed Farmers Group by KIRDI technical staff

KIRDI particpates in communties interventions – Sea Cucumber, Milkfish, Crabs, and Mangroves



Sea cucumber (*Holothuria scabra*) in ponds with fish – can also be farmed with seaweeds

Crabs in cages in a pond with Milkfish

Mangroves conserved and planted around the ponds (Silvo-aquaculture)

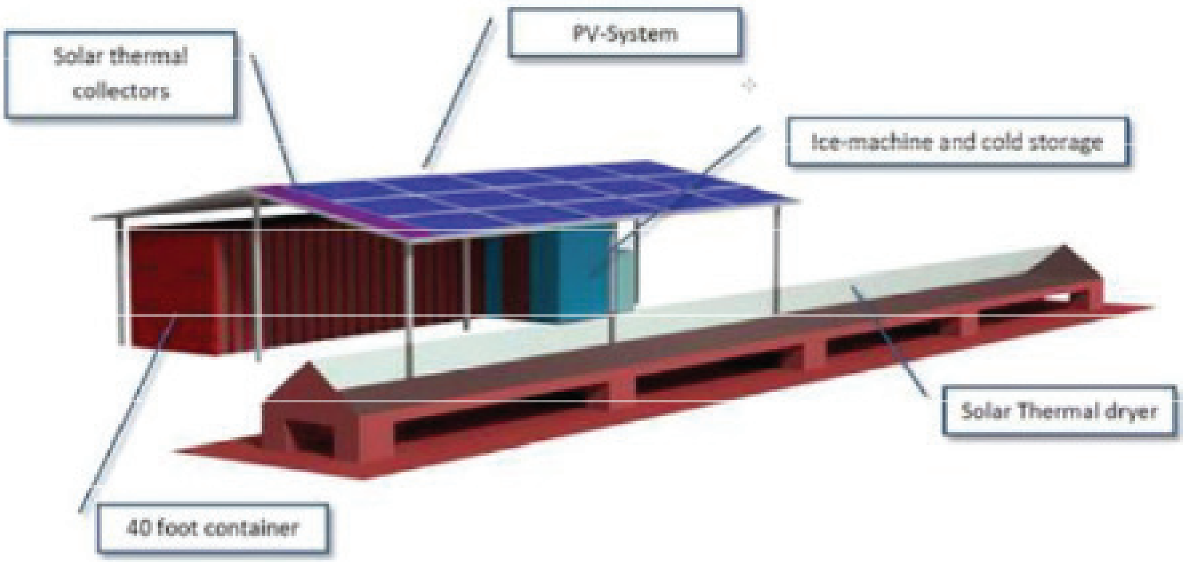
TECHNOLOGY TRANSFER INITIATIVES

KIRDI desinged locally constructed cages at Kibokoni, Kilifi and Kijiweni, Kwale)

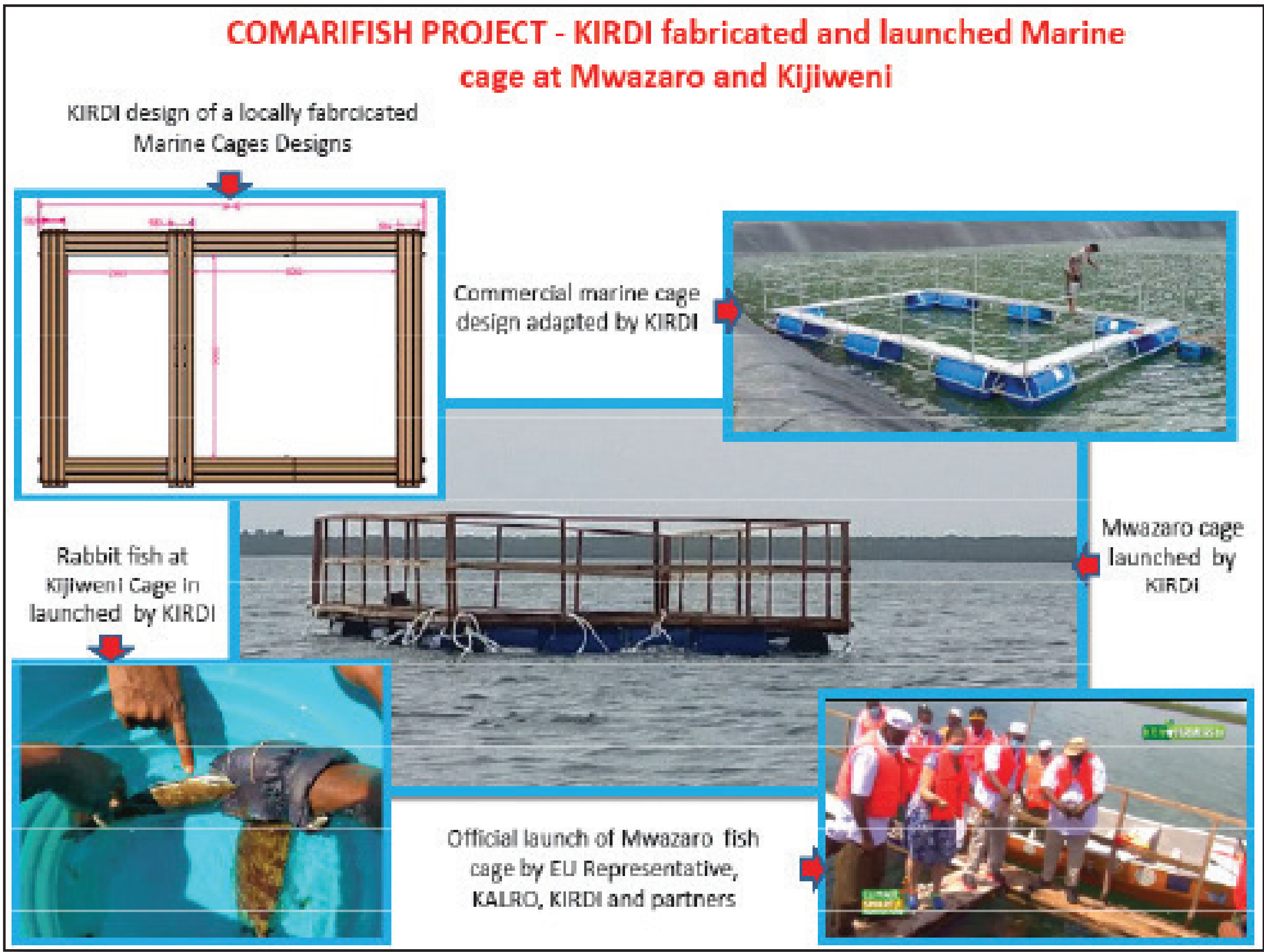
Development and utilization of local resources and capacities important for sustainability

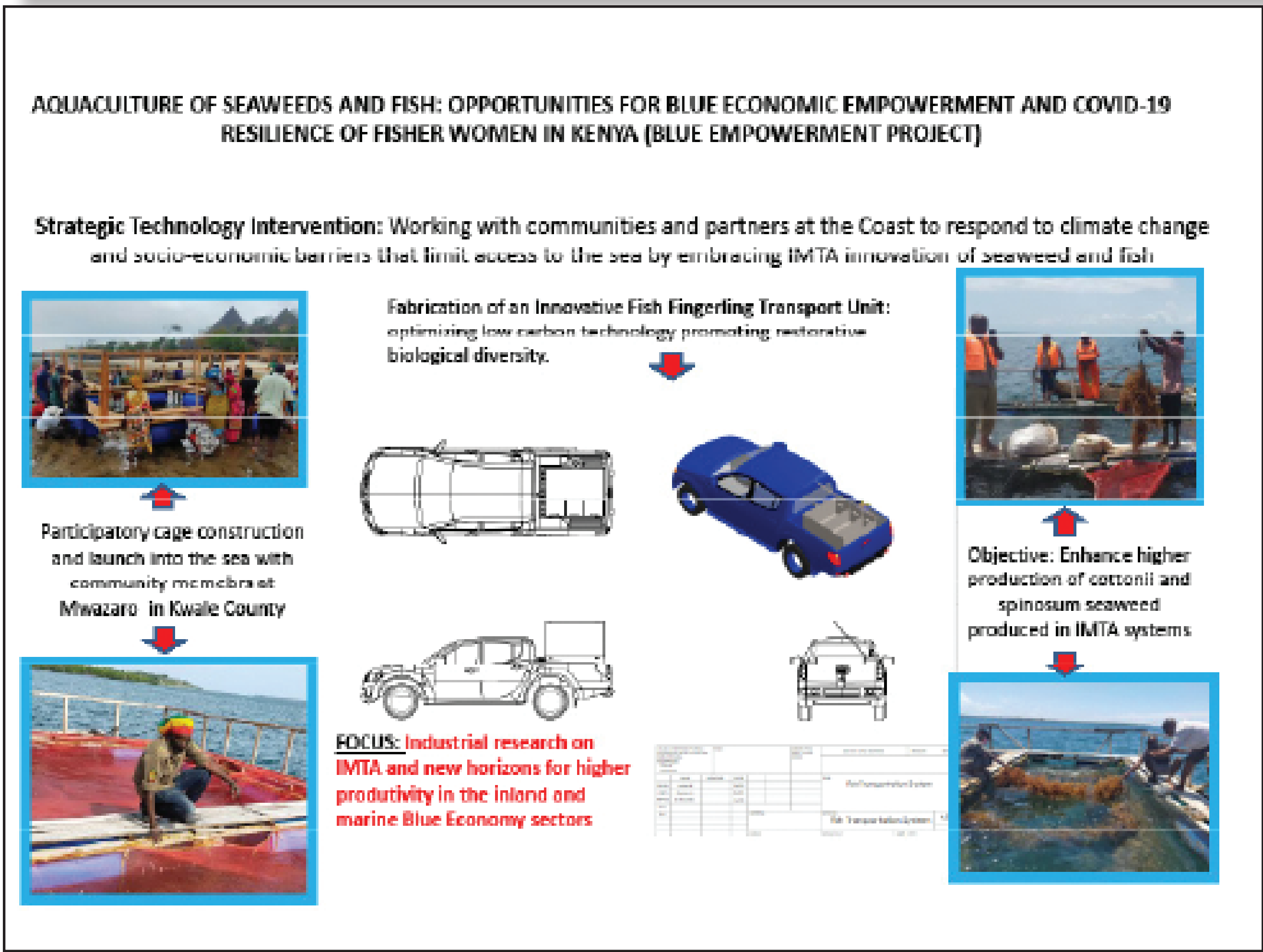
Post Harvest Processing through Solar Power

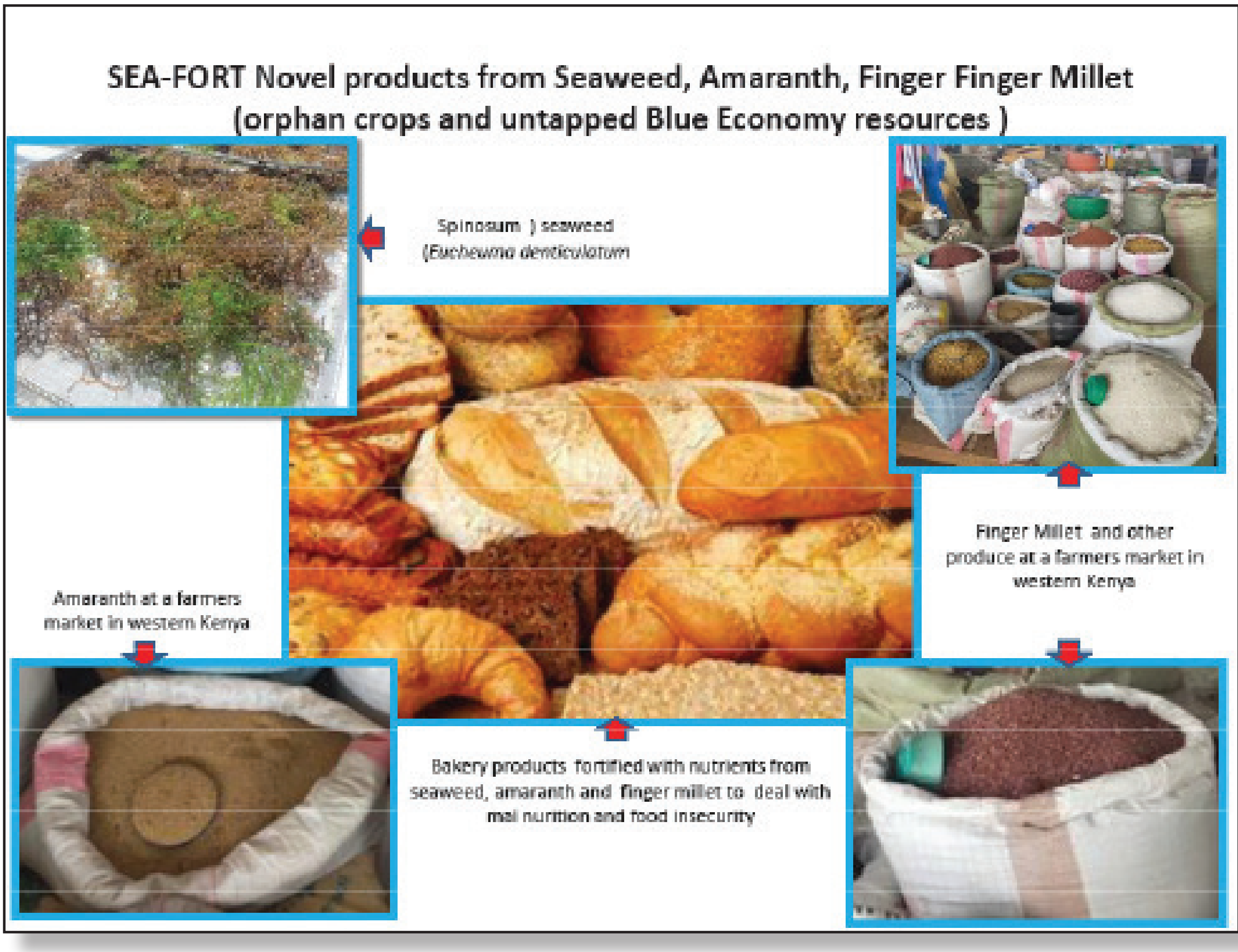
Solar Cooling and Drying System – SolCoolDry System



IMTA supportted by technology ecosystem


COMARIFISH PROJECT - KIRDI fabricated and launched Marine cage at Mwazaro and Kijiweni
KIRDI design of a locally fabricated Marine Cages Designs
Commercial marine cage design adapted by KIRDI
Rabbit fish at Kijiweni Cage in launched by KIRDI
Mwazaro cage launched by KIRDI
Official launch of Mwazaro fish cage by EU Representative, KALRO, KIRDI and partners


AQUACULTURE OF SEAWEEDS AND FISH: OPPORTUNITIES FOR BLUE ECONOMIC EMPOWERMENT AND COVID-19 RESILIENCE OF FISHER WOMEN IN KENYA (BLUE EMPOWERMENT PROJECT)
Strategic Technology Intervention: Working with communities and partners at the Coast to respond to climate change and socio-economic barriers that limit access to the sea by embracing IMTA innovation of seaweed and fish
Fabrication of an Innovative Fish Fingerling Transport Unit: optimizing low carbon technology promoting restorative biological diversity.
Participatory cage construction and launch into the sea with community memebrs at Mwazaro in Kwale County
Objective: Enhance higher production of cottonii and spinosum seaweed produced in IMTA systems
FOCUS: Industrial research on IMTA and new horizons for higher produtivity in the inland and marine Blue Economy sectors



KIRDI RESEARCH PROJECTS AND DEVELOPMENT INITIATIVES

- Commercialize mariculture of tilapia (*Oreochromis niloticus*) and rabbitfish (*Siganus argenteus*) in Kibokoni, Mwazaro and Kijiweni for better livelihoods of fisher communities in Kilifi and Kwale Counties

(CO-MARIFISH PROJECT)

- Development of Milkfish (*Chanos chanos*) and Kimarawali (*Stolephorus delecatulus*) Solar Drying-Cooling Technology, Value Addition and Quality Assurance

(SOLCOOLDRY PROJECT)

- Seaweeds, Amaranth and Finger Millet-Nutrients Fortified Bakery Products for Improved Health and Livelihoods in Kenya

(SEA-FORT PROJECT)

- Aquaculture of Seaweeds and Fish: Opportunities for Blue Economic Empowerment and COVID-19 Resilience for Fisher Women in Kenya

(BLUE-EMPOWERMENT PROJECT)

PARTNERS AND COLLABORATORS IN THE BLUE ECONOMY

ACTS

Knowledge for Better Livelihoods

TECHNICAL UNIVERSITY OF MOMBASA

BAHARI CBO NETWORK

Bahari Yetu Maisha Yetu

K.M.F.R.I

With support from

Federal Ministry of Food and Agriculture

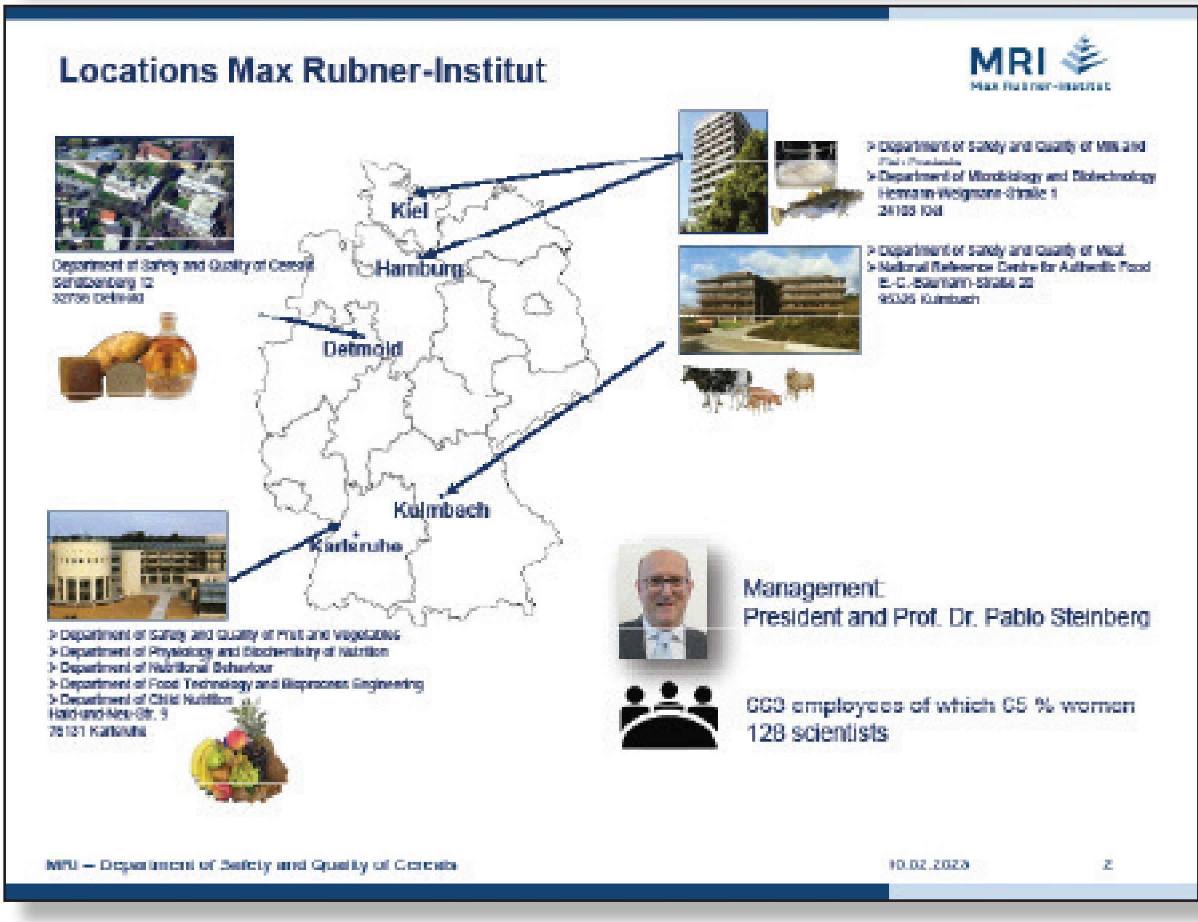
by decision of the German Bundestag

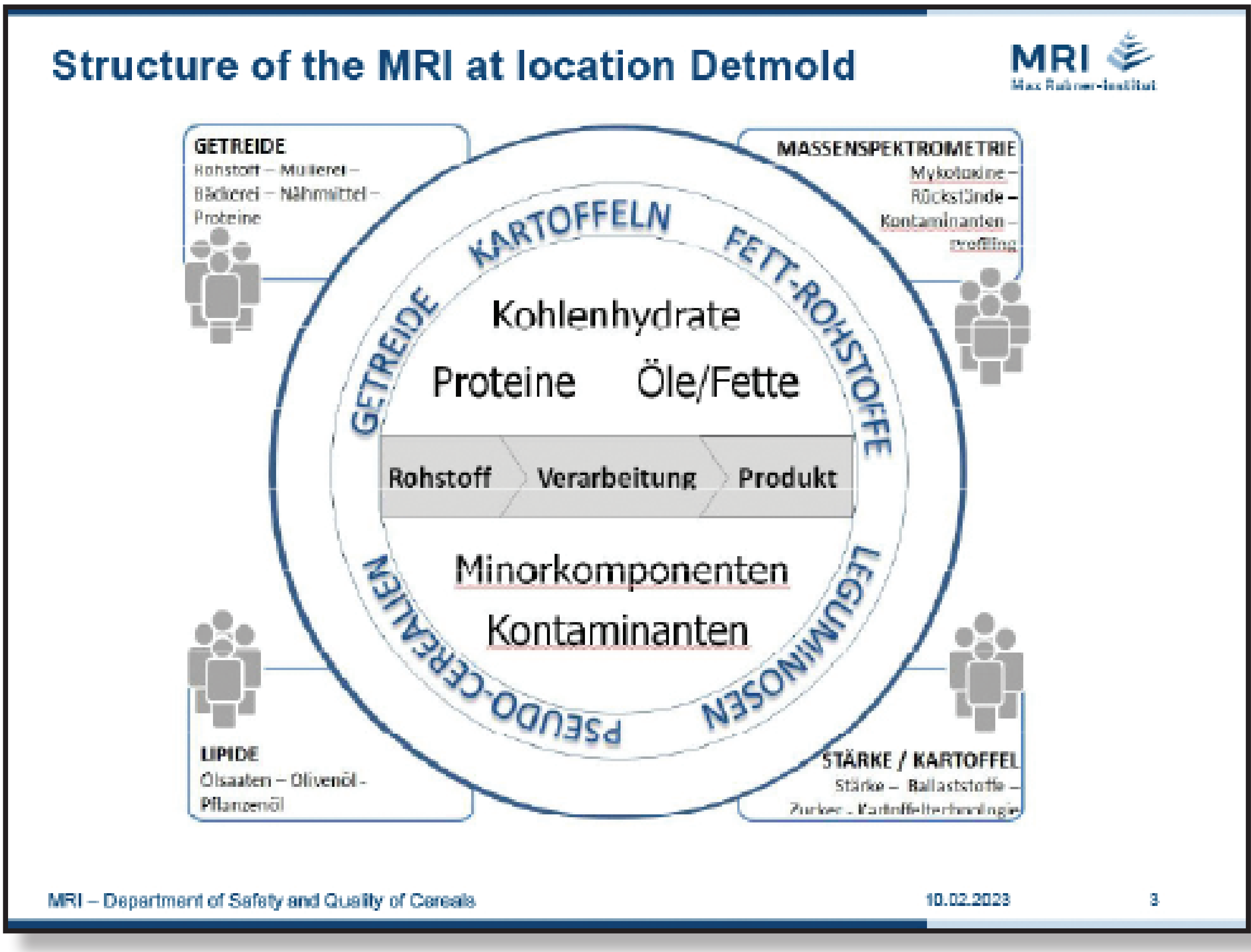
Fraunhofer ISE

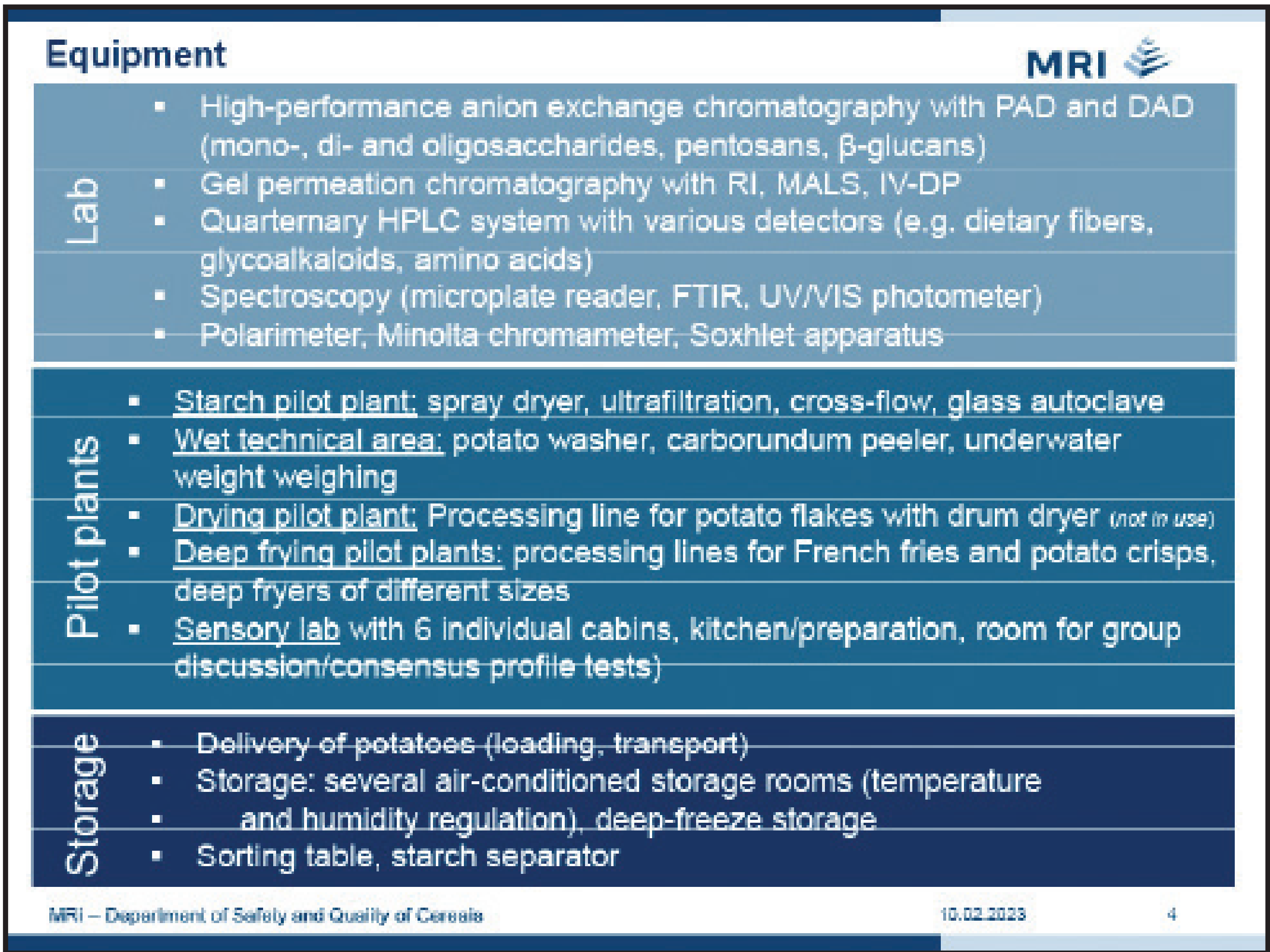
INNOTECH

Thank you!

Session 2, Presentation 2




Structure of the MRI at location Detmold
MRI
Max Rubner-Institut
GETREIDE
Rohstoff – Müllerei –
Bäckerei – Nährmittel –
Proteine
MASSENSPEKTROMETRIE
Mykotoxine –
Rückstände –
Kontaminanten –
Profiling
KARTOFFELN
FETT-ROHSTOFFE
GETREIDE
Kohlenhydrate
Proteine
Öle/Fette
Rohstoff
Verarbeitung
Produkt
Minorkomponenten
Kontaminanten
PSEUDO-CEREALIEN
LEGUMINOSEN
LIPIDE
Ölsaaten – Olivenöl –
Pflanzenöl
STÄRKE / KARTOFFEL
Stärke – Ballaststoffe –
Zucker – Kartoffeltechnologie
MRI – Department of Safety and Quality of Cereals
10.02.2023
3


Equipment
MRI
Lab
High-performance anion exchange chromatography with PAD and DAD (mono-, di- and oligosaccharides, pentosans, β-glucans)
Gel permeation chromatography with RI, MALS, IV-DP
Quarternary HPLC system with various detectors (e.g. dietary fibers, glycoalkaloids, amino acids)
Spectroscopy (microplate reader, FTIR, UV/VIS photometer)
Polarimeter, Minolta chromameter, Soxhlet apparatus
Pilot plants
Starch pilot plant: spray dryer, ultrafiltration, cross-flow, glass autoclave
Wet technical area: potato washer, carborundum peeler, underwater weight weighing
Drying pilot plant: Processing line for potato flakes with drum dryer (not in use)
Deep frying pilot plants: processing lines for French fries and potato crisps, deep fryers of different sizes
Sensory lab with 6 individual cabins, kitchen/preparation, room for group discussion/consensus profile tests)
Storage
Delivery of potatoes (loading, transport)
Storage: several air-conditioned storage rooms (temperature
and humidity regulation), deep-freeze storage
Sorting table, starch separator
MRI – Department of Safety and Quality of Cereals
10.02.2023
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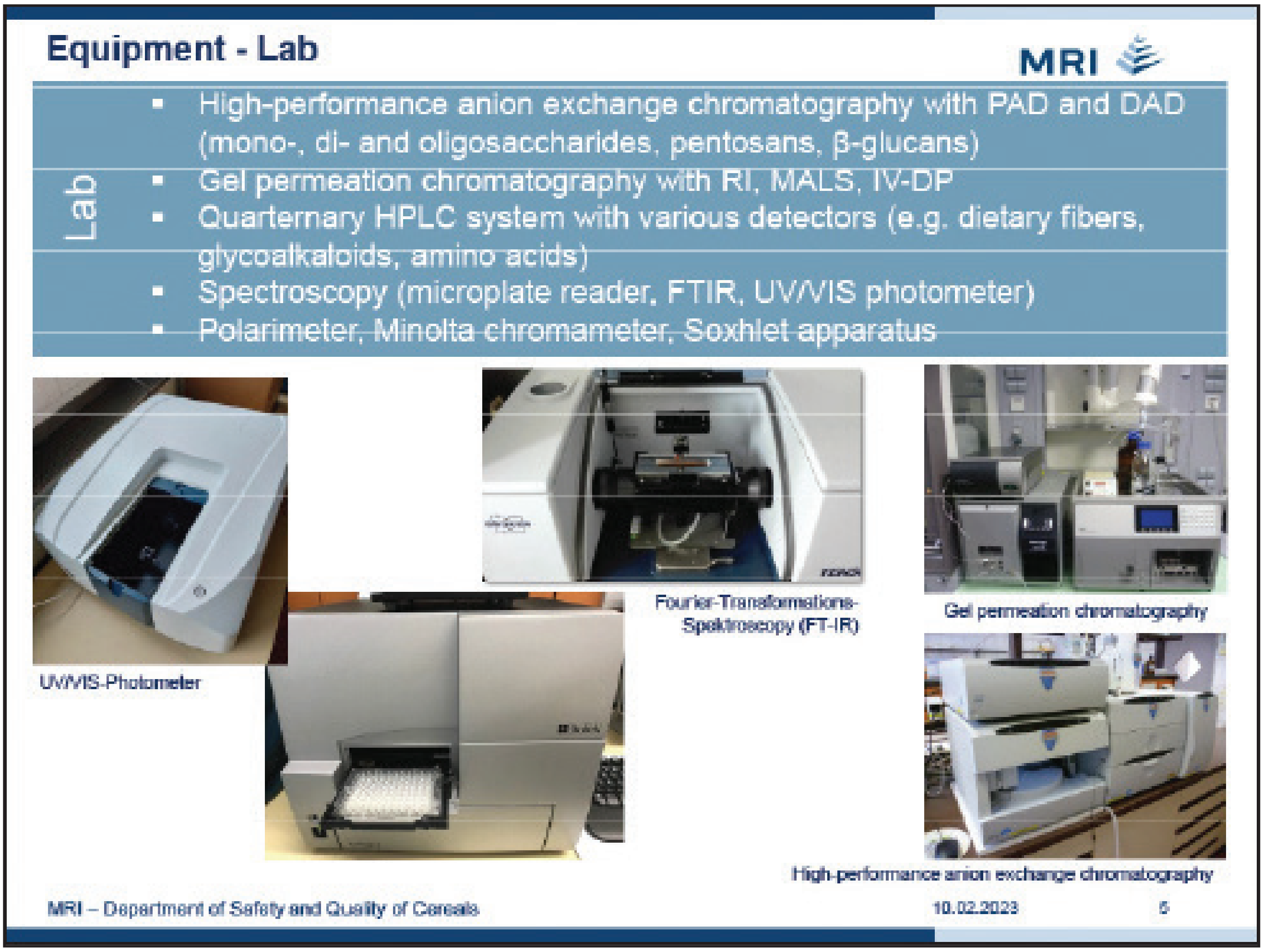
Equipment - Lab
MRI
Lab
High-performance anion exchange chromatography with PAD and DAD (mono-, di- and oligosaccharides, pentosans, β-glucans)
Gel permeation chromatography with RI, MALS, IV-DP
Quarternary HPLC system with various detectors (e.g. dietary fibers, glycoalkaloids, amino acids)
Spectroscopy (microplate reader, FTIR, UV/VIS photometer)
Polarimeter, Minolta chromameter, Soxhlet apparatus
UV/VIS-Photometer
Fourier-Transformations-Spektroskopy (FT-IR)
Gel permeation chromatography
High-performance anion exchange chromatography
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5


Equipment – Lab & pilot plants
MRI
Processing quality – Colour measurement, texture, sensory evaluation etc.
Pilot plants
Starch pilot plant: spray dryer, ultrafiltration, cross-flow, glass autoclave
Wet technical area: potato washer, carborundum peeler, underwater weight weighing
Drying pilot plant: Processing line for potato flakes with drum dryer (not in use)
Deep frying pilot plants: processing lines for French fries and potato crisps, deep fryers of different sizes
Sensory lab with 6 individual cabins, kitchen/preparation, room for group discussion/consensus profile tests)
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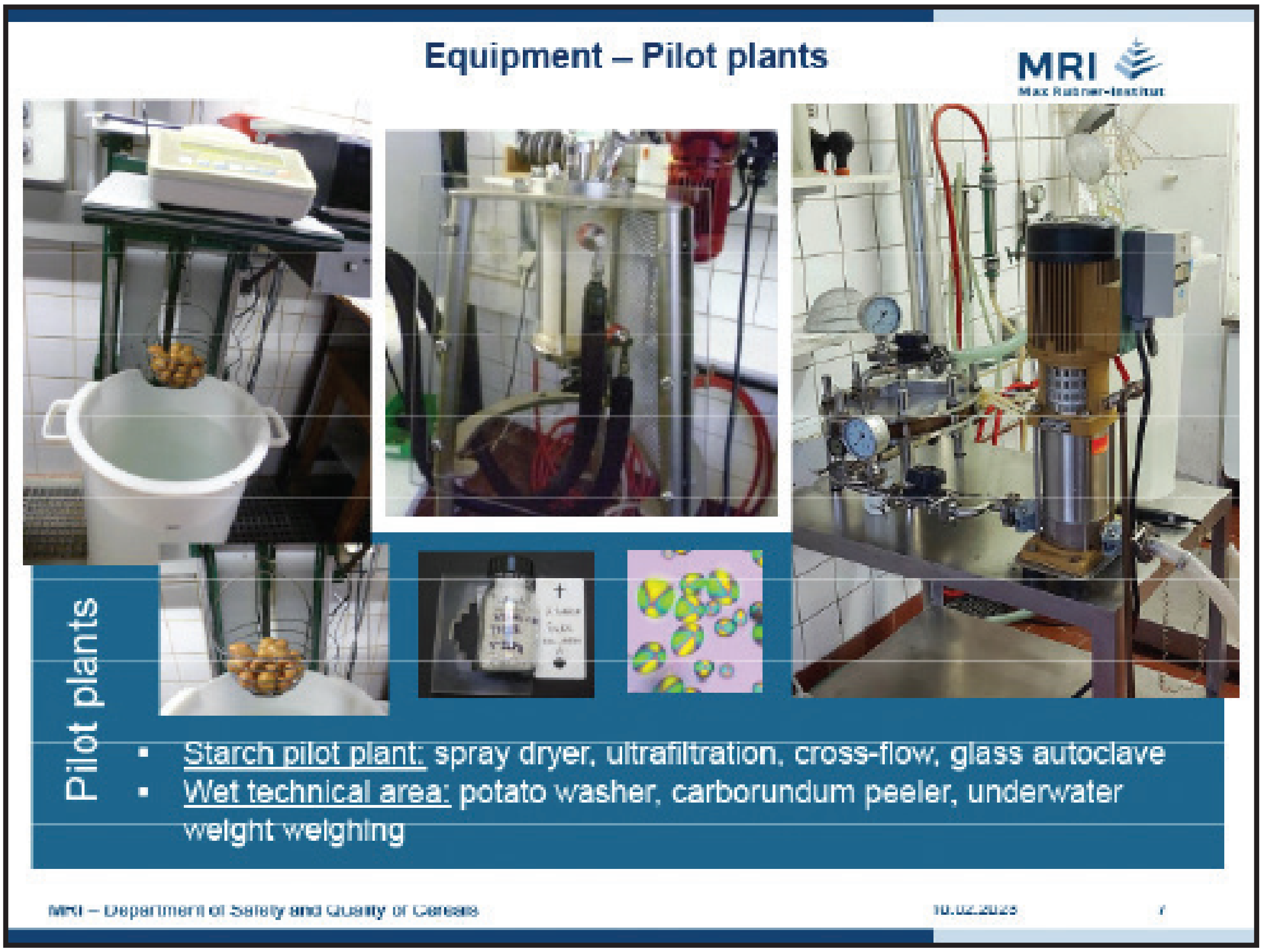
Equipment – Pilot plants
MRI
Max Rubner-Institut
Pilot plants
Starch pilot plant: spray dryer, ultrafiltration, cross-flow, glass autoclave
Wet technical area: potato washer, carborundum peeler, underwater weight weighing
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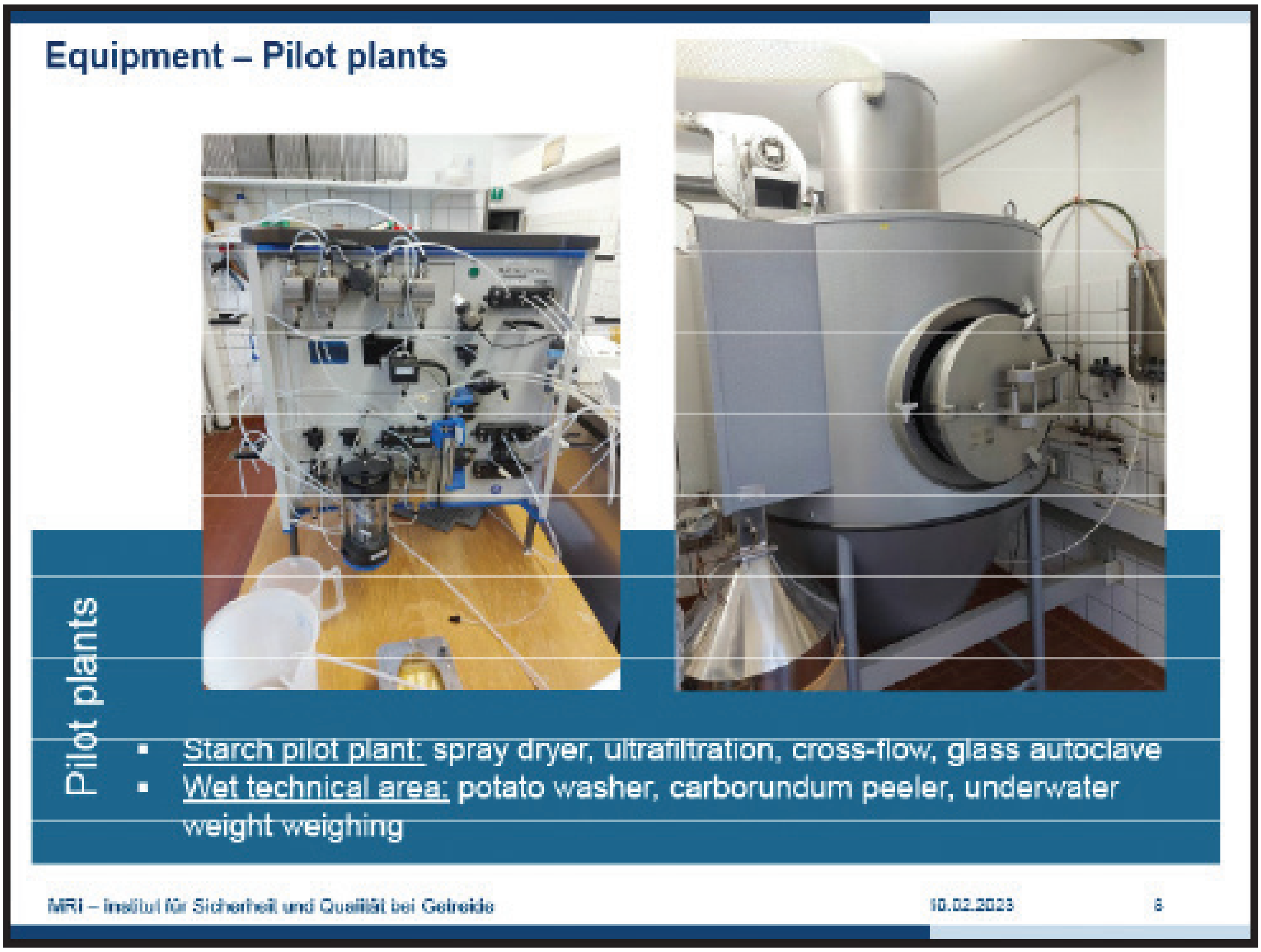
7


Equipment – Pilot plants
Pilot plants
Starch pilot plant: spray dryer, ultrafiltration, cross-flow, glass autoclave
Wet technical area: potato washer, carborundum peeler, underwater weight weighing
MRI – Institut für Sicherheit und Qualität bei Getreide
10.02.2023
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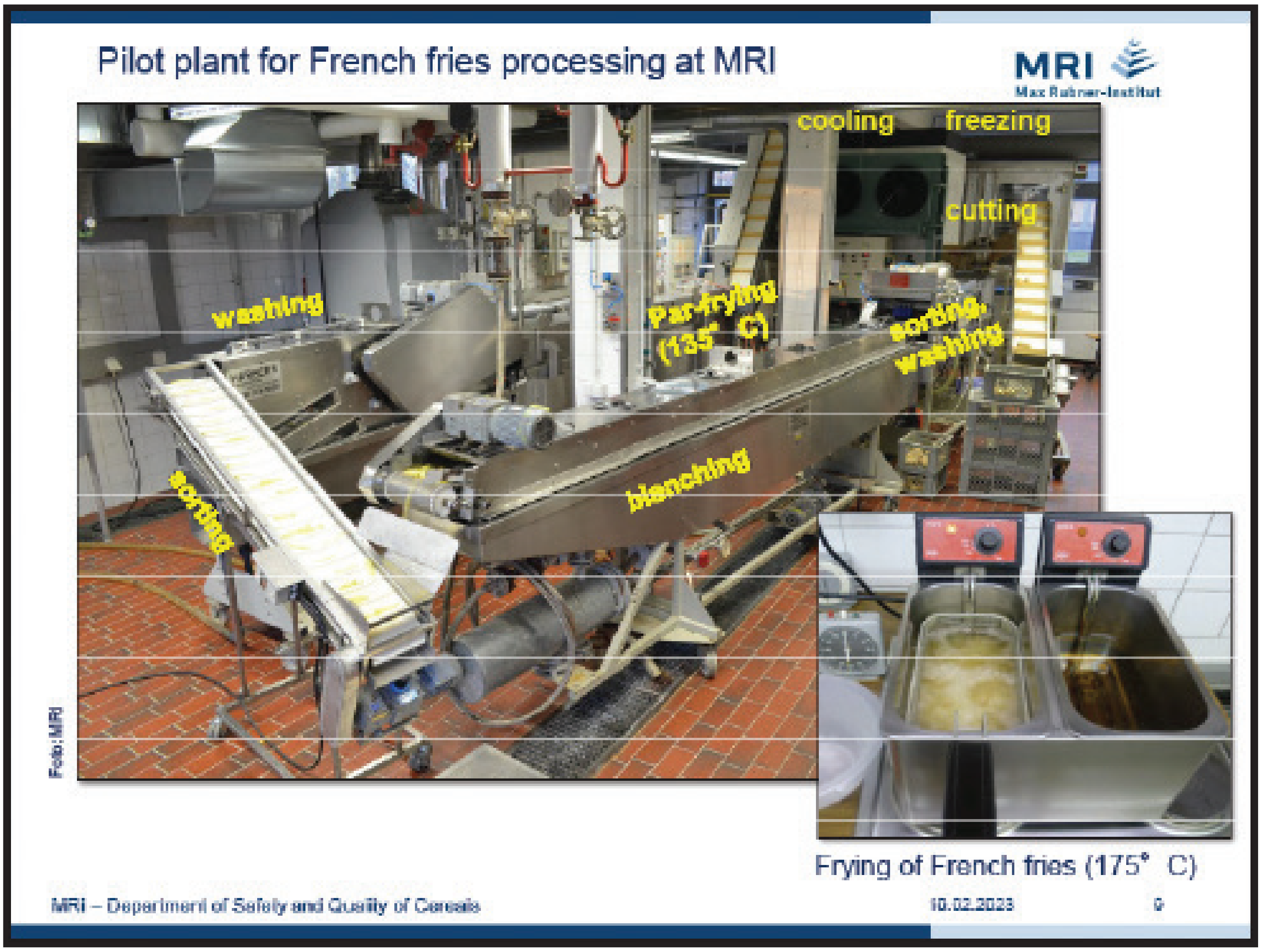
Pilot plant for French fries processing at MRI
MRI
Max Rubner-Institut
cooling
freezing
cutting
washing
Par-frying
(135° C)
sorting,
washing
sorting
blanching
Foto: MRI
Frying of French fries (175° C)
MRI – Department of Safety and Quality of Cereals
10.02.2023
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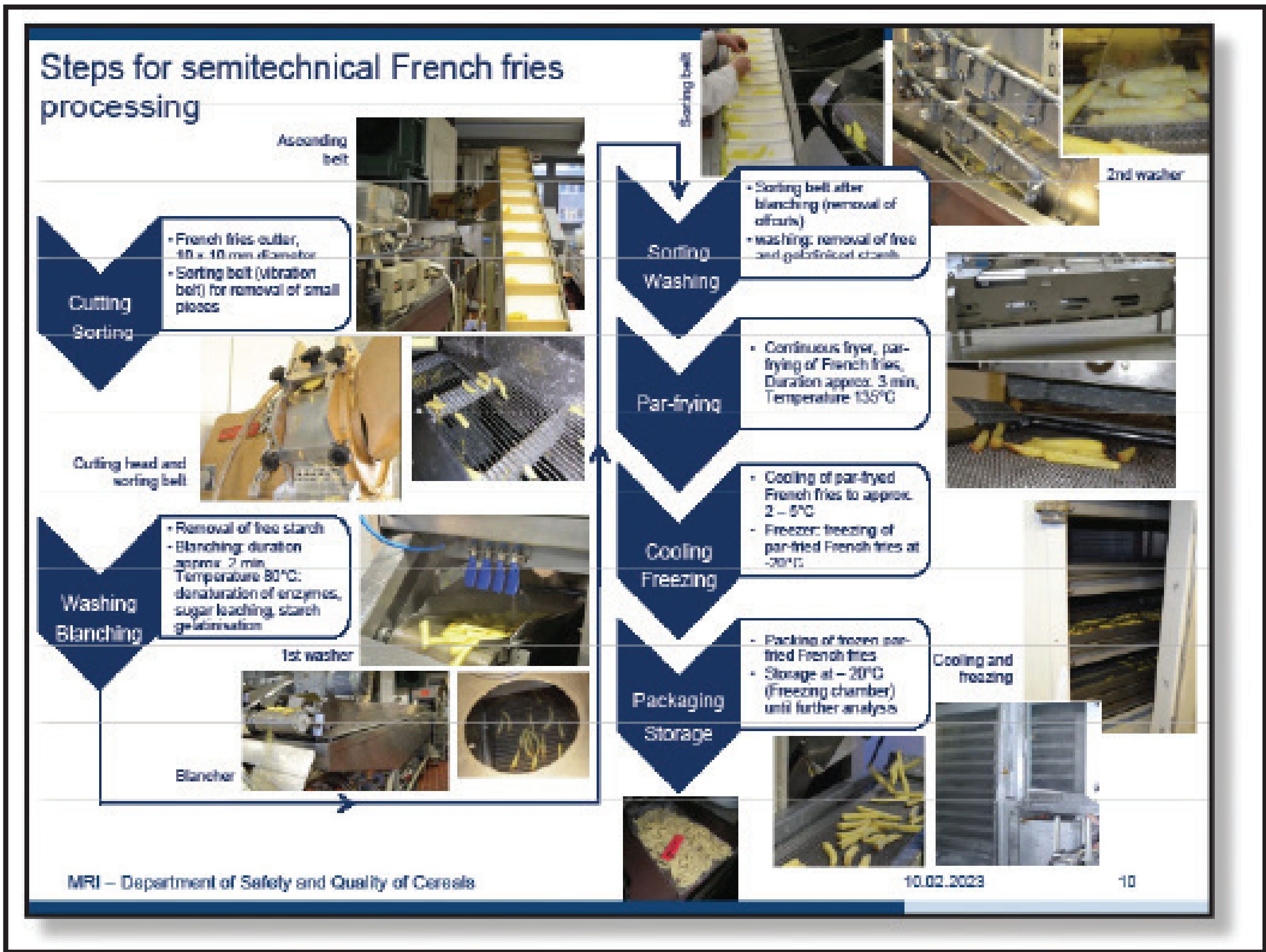
Steps for semitechnical French fries processing
Ascending belt
Cutting
Sorting
• French fries cutter,
• Sorting belt (vibration belt) for removal of small pieces
Cutting head and sorting belt
Washing
Blanching
• Removal of free starch
• Blanching: duration
Temperature 80°C: denaturation of enzymes, sugar leaching, starch gelatinisation
1st washer
Blancher
Sorting belt
Sorting
Washing
• Sorting belt after blanching (removal of offcuts)
• washing: removal of free
2nd washer
Par-frying
• Continuous fryer, par-frying of French fries, Duration approx. 3 min, Temperature 135°C
Cooling
Freezing
• Cooling of par-fryed French fries to approx. 2 – 5°C
• Freezer: freezing of par-fried French fries at
Packaging
Storage
• Packing of frozen par-fried French fries
• Storage at – 20°C (Freezing chamber) until further analysis
Cooling and freezing
MRI – Department of Safety and Quality of Cereals
10.02.2023
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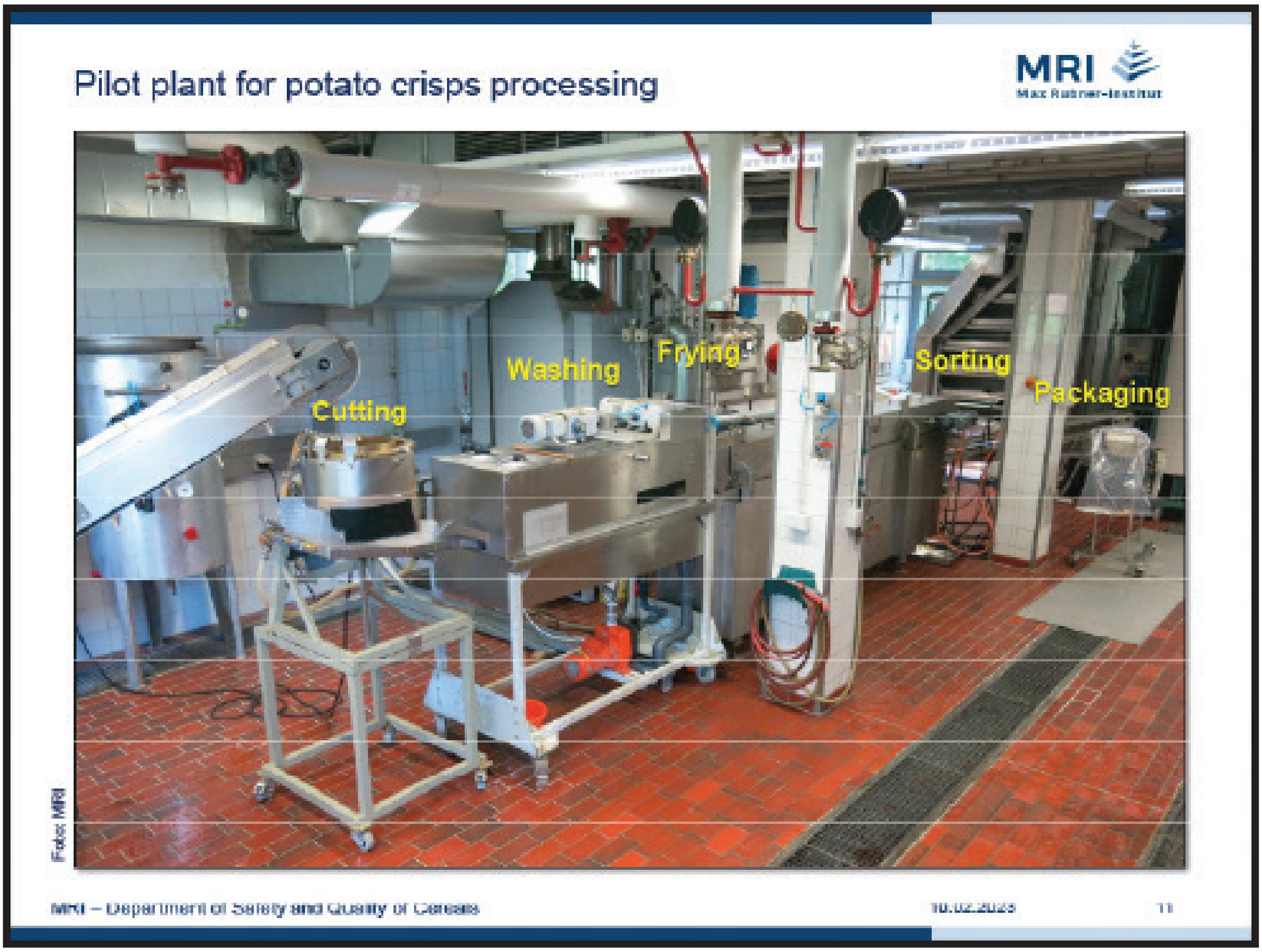
Pilot plant for potato crisps processing
MRI
Max Rubner-Institut
Cutting
Washing
Frying
Sorting
Packaging
Foto: MRI
MRI – Department of Safety and Quality of Cereals


Steps for semitechnical potato crisps processing
MRI
Max Rubner-Institut
Boxes in air-conditioned storage room
Storge
- rel. humidity 80 %
- Temperature 8 °C
- sprout control
Washing
- Mechanical cleaning/washing Duration approx. 2 min
Drum cleaner
Peeling
- Abrasion peeler Carborundum peeler Duration approx.3.5 min
Before peeling
After peeling
Cutting head
Cutting
- Centrifugal force cutter, slice thickness approx. 1.2 – 1.4 mm
Washer
Washing
- removal of starch and sugar released by cutting, minimisation of browning
View in the washer
Fryer
Frying
- Duration approx. 3 min (continuous deep fryer, 280 L)
- Temperature 175°C
- Residual moisture of crisps <3%
Compressed air nozzles (blue) for fat reduction immediately after frying
Salting Flavouring
- Discharge belt
- Possibility of flavouring
Packaging
- Storage of potato crisps for further investigation

Internally funded projects

MRI Max Rubner-Institut

- Investigations on the degradation of FODMAP in wheat and rye doughs and pastries
- Data generation on dietary fiber and sugar content for databases (Bundeslebensmittelschlüssel)
- Isolation, structural and techno-functional characterization of ß-glucan from barley flour
- In vitro digestion and characterization of starch in table potato varieties
- Comparison of methods for quantification of relevant mono- and disaccharides in processing potatoes: from rapid methods to high-resolution ion chromatography
- Ethylene sensitivity and its effects on storage and quality of potatoes
- Biosynthesis of glycoalkaloids in germinating table potatoes

Current and recently completed third-party funded projects

- Development of Novel Screening Tools to identify Potato Genotypes with Low Acrylamide Potential (DEPOLA)
- Use of rapeseed oil-based oleogels to improve the fatty acid profile of fried foods (Oleofry)
- Hydrothermally processed finger millet as a functional ingredient in bread and porridge
- Wheat pulp as a source of dietary fibre for human nutrition (Pülpegas)
- Minimising strategies of glycoalkaloid formation in potatoes and potato prod-ucts considering glycoalkaloid stability aspects (Minglyka)

Projects in planning

- Development of screening methods for the identification of drought-tolerant potatoes with improved protein useability for human nutrition (ProSol) Proposal submitted
- Nutritious and Value-Added Seaweed and Sweetpotato Foods in Kenya and Indonesia through IMTA and Solar Powered Innovations (Nutri-KI) – Proposal submitted

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Nutritious and Value-Added Seaweed and Sweetpotato Foods in Kenya and Indonesia through IMTA and Solar Powered Innovations (Nutri-KI)

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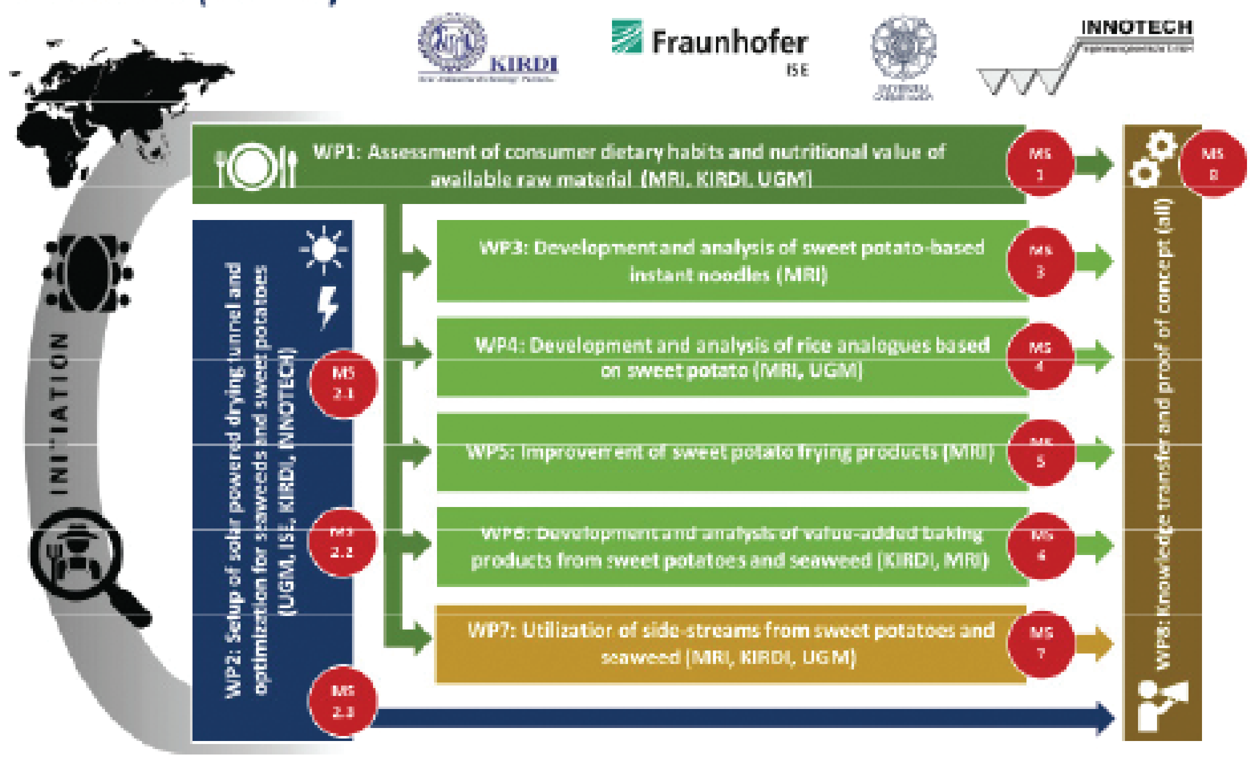

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Nutritious and Value-Added Seaweed and Sweetpotato Foods in Kenya and Indonesia through IMTA and Solar Powered Innovations (Nutri-KI)

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- **MS 1** Goals for the production of seaweed and sweet potato based products are specified and nutritional value of raw material is known
- **MS 2.1** Solar tunnel dryer in Indonesia is set up and ready for operation
- **MS 2.2** Laboratory dryers are installed and put into operation in Kenya and Indonesia
- **MS 2.3** Optimal drying conditions are defined for sweet potatoes and seaweed with regard to ideal product quality for further processing
- **MS 3** Recipes and processing conditions of instant noodles are optimized and technological, quality and safety parameters are known

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WP 5 Improvement of sweet potato frying products - Impact of vacuum frying on quality of fried potatoes and sweet potatoes

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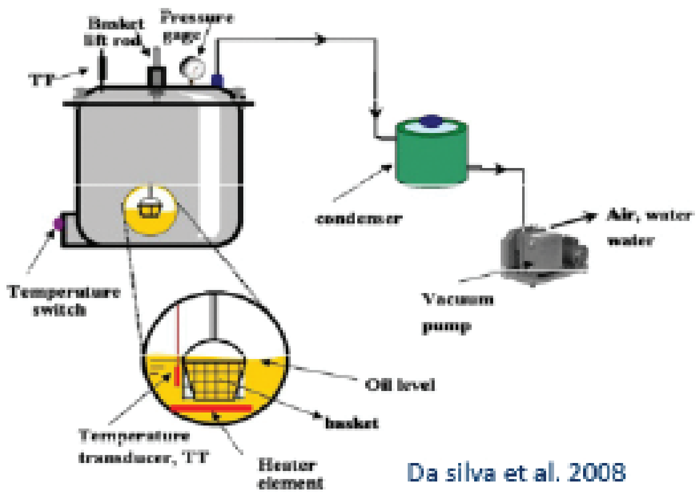
- Vacuum-frying has been identified as an alternative to traditional frying.
- It is also highly suitable for frying of sugar rich fruits and vegetables which otherwise is not possible in traditional frying as it leads to browning of the end product making them unacceptable.



Laboratory vacuum frying system.

Da silva et al. 2008

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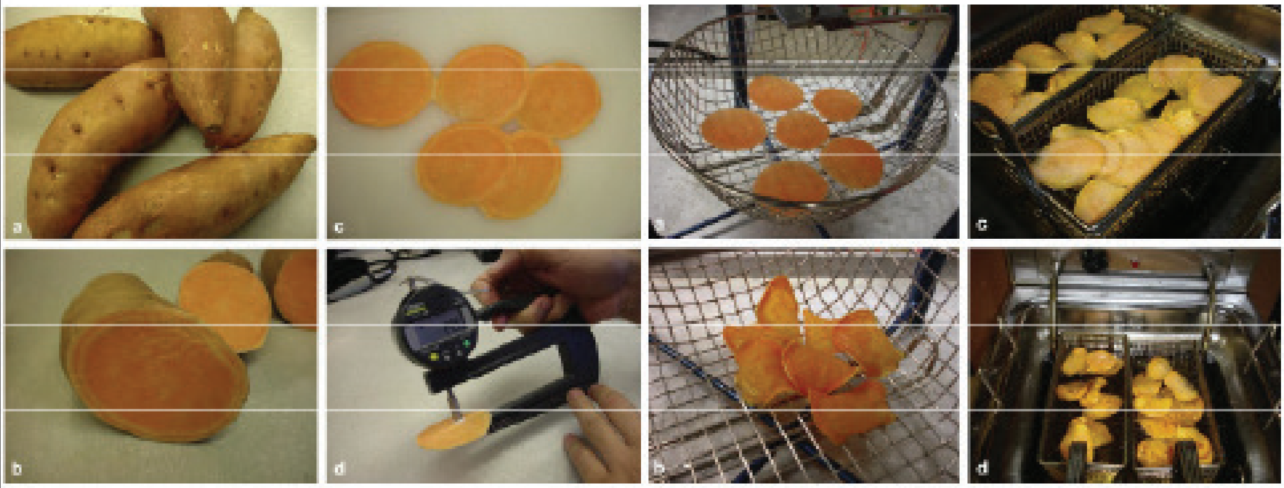
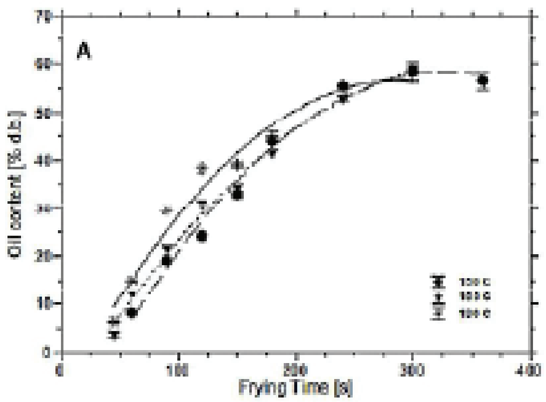
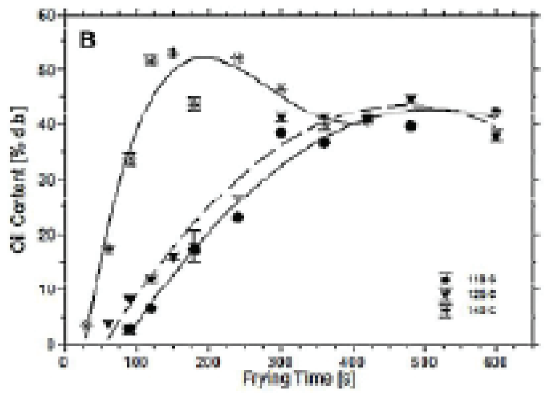


Da Silva et al. 2008

Oil Uptake

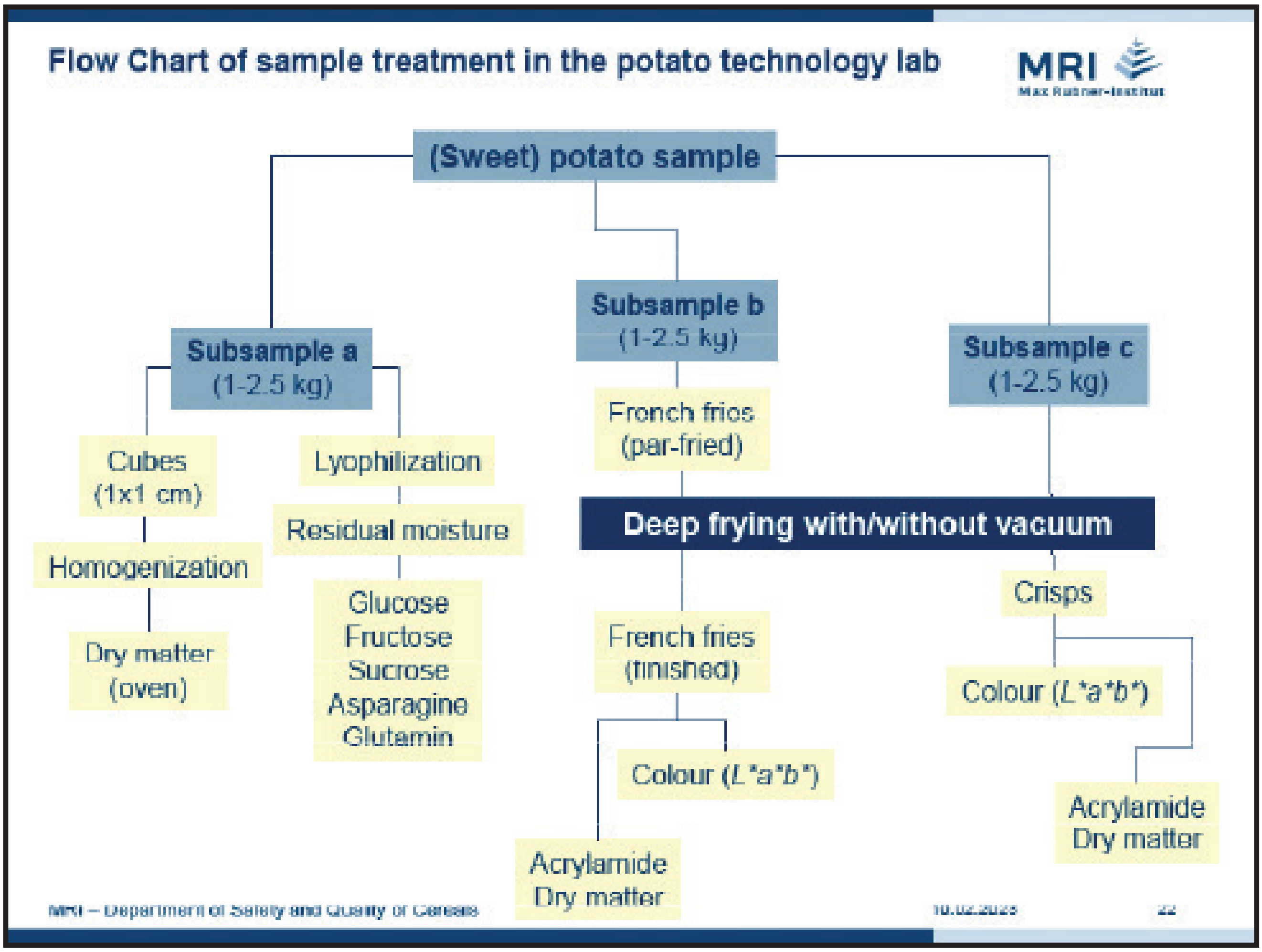


(A) Oil absorption rate of potato chips fried under traditional (101.33 kPa) frying at different frying oil temperatures;



(B) Oil absorption rate of potato chips fried under vacuum (1.33 kPa) frying at different frying oil temperatures.

Moreira (2014) Eur. J. Lipid Sci. Technol. 116, 723–734


Flow Chart of sample treatment in the potato technology lab
MRI
Max Rubner-Institut
(Sweet) potato sample
Subsample a
(1-2.5 kg)
Subsample b
(1-2.5 kg)
Subsample c
(1-2.5 kg)
Cubes
(1x1 cm)
Homogenization
Dry matter
(oven)
Lyophilization
Residual moisture
Glucose
Fructose
Sucrose
Asparagine
Glutamin
French fries
(par-fried)
Deep frying with/without vacuum
French fries
(finished)
Colour (L*a*b*)
Acrylamide
Dry matter
Crisps
Colour (L*a*b*)
Acrylamide
Dry matter
MRI – Department of Safety and Quality of Cereals
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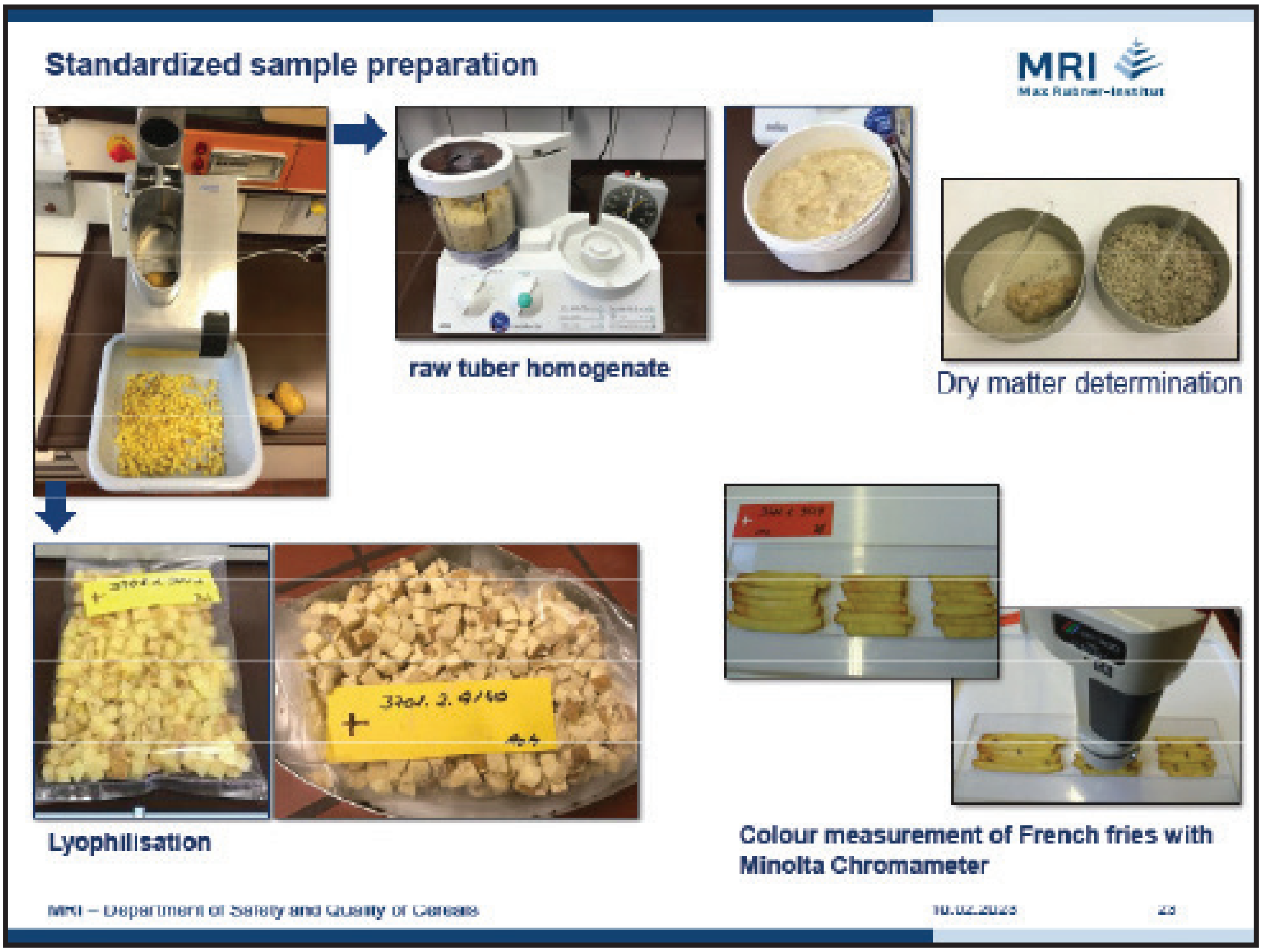
Standardized sample preparation
MRI
Max Rubner-Institut
raw tuber homogenate
Dry matter determination
Lyophilisation
Colour measurement of French fries with
Minolta Chromameter
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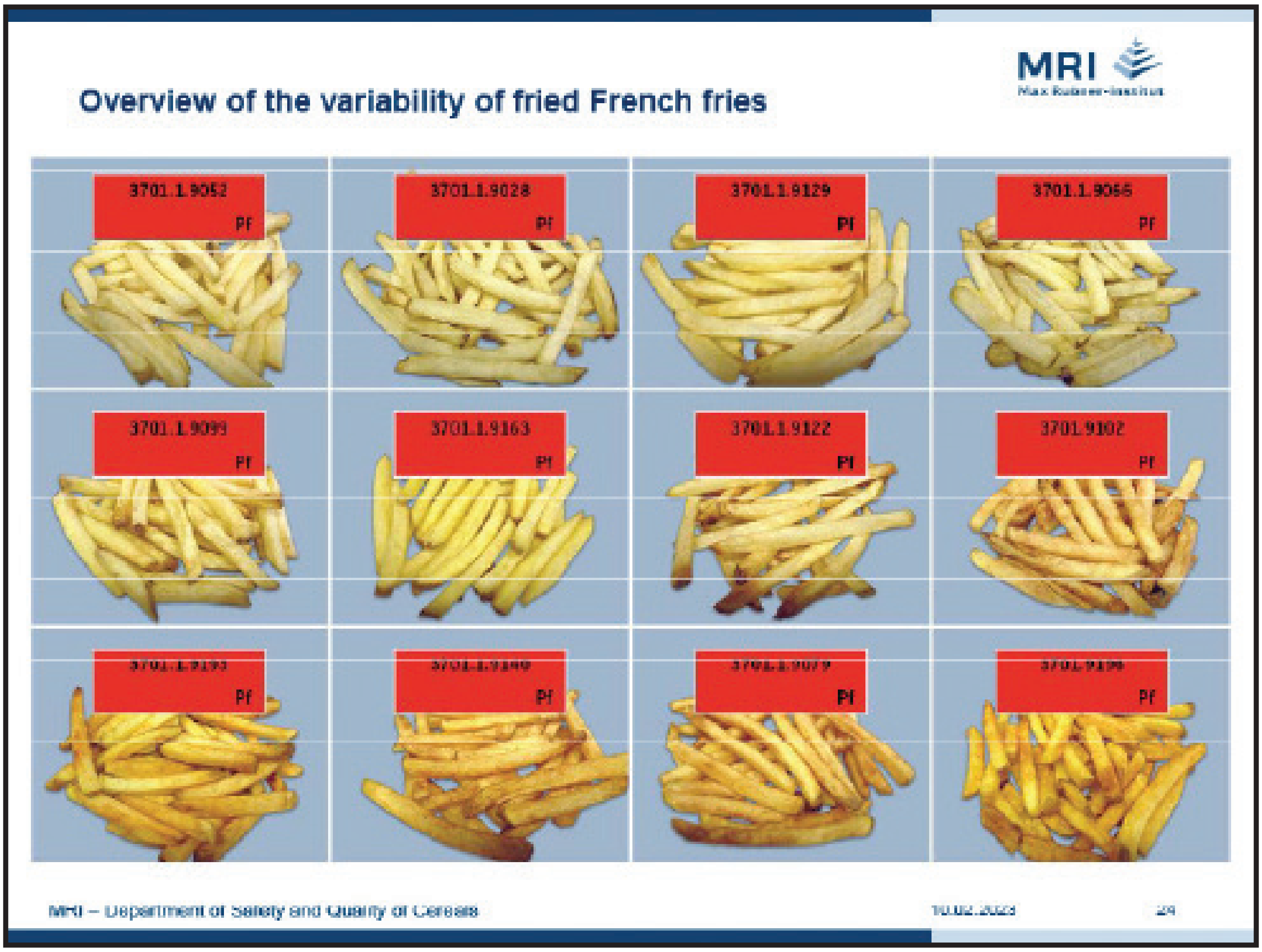
Overview of the variability of fried French fries
MRI
Max Rubner-Institut
3701.1.9052 Pf
3701.1.9028 Pf
3701.1.9129 Pf
3701.1.9066 Pf
3701.1.9099 Pf
3701.1.9163 Pf
3701.1.9122 Pf
3701.9102 Pf
Pf
Pf
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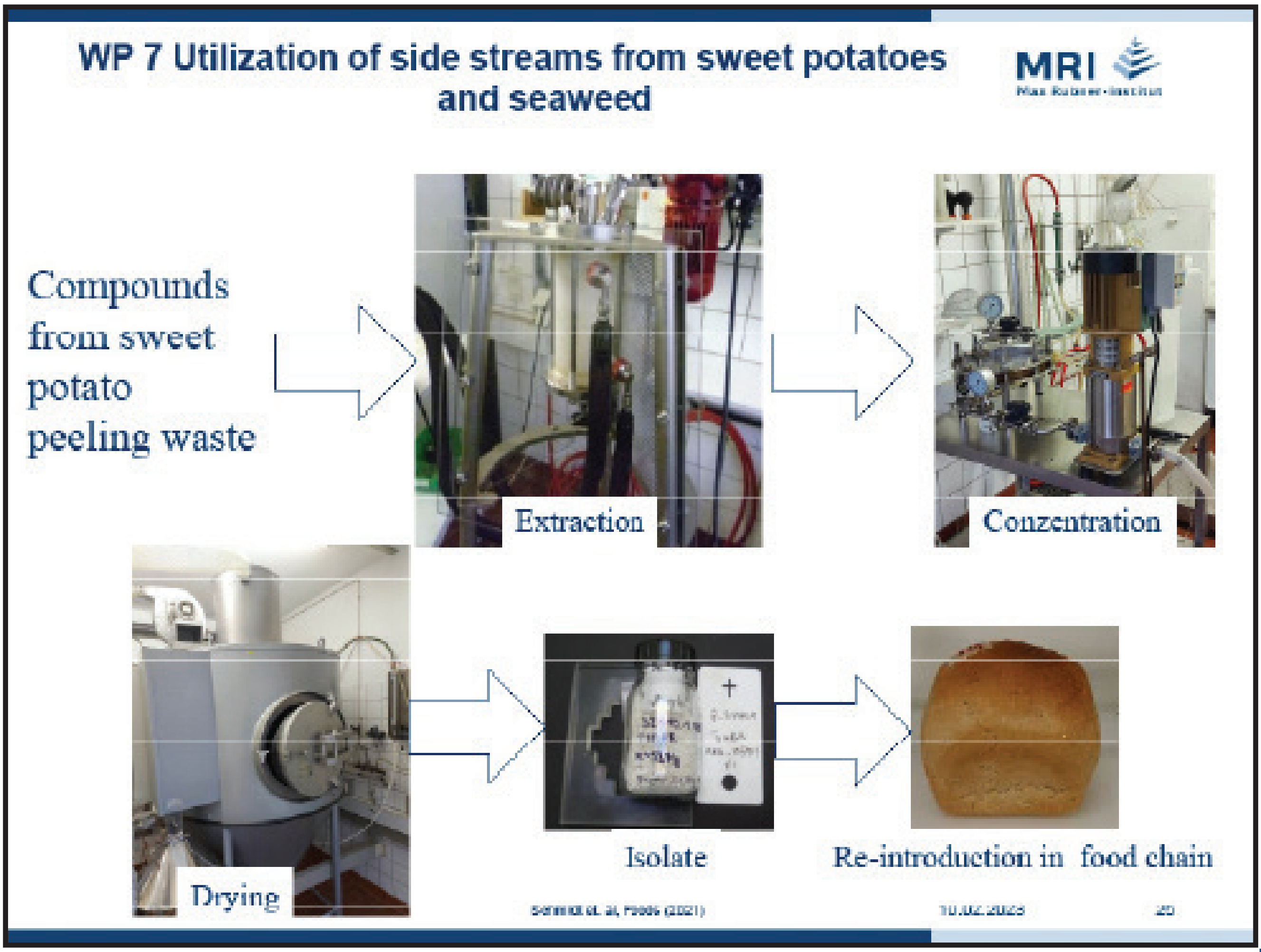
Pf
MRI – Department of Safety and Quality of Cereals
10.02.2023
24


WP 7 Utilization of side streams from sweet potatoes and seaweed
MRI
Max Rubner-Institut
Compounds from sweet potato peeling waste
Extraction
Conzentration
Drying
Isolate
Re-introduction in food chain
Schmidt et. al, Foods (2021)
10.02.2023
25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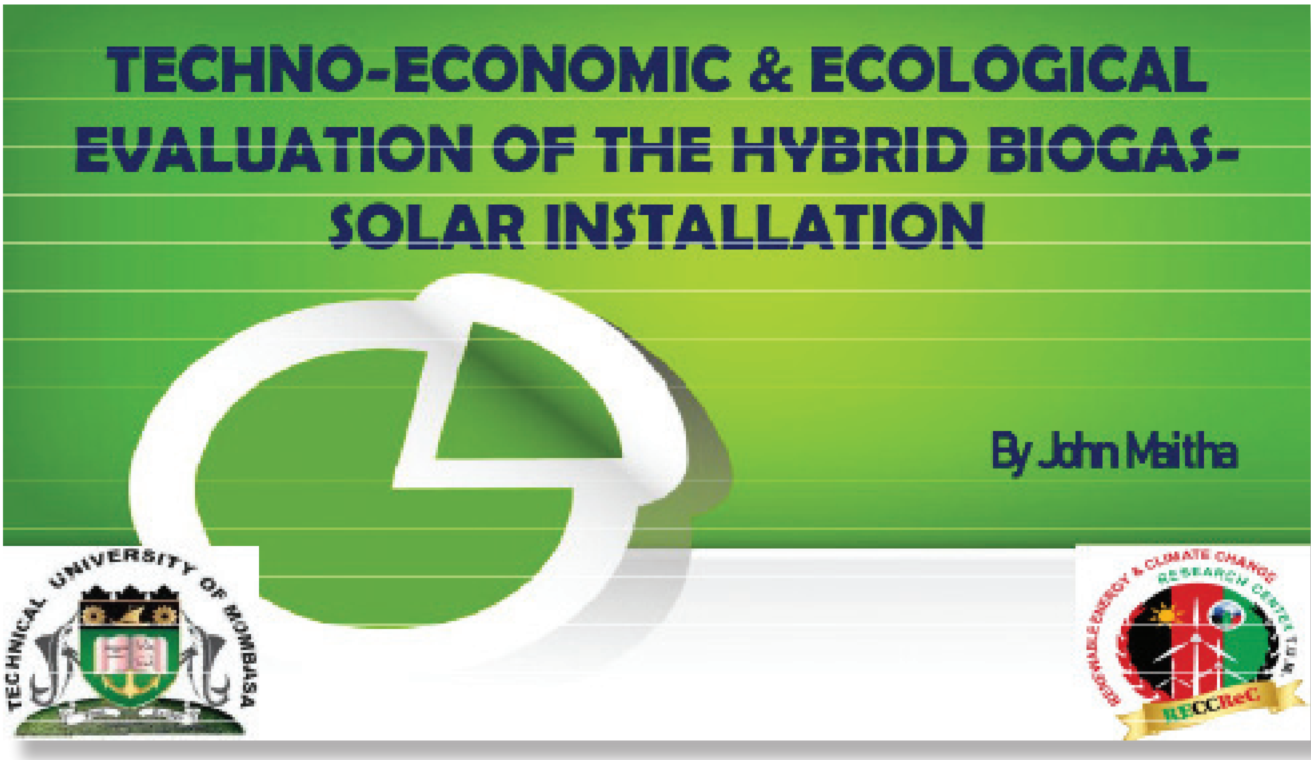
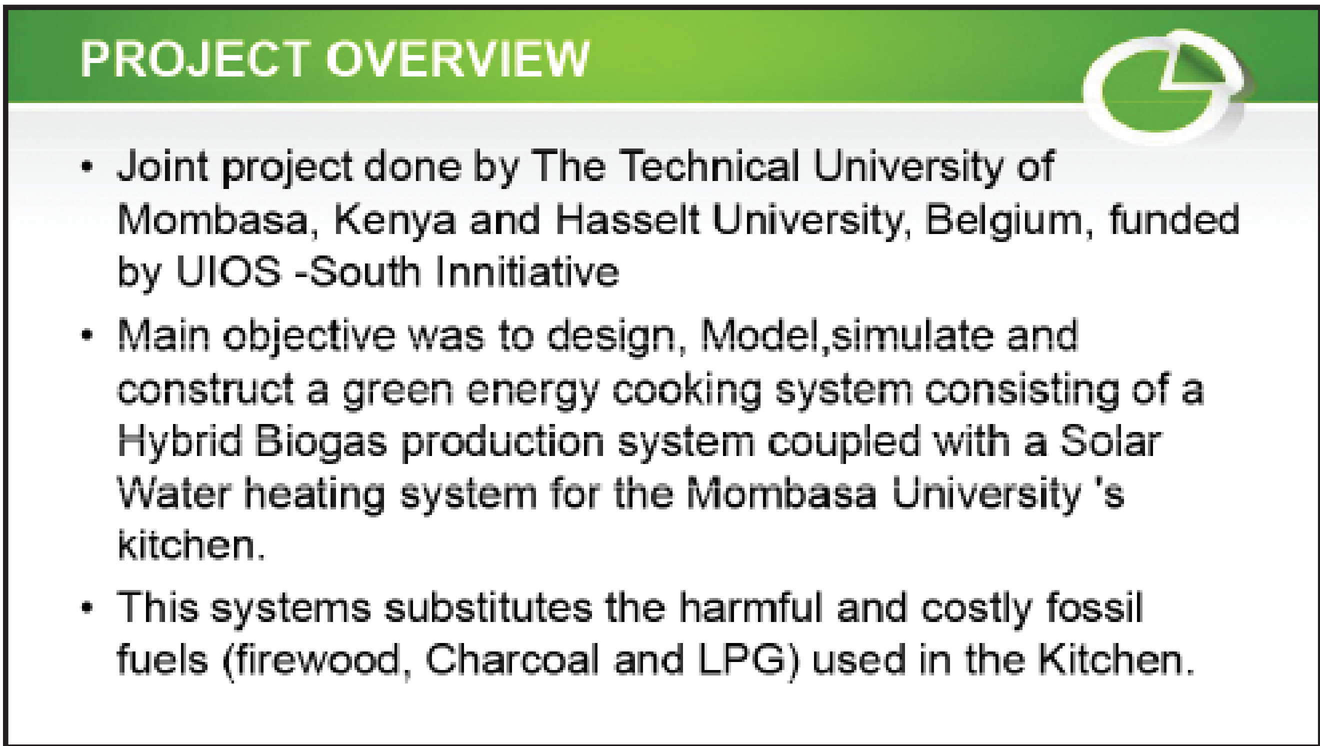
Thank you for your attention!

Session 2, Presentation 3





RESEARCH TEAM

Name	Title*	University	Speciality	Expertise	Responsibility
Wim DeFerme	Associate Proffesor	Hasselt	Functional Materials and Renewable Energy	Renewable Energy Materials and Thermal.Energy	Principal Researcher
Michael Saulo	Senior Lecturer	TUM	Sustainable Energy and Electric power systems	Renewable Energy power system design aandTechno-economic asessment	Lead Researche
Eric Jobunga	Senior Lecturer	TUM	Theoretical and Environmental Physics	Modelling, and Environmental impact Asssessment	Supervisor
John Maitha	Tutorial Fellow/Master student	TUM	Sustainable energy	Mechanical energy systems	Pproject Manager
Emmanuel Karavina	PHD student	TUM	Renewable energy and Environment	Renewable Energy Design and EIA	Project Manage
Tobias Courthourts & Dann Vanhoudt	Master students	Hasselt	Renewable energy	Design, modelling and SImulation	Biogas Lead Reseachers
Kjel Schijndel & Leon Vandenbergh	Master students	Hasselt	Renewable energy	Design, modelling and SImulation	Solar Heater Lead Researchers
Salsabila Abdulhalim and Khaula Khalid	Undergraduate students	TUM	ICT	Renewable Energy, Data collectIon and anlysis.	Research Assistants

OBJECTIVES OF THE RESEARCH

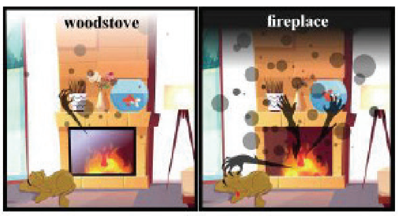
- To design, simulate and construct a Hybrid solar-assisted Biogas production System.
- To perform a Technological and ecological analysis of the system using the Life Assesment Cycle (LCA) method.
- To perform an economic assesment of the system using the Discounted Cash-flow Micro-economic assesment method.
- To relate and comment on the results with those of only using fossil fuels.

TECHNICAL UNIVERSITY OF MOMBASA

- Only university at sea level, located along Tudor creek in Mombasa island
- It has over 15000 students and over 1000 staff members
- It has 3 kitchens, a cafeteria for staff ,another for students and The Kiziwi hospitality and conference center
- Serves over 2000 students, over 500 staff members and over 200 outsiders

Statement of the problem

- Use of firewood and Coal
  - Unhealthy to due to production of soot and ash
  - Expensive due to scarcity
  - Causes environmental pollution



Proposed Solution

- POLLUTANT
- EXPENSIVE
- SCARCE
- LOW CALORIFIC VALUE

- NO SOOT
- CHEAP
- AVAILABLE
- HIGHER CALORIFIC VALUE

Biogas

- Biogas is generated by the activity of anaerobic bacteria on organic compounds in a biodigestor.
- Biogas is comprised of about 60% of methane, 40% of carbon dioxide, and small amount of hydrogen sulfide, nitrogen, and hydrogen.
- The heating value of biogas is about 60% of natural gas and about 25% of propane.
- Biogas burns without soot or ash being produced

Factors effecting the process

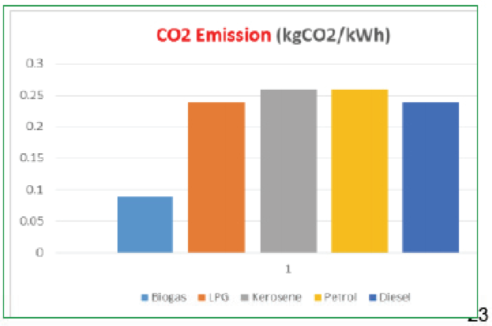
- pH Value
- Temperature
- Retention time
- Loading rate
- Toxicity
- C/N ratio
- Slurry

COMPARISON OF BIOGAS WITH OTHER FUELS

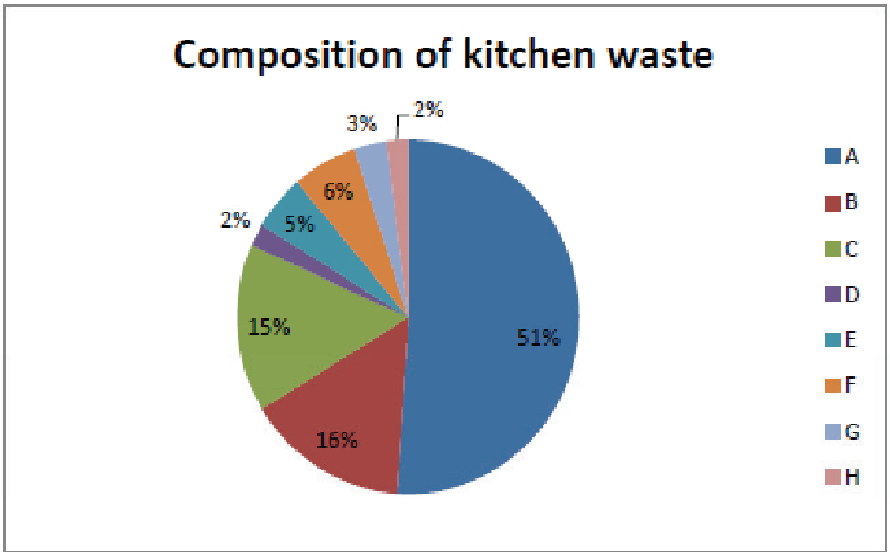
S no	Fuel	Calorific Value (kcal/kg)	Power generation	CO2 Emission (kgCO2/kWh)
1	Biogas	5200	6 kWh/m3	0.09
2	LPG	10500	12.2 kWh/m3	0.24
3	Kerosene	10000	12 kWh/kg	0.26
4	Petrol	11200	9.06 kWh/liter	0.26
5	Diesel	10746	9.8 kWh/liter	0.24

Biogas equivalent to Fossil Fuels and its emission comparison

	Fuel	Quantity (kg)
1 m3 of Biogas Equivalent to	LPG	0.45
	Kerosene	0.6
	Fire wood	3.50
	Furnace Oil	0.4
	Petrol	0.7
	Diesel	0.5



FEED STOCK CHARACTERIZATION



(A) PROTEINS AND
(B) FRUITS AND VEGETABLES

(C) CARBOHYDRATES
(D) LEGUMES
(E) ROUGHAGES/FIBERS
(F) LIPIDS
(G) WASTE WATER
(H) FATS & OILS

Composition of organic kitchen waste- 100kgs

CONCEPT LAYOUT OF THE SYSTEM

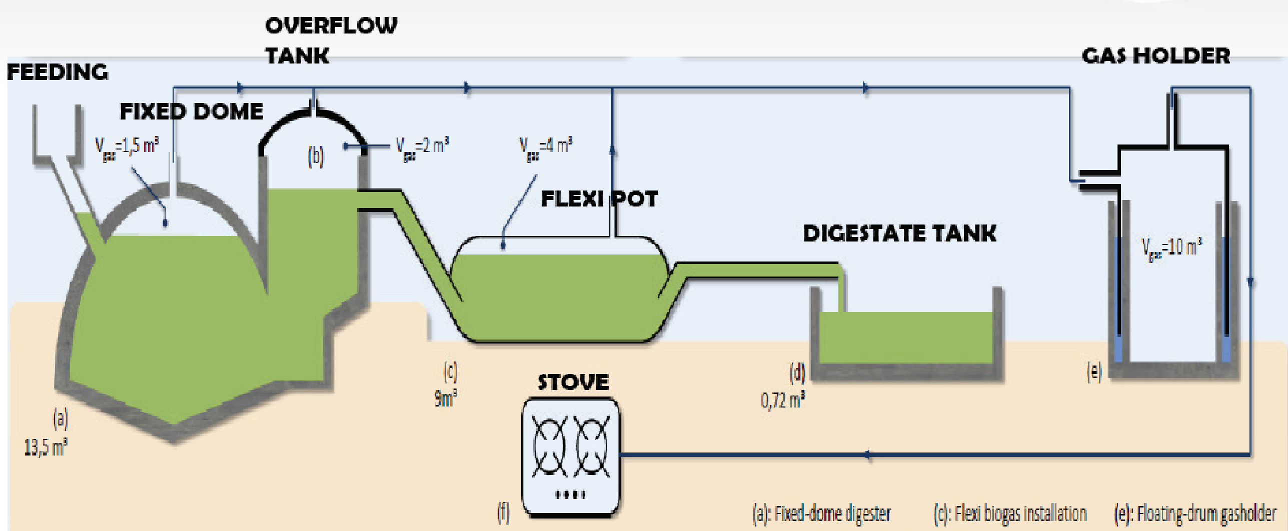


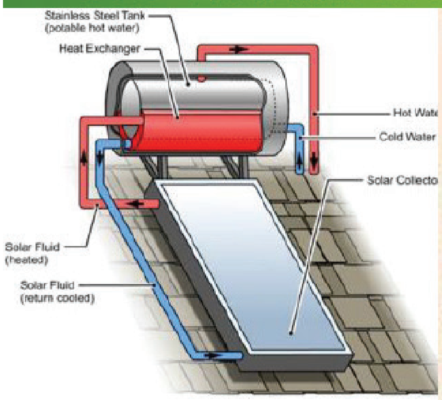
Figure 2: Hybrid biogas installation

PICTORIAL REPRESENTATIONS

MODIFIED FIXED DOME

FLEXI-BALOON TYPE

300L THERMOSYPHONIC SOLAR WATER HEATER



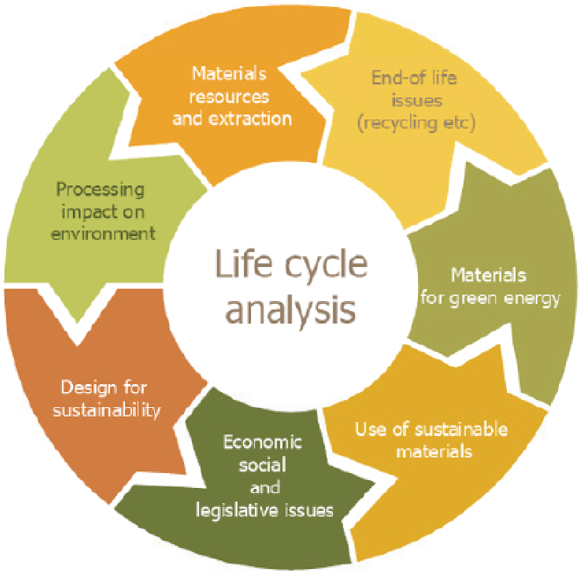
The hot water reduces the amount of time used for cooking by over 50%

SOLAR-BIOGAS PLANT

RESULTS

LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) is defined as the systematic analysis of the potential environmental impacts of products or services during their entire life cycle.



DISCOUNTED CASH-FLOW METHOD

Discounted cash flow (DCF) refers to a valuation method that estimates the value of an investment using its expected future cash flows.

RESULTS USED IN ANALYSIS

BIOGAS PRODUCTION

Item	Value
Food waste (kgs)	100
Feedstock Fs (Kgs)	400Kgs
Solids content (TS)	10%
Dry matter (kg)	10
Volatile matter (Vs)	80%
Vs_1 for 1000litres of Fs (kgs)	20
OLR for Vs_1 (kgs/day)	0.67
Assumed methane content	65%
Average biogas yield (m^3/kgs Vs)	0.66
Approximate biogas yield (m^3)	5.28
Gas production rate (m^3/day)	0.44
Specific Gas Production (m^3/kg VS)	0.65
Lifespan of fixed dome biodigester	25 years
Lifespan of flexible dome biodigester	10 years

SOLAR WATER HEATER

Item	Value
Water storage (liters)	300
Maximum Temperature of water (^oC)	66
Minimum Temperature of water (^oC)	38
Average Temperature (^oC)	52
Average Temperature loose (^oC)	2
Average radiation W/m^2	4639
Vs_1 for 1000litres of Fs (kgs)	20
Daily usage (l/day)	200
Average energy saving	55%
Energy costs savings for boiling water	65%
Lifespan of solar water heater (years)	20

TECHNO-ECONOMIC ANALYSIS RESULTS

- Relevant formulaes and comparative assesments were used to obtain results for ecological and energy savings as presented in the LCA method
- Relevant DCF method formulae were used to calculate the Discounted Pay Back Period (DPP), Net Present Value (NPV), Internal Rate of Return (IRR),Benefit-Cost Ratio (B/C) and thePay-backPeriod (Pt)of the three systems.

GREEN HOUSE GAS EMISSIONS

Fuel	Gas emission per 1MJ of delivered energy			
	CO_2(g)	CH_4 (mg)	CO(g)	N_2O (mg)
Biogas	81.50	57	0.11	5.40
Firewood	682	1.300	26.20	1.40
Charcoal	532	8.90	14.56	4.30
LPG	139	8.90	0.89	6.0

- Savings of 45.54% are obtained when Biogas is used as opposed to fossil fuels

ENERGY AND ECOLOGICAL SAVINGS

Hybrid Biogas Plant

Firewood [kg]	Charcoal [kg]	LPG	Biogas equivalent [m³]	Biogas produced (m³]	Biogas deficit [m³]	Energy cost savings (%)
250	160	70	10	4	6	45.45

Solar Water Heater System

Average Temp ° C	Ambient water Temperature (° C)	Energy to raise 200litres of water from 20 to 52° C	Energy savings [%]
52	20	*34.02*	*45.23*

Forest cover savings

Firewood savings [kg]	Charcoal savings [kg]	Equivalent Number of average trees	Savings (%)
120	80	4	55%

ECONOMIC ANALYSIS RESULTS

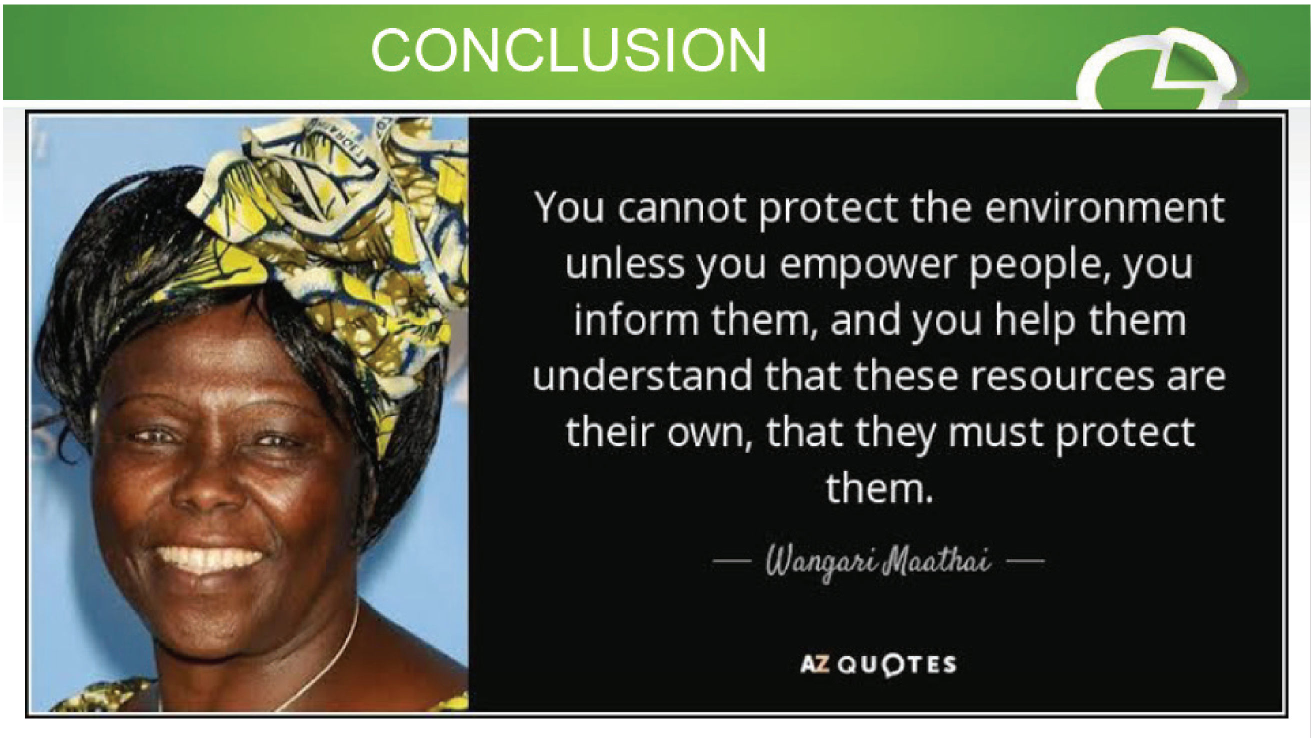
System	I (€)	r (%)	CF (€)	N(yr)	NPV(€)	DPP(yr)	IRR(%)	B/C	Pt(yr)
Fixed dome biodigester	2580	0.38	860	20	10160	6.14	11.5	2.48	7.2
Flexible biodigester	360	0.38	120	15	1320	6.11	12.3	2.22	7.3
Solar water heater	750	0.38	250	20	2879	2879	13.5	2.31	7.1

Where;
I- Initial Investment
r- discount rate
CF-Cash Flow
N-Project Life Cycle

NPV - Net Present Cost
DPP- Discounted Pay back Peri
IRR -Internal.Rate of Return
B/C-Benefit Cost Ratio
Pt--Payback.period

DISCUSSIONS AND RECOMMENDATIONS

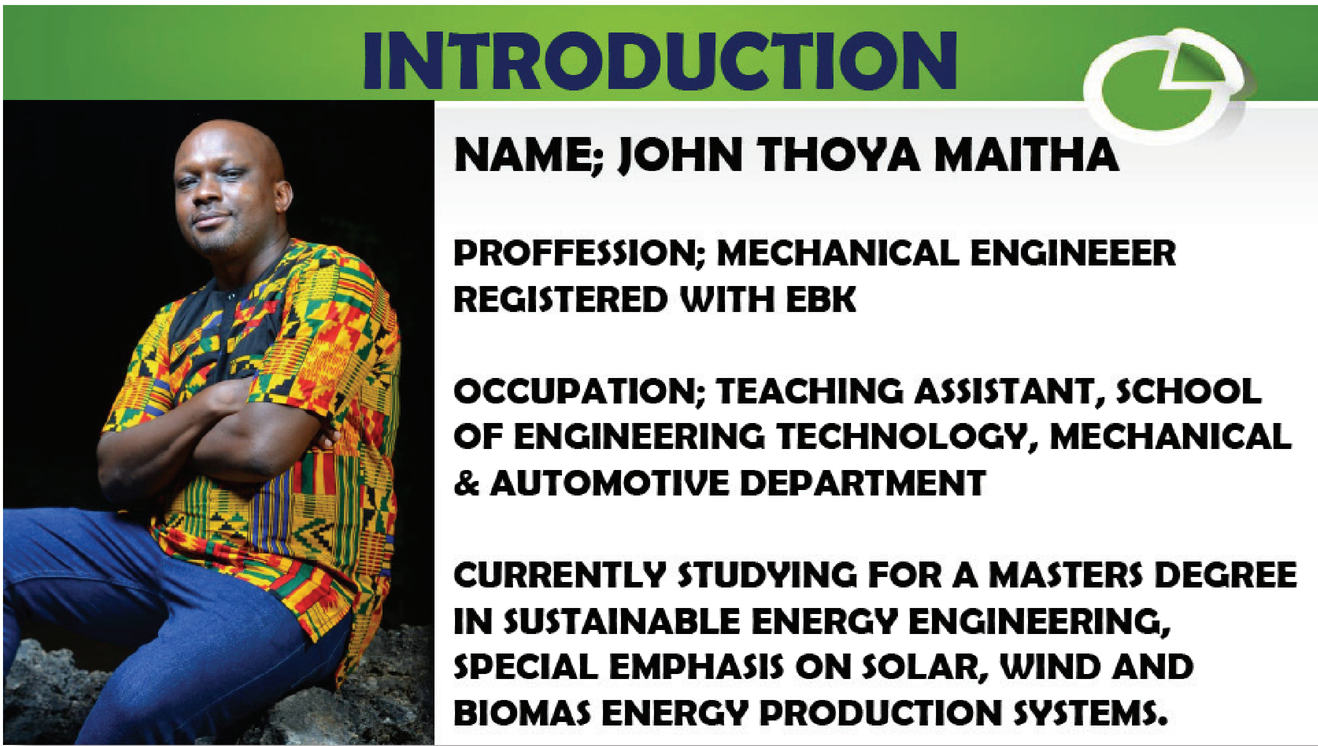
- From the LCA analysis, the project forecasts an eenergy saving of 45.36% and forest cover saving of 55.56%.
- From the DCF economic analysis, a cost saving of 45.36% is realized. Also the NPV forecasts aneconomic profitability of 120%, whilst a positive and greater than 1 B/C and the IRR being greater than represents a profitable business venture where income is much more than expenses. An avergae payback period of 6 years entails a worthwhile investment considering the average lifespan of 25 years of the system.
- The system is recommended for use in learning institutions as a worthwhile economic and ecological investment


CONCLUSION
You cannot protect the environment unless you empower people, you inform them, and you help them understand that these resources are their own, that they must protect them.
— Wangari Maathai —
AZ QUOTES


The environment and the economy are really both two sides of the same coin. If we cannot sustain the environment, we cannot sustain ourselves.
- Wangari Maathai
GREENPEACE


• Thank you for your attention and listening ear!!!
• GOD BLESS YOU!
• QUESTIONS??????

Session 2, Presentation 4



OVERVIEW

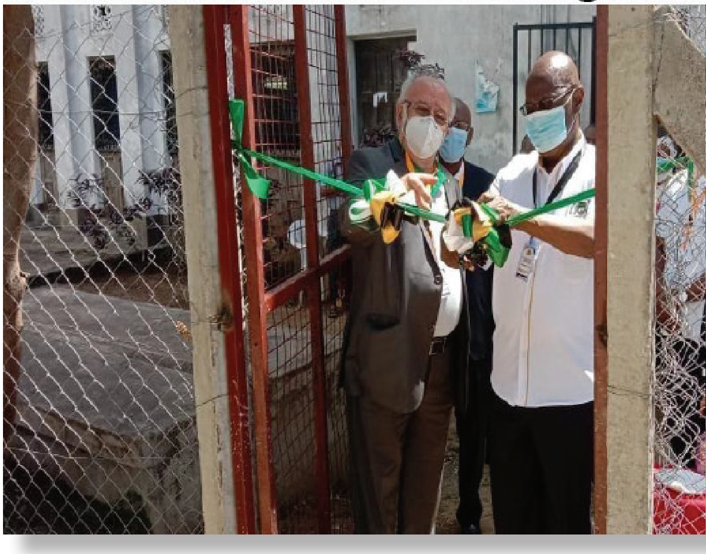
- Premised on TUM's Strategic Plan 2018 - 2022, the Vision 2030 and the BIG4 agenda.
- Inspired by the 17 United Nations Sustainable Development Goals meant to improving living standards.

VISION

To achieve excellence in facilitating sustainable transition in Sub Sahran Africa through research and innovation at the interface of Energy access, Energy efficiency, Sustainable development and Climate change, providing realistic solutions and policy advice to urgent sustainability issues by means of teaching, training and research.

INNAGURATION

- Officially inaugurated on the 23rd JUNE 2021 by University Council Chairman Dr. Arunga



OBJECTIVES

- Build the research infrastructure and develop an innovation eco system in TUM.
- Providing the ideas, the reasoning, the means and tools and the solutions to a more sustainable world
- Assist Students and staff on Research & Innovation ideas and offer guidance.
- Offer Long and short trainings/courses on Energy & Climate(short courses, Bachelors, Masters, PhD)

ONGOING RESEARCH PROJECTS

HYBRID SOLAR ASSISTED BIOGAS PRODUCTION PLANT. Consists of

- **12 M^3 FIXED DOME BIODIGESTOR**
- **8M^3 CONTINOUS FLOW FLEXI DIGESTOR**
- **300L SOLAR WATER HEATER THERMOSYPHON SYSTEM**

–VLIR-UOS Global South Initiative Project/UHasselt

300L THERMOSYPHONIC SOLAR WATER HEATER

The hot water reduces the amount of time used for cooking by over 50%

Biogas production plant

SOLAR PHOTOVOLTAIC TRAINING KIT

- 4 SOLAR PV PANELS ARRAY
- CHARGE CONTROLER
- INVERTER
- 2 SOLAR BATTERIES
- METERS AND SENSORS

–Funded by TUM-PRI

PV PANELS ARRAY

CONTROL UNIT

REMOTE WEATHER STATION

Consists of remote sensing instruments for measuring; Temperature, Pressure, Humidity, Precipitation, Solar radiation and wind.

Session 2, Presentation 5

PROFILING THE STATUS OF DIRECT SOLCOOLDRY TECHNOLOGY RECIPIENTS IN KWALE COUNTY, KENYA AND THEIR PERSPECTIVES ON FISH PRESERVATION TECHNOLOGIES

Morine M. Ngarari, Josephine M. Njeru, Rael Achieng', Peter Oduor-Odote, Linus Kosambo, James Mwaluma, Raymond Ruwa, Winnie Jefwa, Huxley Makonde, Derrick Gitari, Immaculate Kinyua, Maurine Kinyua

Kenya Marine and Fisheries Research Institute, Mombasa

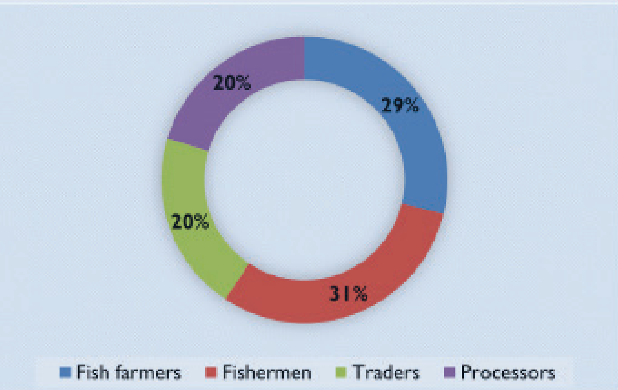
SolCoolDry

WHY THE STUDY

- To understand the status of the direct technology recipients
- To evaluate the production potential of raw resources
- To obtain feedback from locals who have utilized the system and their perspectives

METHODOLOGY

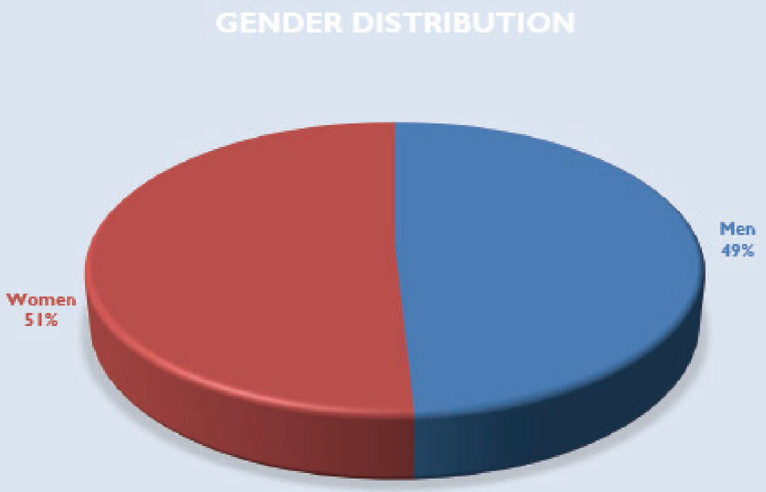
- Questionnaire preparation
- Determination of target group and sample
- Interviews at Gazi, Shimoni, Mwazaro and Kibuyuni
- Data analysis



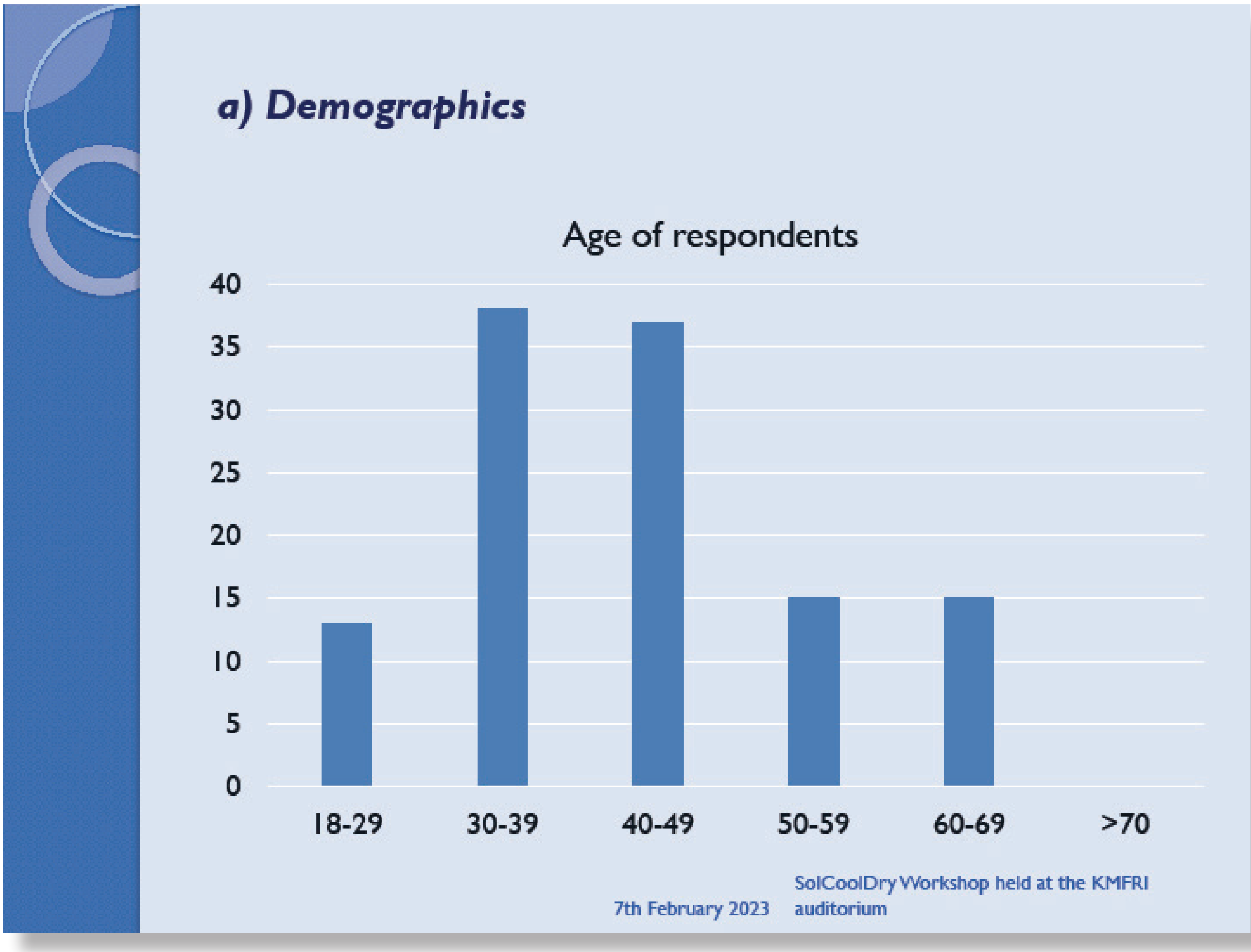
SolCoolDry Workshop held at the KMFRI auditorium 7th February 2023

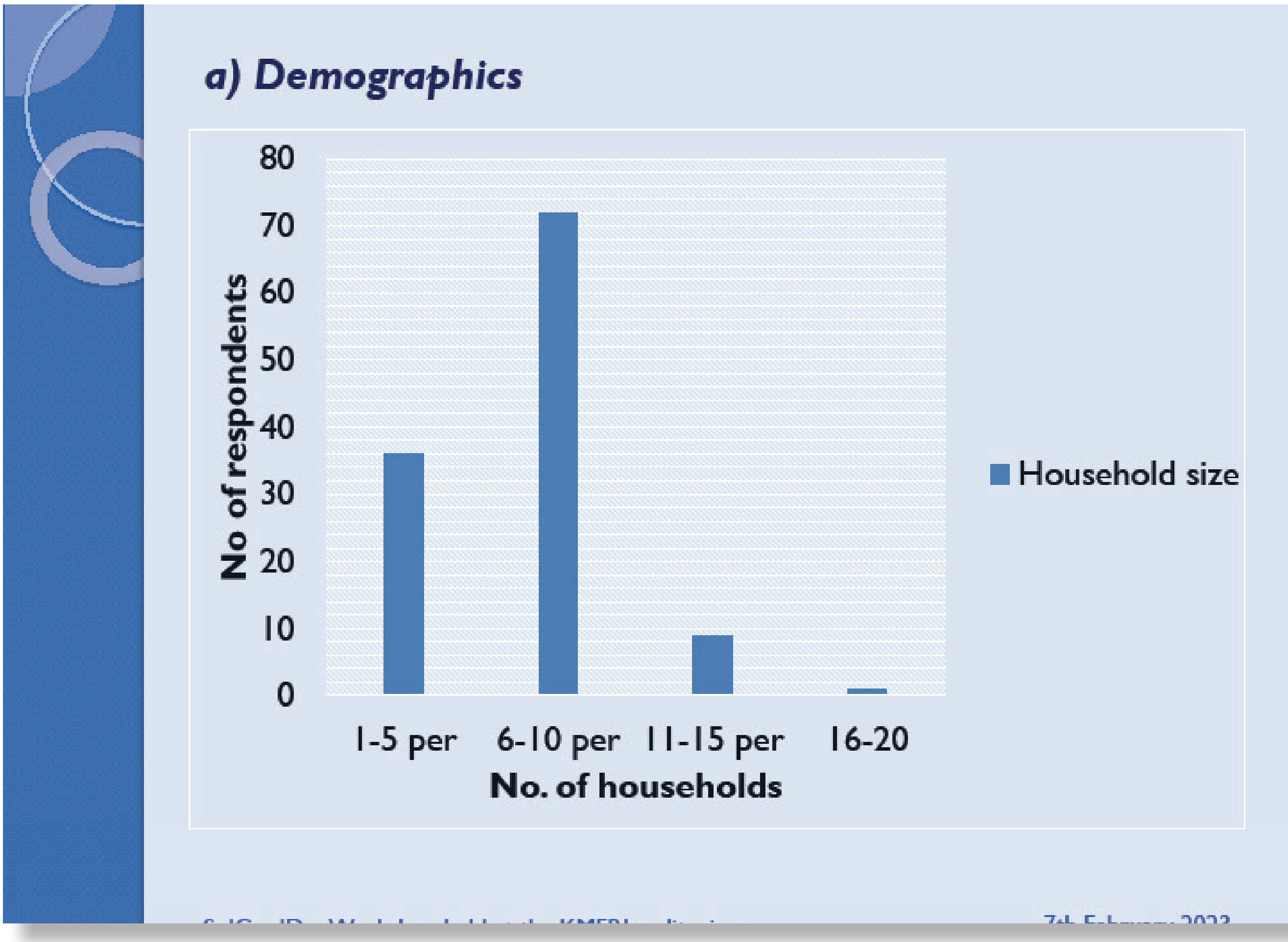
RESULTS

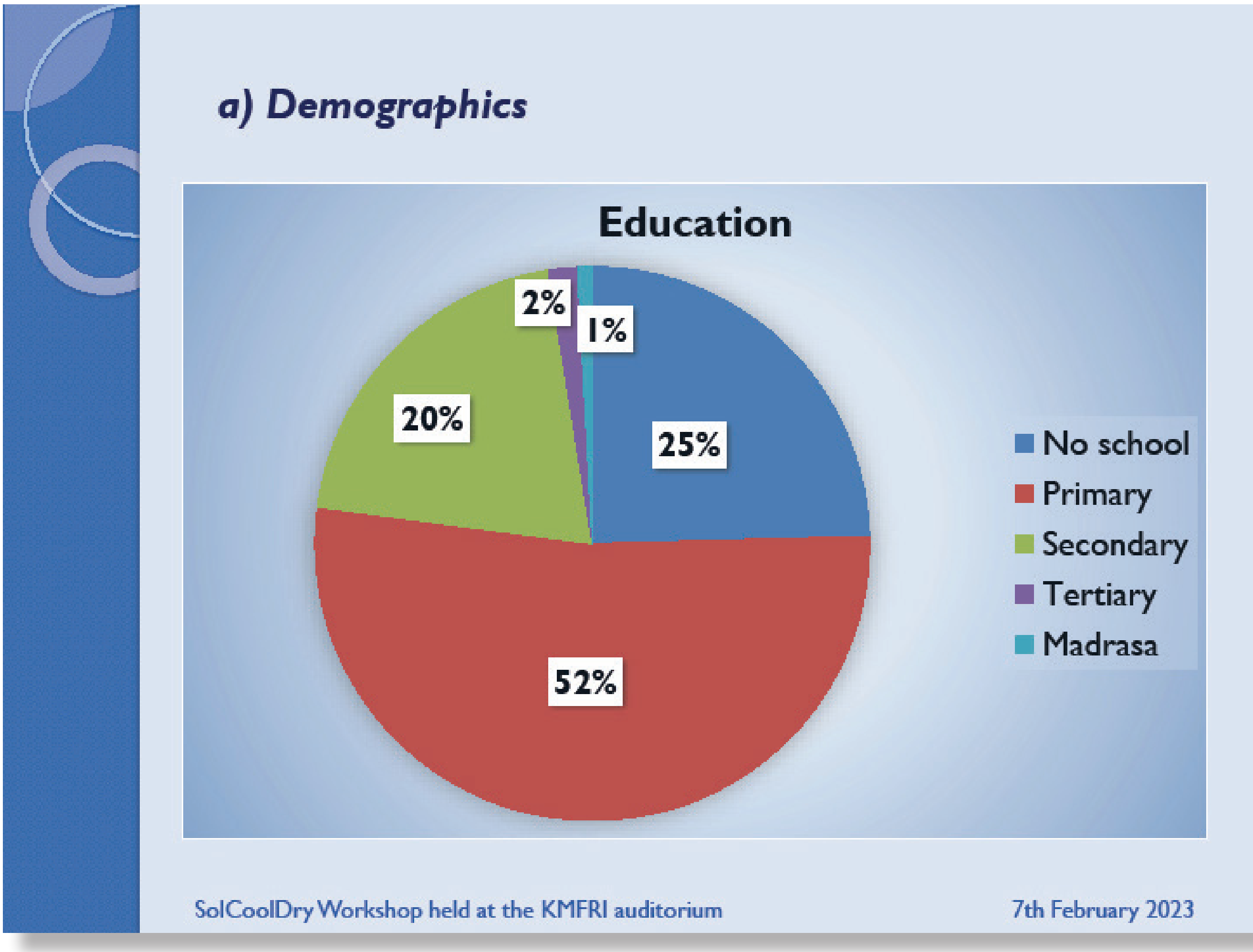
a) Demographics



SolCoolDry Workshop held at the KMFRI auditorium 7th February 2023


a) Demographics
Age of respondents
40
35
30
25
20
15
10
5
0
18-29
30-39
40-49
50-59
60-69
>70
7th February 2023
SolCoolDry Workshop held at the KMFRI auditorium


a) Demographics
No of respondents
80
70
60
50
40
30
20
10
0
1-5 per
6-10 per
11-15 per
16-20
No. of households
Household size


a) Demographics
Education
2%
1%
20%
25%
52%
No school
Primary
Secondary
Tertiary
Madrasa
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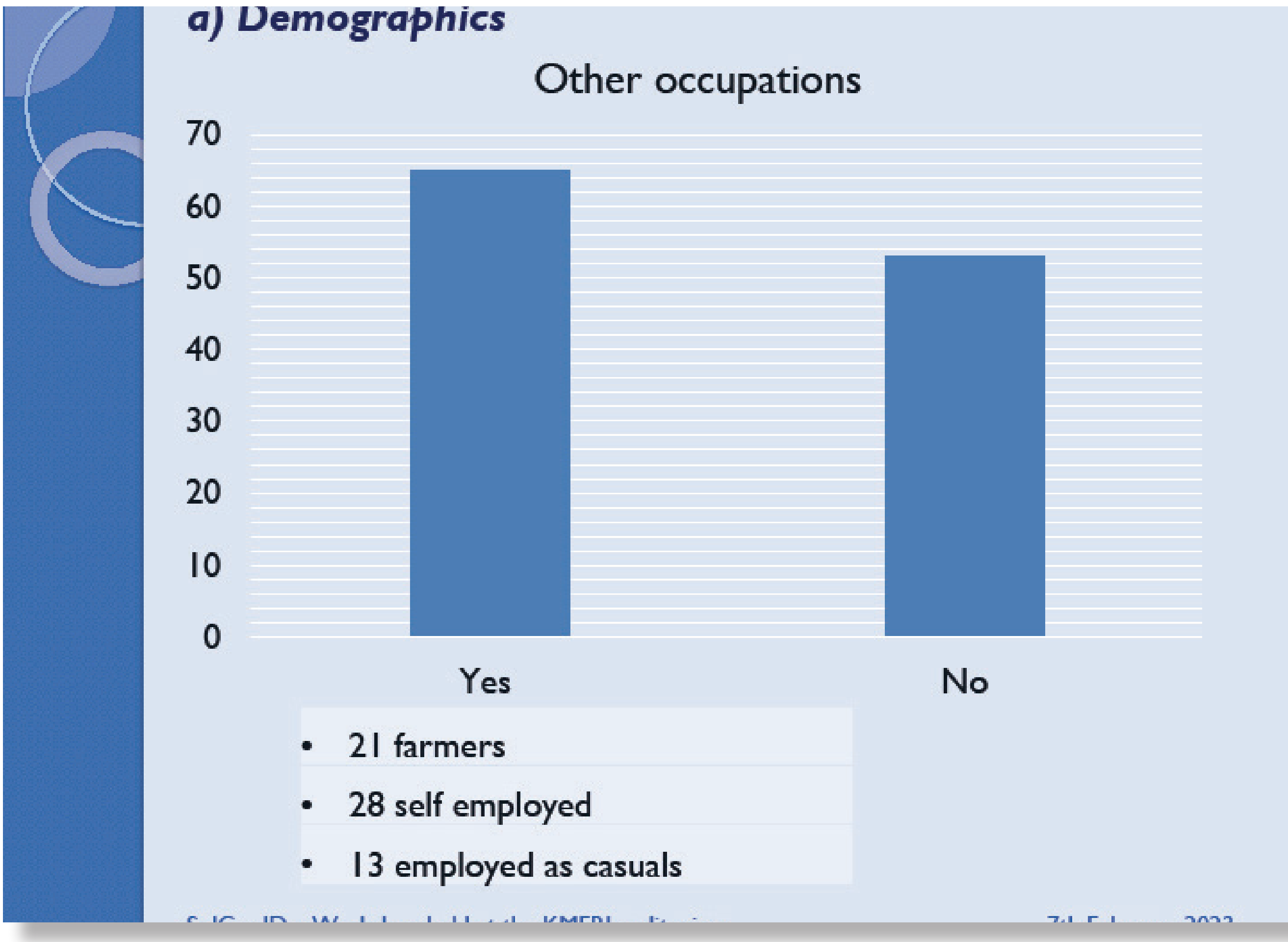
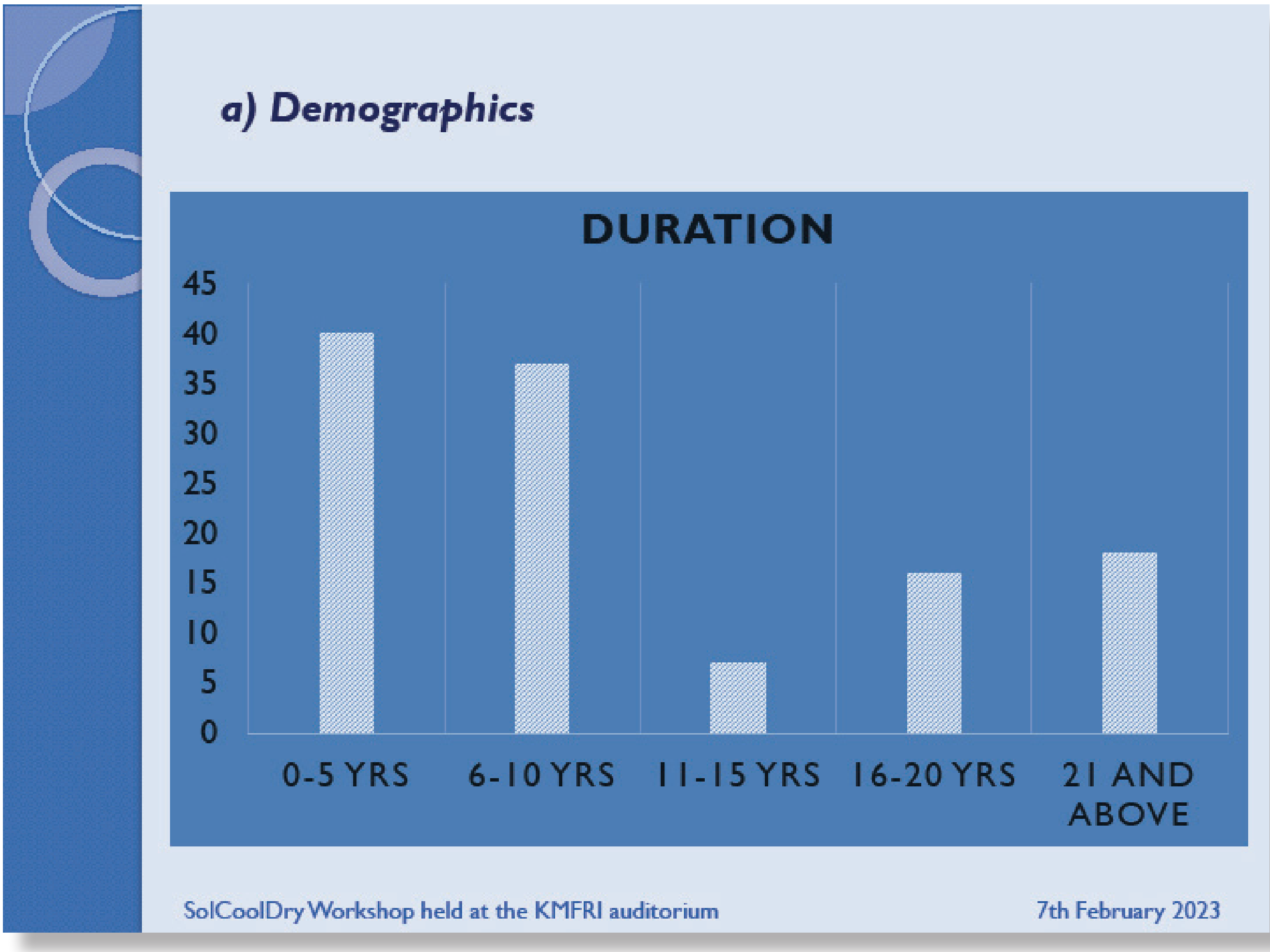
7th February 2023


a) Demographics
Other occupations
70
60
50
40
30
20
10
0
Yes
No
• 21 farmers
• 28 self employed
• 13 employed as casuals


a) Demographics
DURATION
45
40
35
30
25
20
15
10
5
0
0-5 YRS
6-10 YRS
11-15 YRS
16-20 YRS
21 AND ABOVE
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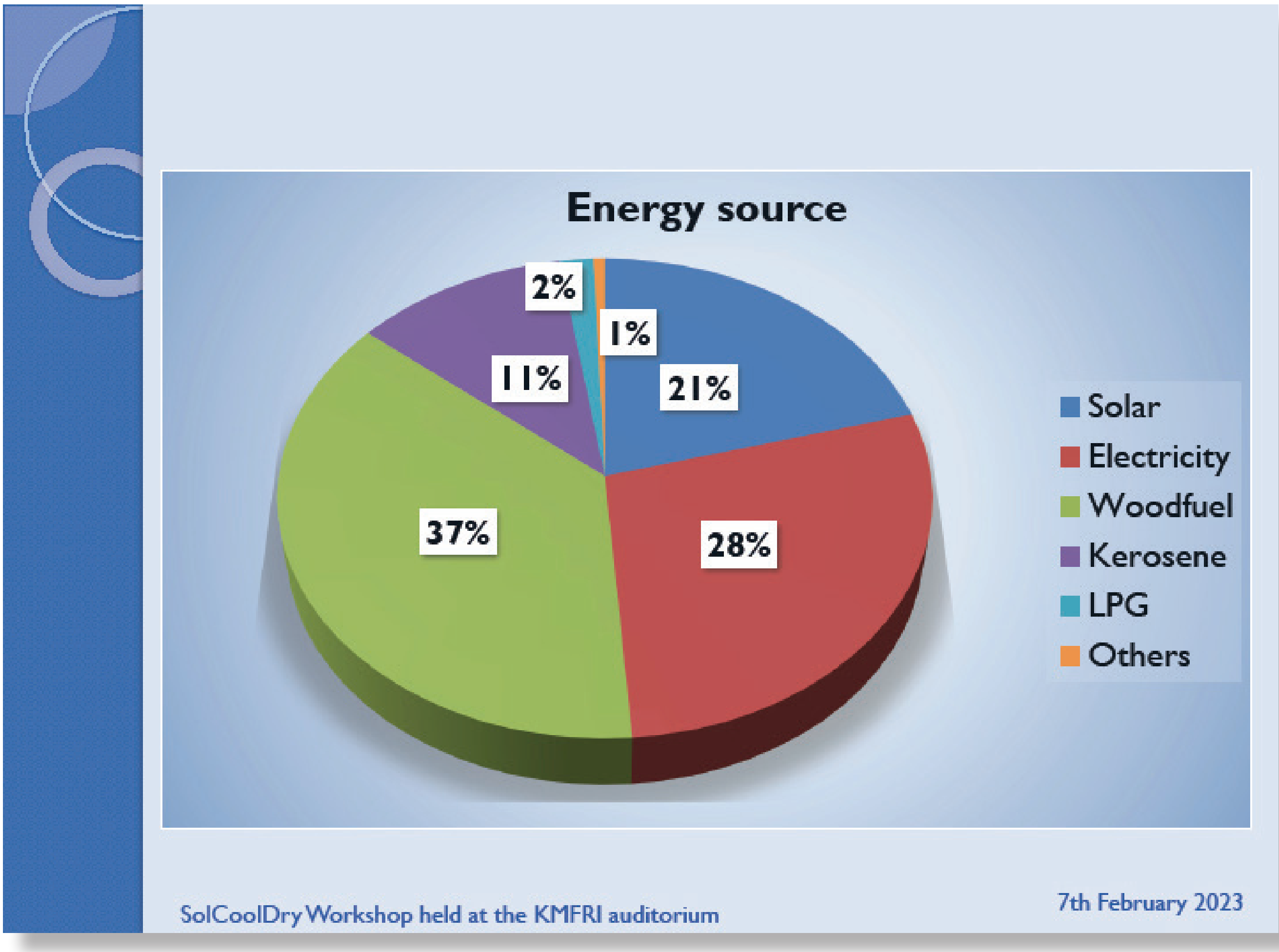
Energy source
2%
1%
11%
21%
37%
28%
Solar
Electricity
Woodfuel
Kerosene
LPG
Others
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7th February 2023

PRELIMINARY RESULTS

b) Aggregation of direct technology recipients

- Mainly organized into Beach Management Units (BMUs)
- Other groups within the BMUs (especially for seaweed & fish farmers) include:
  - Bati Seaweed Farmers
  - Kibuyuni Seaweed Farmers Cooperative
  - Baraka Conservation Group
  - Imani seaweed farmers
  - Mwazaro Fish Farmers
- Shared resources include fishing grounds, drying racks, office space, processing areas at the landing site and storage facilities
- 62.5% use community-owned land/ fishing grounds

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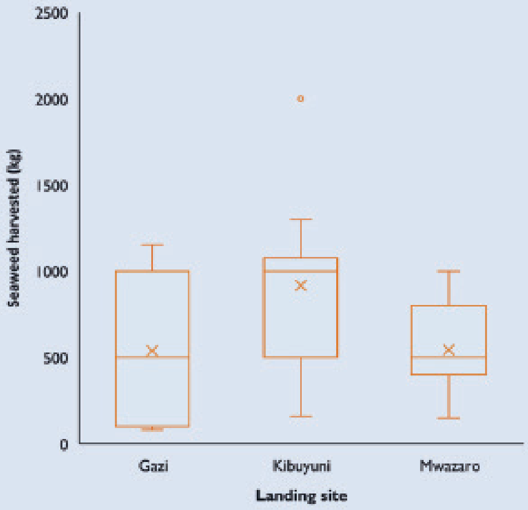
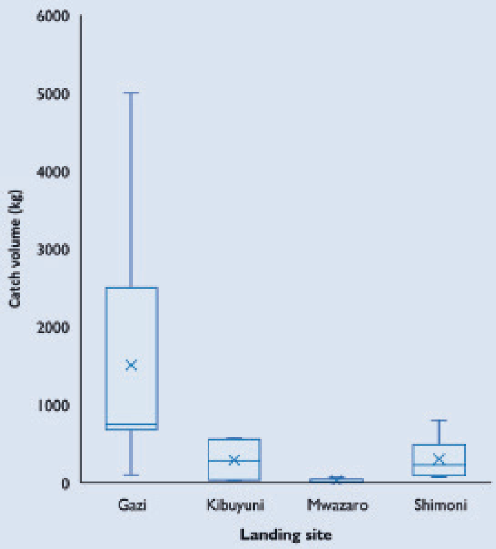
PRELIMINARY RESULTS

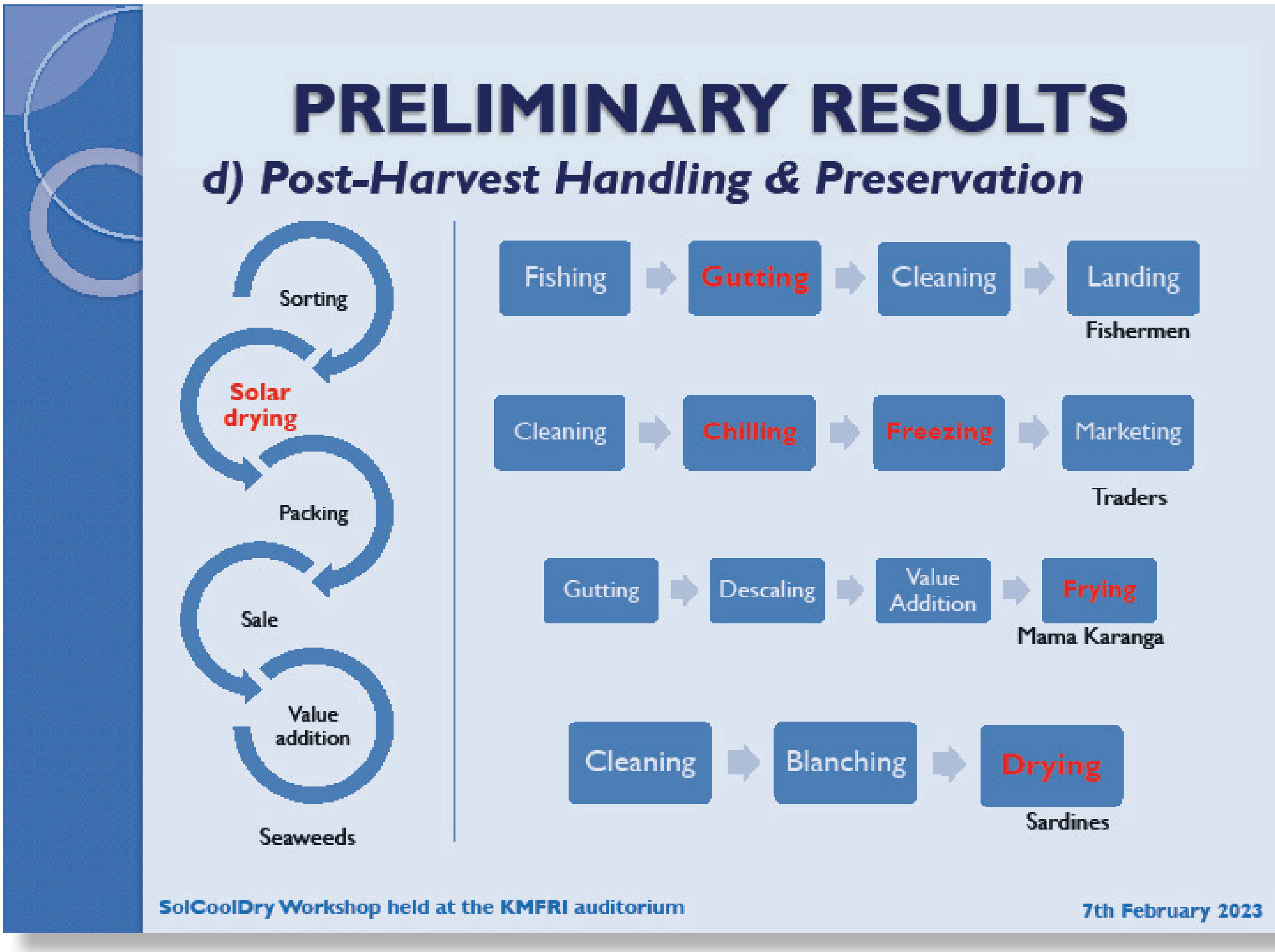
c) Production Capacity



- 60% Spinosum;
- 37% Spinosum + Cottonnii: Spinosum is dominant (80%-90%)
- **Harvest volumes:**
  - **Kibuyuni:** Average 1000kg/farmer/season
  - **Mwazaro & Gazi:** Average. 500kg/farmer/season



Gazi: Sardines & Mixed species;
Kibuyuni, Shimoni, Mwazaro: Mixed fish
System: In/off shore
Catch volumes:
Kibuyuni: Average 290kg; **Shimoni:** Av. 300kg
Mwazaro: Average. 25kg **Gazi:** Av.1500kg


PRELIMINARY RESULTS
d) Post-Harvest Handling & Preservation
Sorting
Solar drying
Packing
Sale
Value addition
Seaweeds
Fishing
Gutting
Cleaning
Landing
Fishermen
Cleaning
Chilling
Freezing
Marketing
Traders
Gutting
Descaling
Value Addition
Frying
Mama Karanga
Cleaning
Blanching
Drying
Sardines
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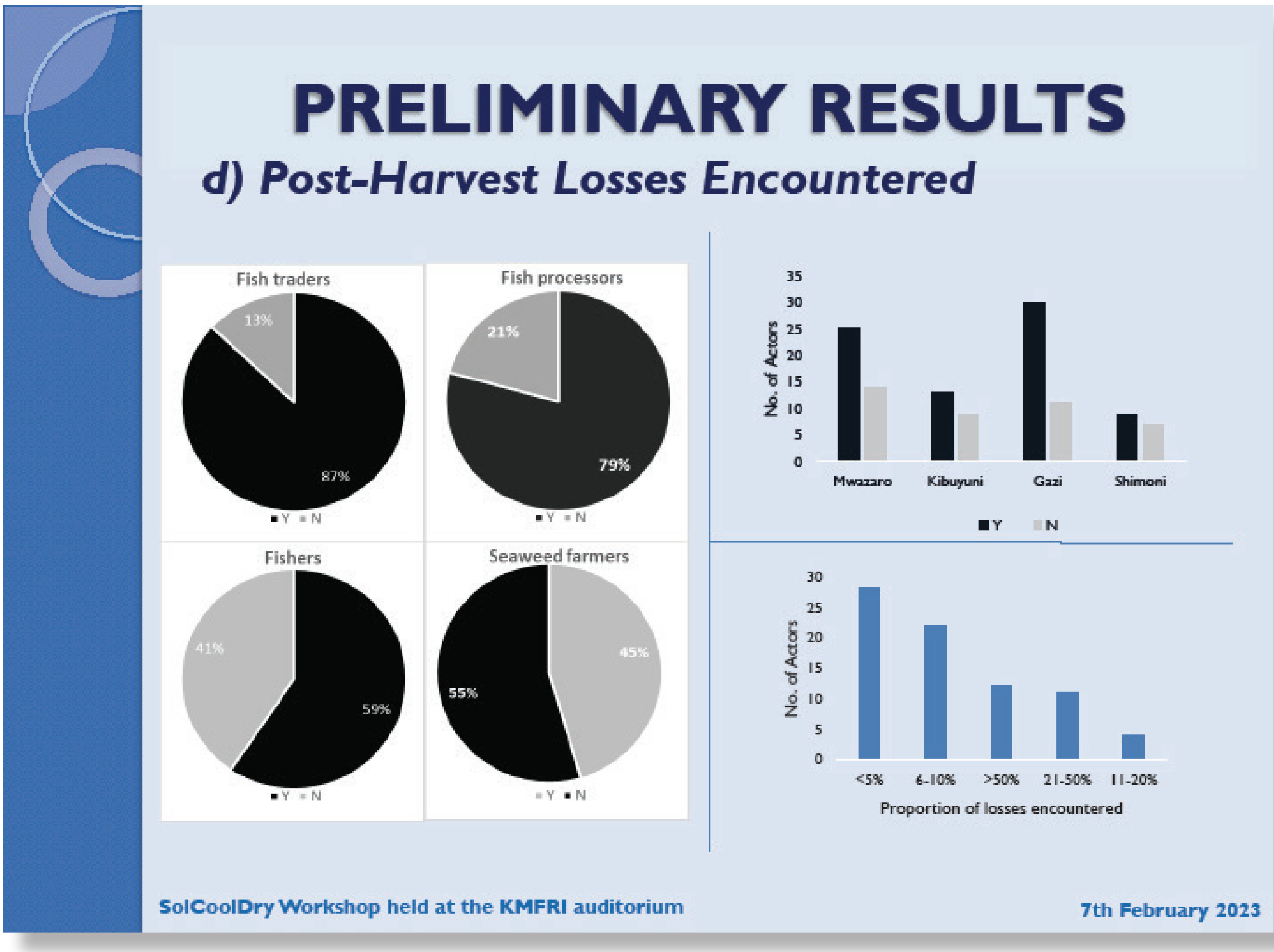
PRELIMINARY RESULTS
d) Post-Harvest Losses Encountered
Fish traders
13%
87%
Y N
Fish processors
21%
79%
Y N
Fishers
41%
59%
Y N
Seaweed farmers
55%
45%
Y N
No. of Actors
Mwazaro
Kibuyuni
Gazi
Shimoni
Y N
No. of Actors
<5%
6-10%
>50%
21-50%
11-20%
Proportion of losses encountered
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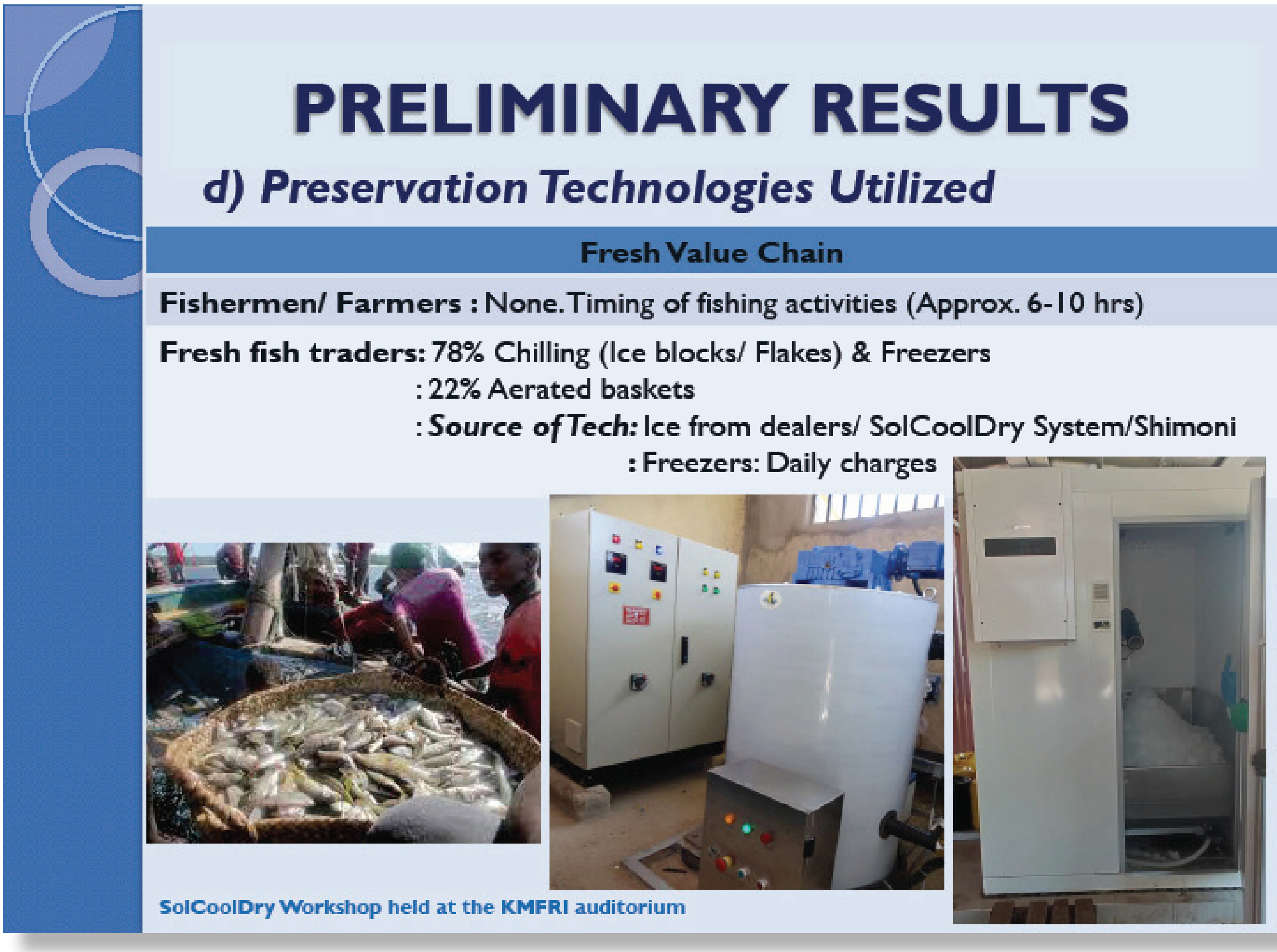
PRELIMINARY RESULTS
d) Preservation Technologies Utilized
Fresh Value Chain
Fishermen/ Farmers : None. Timing of fishing activities (Approx. 6-10 hrs)
Fresh fish traders: 78% Chilling (Ice blocks/ Flakes) & Freezers
: 22% Aerated baskets
: Source of Tech: Ice from dealers/ SolCoolDry System/Shimoni
: Freezers: Daily charges
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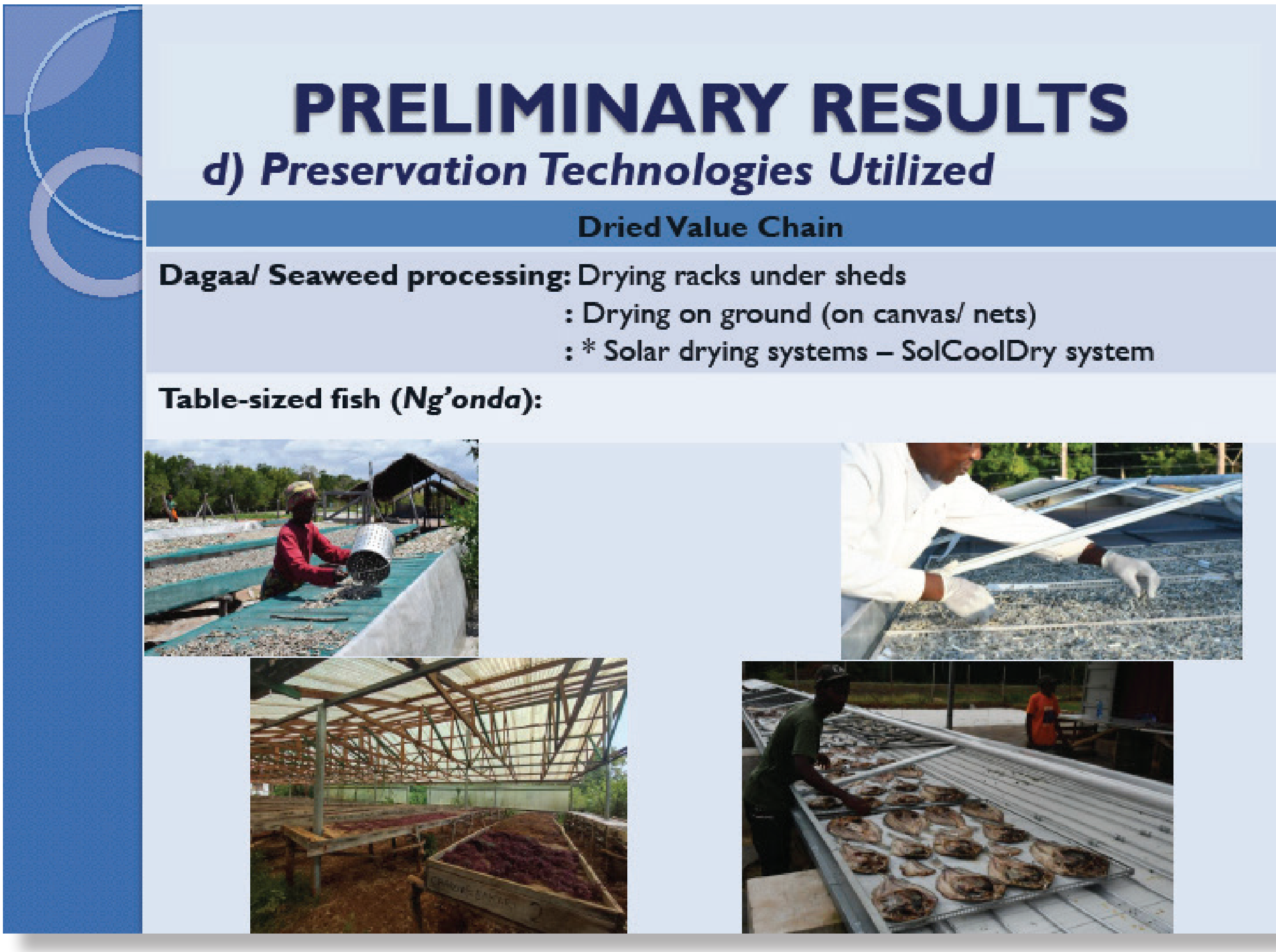
PRELIMINARY RESULTS
d) Preservation Technologies Utilized
Dried Value Chain
Dagaa/ Seaweed processing: Drying racks under sheds
: Drying on ground (on canvas/ nets)
: * Solar drying systems – SolCoolDry system
Table-sized fish (Ng'onda):

PRELIMINARY RESULTS

e) *Main Challenges during Preservation*

Fresh Value Chain	
Challenge	**% Actors Affected**
Inadequate ice production from local sites	95
Lack of cooler boxes (Fish traders/ processors)	89
High expenditure of hiring freezers (Traders)	83
Lack of fishing vessels with cold storage (Fishers)	100

Dried Value Chain (Sardines and Seaweeds)	
Challenge	**% Actors Affected**
Inadequate shaded drying racks (Processors)	100%
Inadequate all season drying systems	93%

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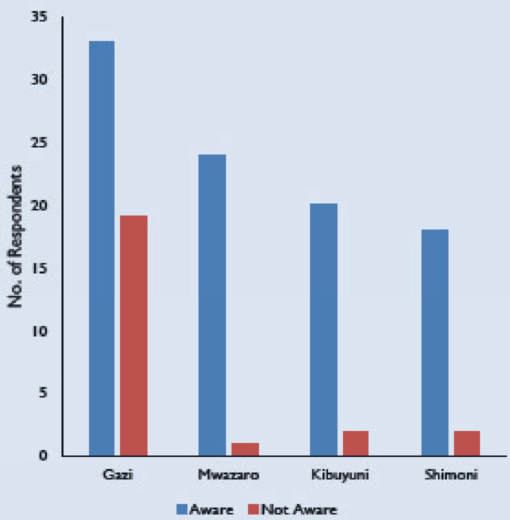
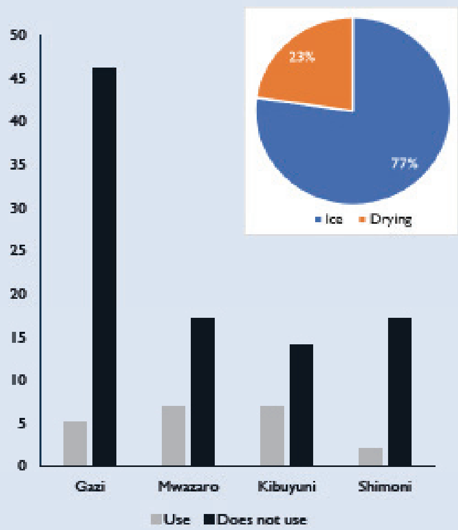
PRELIMINARY RESULTS

f) *Technology Transfer of the SolCoolDry System*



20%: Not Aware 80%: Aware



82%: Do not use 18%: Use

SolCoolDry Workshop held at the KMFRI auditorium

7th February 2023

PRELIMINARY RESULTS

g) Feedback on the SolCoolDry System

Positive	
Applicability	Very suitable to address post-harvest system
Accessibility	System located next to the road = Ease
Ice availability	Eases access to ice by value chain actors
Negative	
Ice quality	Poor: Melts faster than block ice
Drying racks	Inadequate for use during bulk systems
Price of ice	Could be lower (Proposed Ksh. 6-7 per kg)

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RECOMMENDATIONS

Increase	Increase ice production capacity to meet demand
Improve	Improve the quality of the ice to ensure it extends its preservation potential (reduce melting rates)
Increase	Increase drying racks to accommodate bulk sardine landing and seaweed harvests
Engage	Engage County Governments & Marine Spatial Planners on selection of ideal sites to scale up the project
Sensitize	Create awareness on the presence of the innovation to improve technology uptake
Capacity build	Increase capacity building for direct technology recipients to ensure sustainability of the project

SolCoolDry Workshop held at the KMFRI auditorium 7th February 2023


THANK YOU

Annex III. Workshop and Technology Day Program

REPUBLIC OF KENYA

KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE

PROGRAM FOR THE SOLCOOLDRY WORKSHOP, TECHNOLOGY DAY AND OFFICIAL LAUNCH

Time	Event	Participant
Day1: 7th February 2023 - KMFRI Conference Center - Mombasa		
08.000 – 08.10 am	Arrival of Guests, Signing of Visitors' Book and Registration	Priscilla Githui and Phionalorna Nzikwa
08.10 - 09.00 am	Viewing of Posters and Exhibits	All
	Introductions and Welcoming Remarks	
	Session Chair: Dr. Arthur Onyuka (KIRDI) Session Rapporteur: Dr. Wanjala (KIRDI)	
09.00 – 09.20 am	Introductions and Workshop Agenda and Program-KMFRI SolCoolDry	Dr. Peter Oduor-Odote
09.20 - 09.40 am	SolCoolDry Background Information & Partnerships - KIRDI Kenya Coordinator	Dr. Linus K'osambo
09.40 - 09.50 am	Overview of SolCoolDry System - Coordinator - Fraunhofer ISE	Dr. Alexander Morgenstern
09-50 – 10.00 am	Address - TUM Representative	Dr. Hamisi Mwaguni
10.00 – 10.10 am	Remarks - Director- General KIRDI	Dr. (Ing.) Calvin Onyango
10.10 – 10.20 am	Remarks - Director General KMFRI	Dr. James M. Mwaluma
	10.20 - 11.00 am - Tea Break	
	11.00 - 12.40 pm - Papers Presentations	
	Session Chair: Mr. Thoya Maitha (TUM) Session Rapporteur: Mr. Kassim Ziro (TUM)	
11.00 – 11.20 am	SolCoolDry Research, Innovation & Business Hub: Installation and Recommendations for Processes Engineering for Sustainability	Dr. Linus K'osambo - KIRDI
11.20 – 11.40 am	Solar ice production and drying in an off-grid system in Mwazaro/Kenya – Project review	Alexander Morgenstern, Fraunhofer ISE:
11.40 - 12.00 pm	The Evolution of Dry Chain Technologies in Kenya	Dr. Peter Oduor-Odote - KMFRI
12.00 - 12.20 pm	Future Perspectives of Drying	Dr. Ing. Albert Esper - INNOTECH
12.20 - 12.40 pm	Situational Analysis on Establishment of Hazard Analysis and Critical Control Points (HACCP) Plan for SolCoolDry Fish Processing Facility at Mwazaro Beach Management Unit Self Help Group	Dr. George Wanjala - KIRDI
	1.00 pm - 02.00 pm - Lunch Break	
	02.00 pm - 05.00 pm - Papers Presentations	
	Session Chair: Dr. Melckzedeck Osore (KMFRI) Session Rapporteur: Ms. Josephine Marigu (KMFRI)	
02.00 - 02.20 pm	KIRDI Fostering Industrial Research in the Blue Economy: - Opportunities and Perspectives in the new Horizon	Dr. Linus K'osambo - KIRDI
02.20 - 02.40 pm	Seaweed- and sweet potato-based nutritious food alternatives for sustainable food systems in Kenya and Indonesia through Solar Powered Innovations (Nutri-KI)	Dr. Marcus Schmidt - MRI

2.40 - 3.00 pm	Techno-economic Assessment of a hybrid solar-biogas system to mitigate environmental impact of cooking with fossil fuels at the Technical University of Mombasa Kitchen	Mr. Thoya Maitha - TUM
3.00 - 3.20 pm	Renewable Energy and Climate Change Research Centre at the Technical University of Mombasa	Dr. Huxley Makonde - TUM
3.20 - 3.40 pm	Profiling the status of direct SolCoolDry technology recipients in Kwale County, Kenya and their perspectives on fish preservation technologies	Ms. Morine Mukami & Josephine Marigu - KMFRI
3.40 - 4.00 pm Plenary Session		
04.00 - 04.30 Tour of Posters, Exhibits and Closing Ceremony (Tea Break)		

Day 2 - 8th February 2023 - Technologies Exhibitions and Official Launch - Mwazaro SolCoolDry Site		
08.000 – 08.10 am	Arrival of Guests, Signing of Visitors' Book and Registration	All
08.10 - 08.30 am	Viewing of Posters and Exhibits	All
Introductions and Welcoming Remarks		
08.30 – 08.40 am	Technology Open Day and Launch and Program -KIRDI SolCoolDry Kenya Coordinator	Dr. Linus K'osambo
08.40 - 09.00 am	Overview of the SolCoolDry Assembly and Installation Process	Dr. Alexander Morgenstern
9.00 - 11.00 - Guided Tour of the SolCoolDry System		
09.00 - 09.20 am	SolCoolDry Solar Power and Storage	Dipl Ing. Norbert Pfanner
09.20 - 09.40 am	SolCooDry Tunnel Dryer	Dr. Ing. Albert Esper
09.40 - 10.00 am	SolCoolDry Ice Production	Dr. Alexander Morgenstern
10.00 am - 10.20 am	PPP Modelling - SolCoolDry Products, SolCooDry System as a Research, Innovation and Business Hub	Dr. Linus K'osambo and Mr. Benard Osawa (Timiza Utafiti)
10.20 - 10.40 - Guided Tour of Other Exhibits - Community and Blue Economy Innovation		
10.40– 11.00 - Tea and Health Break		
11.00 - 1.00 pm - Official Launch		
11.00 am - 11.20 am	Remarks - Director General KMFRI	Dr. James M. Mwaluma
11.20 am - 11.40 am	Remarks - Director-General KIRDI	Dr. (Ing.) Calvin Onyango
11.40 am – 12.00 am	Remarks - Vice Chancellor - TUM	Prof. Laila Abubakar
12.00 am - 12.20 pm	Governor, Kwale County	Eng. Lucy Mutinda
12.20 am – 12.40 pm	BLE/German Cooperation Representative	Governor
12.40 am – 01.00 pm	Official Launch - KIRDI BoD	**Chief Guest**
Lunch and Sightseeing **Kibuyuni Seaweeds Processing** **Kijiweni Marine Cage Farming** **Mwazaro Pond Farming Initiative** **Kijiweni Boardwalk Restaurant**		

Annex IV. List of Participants

Title	First Name	Last Name	Gender	Age	Affiliation	Designation	Contact
Dr.	James	Mwaluma	M	>35yrs	KMFRI	DOCS	jamesmwaluma@gmail.com
Dr.	Peter	Odote	M	>35yrs	KMFRI	Research Scientist	podote@gmail.com
Dr.	Melckzedek	Osore	M	>35yrs	KMFRI	Research Scientist	babaalmasi@yahoo.co.uk
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Annex V. SolCoolDry Brochure

REPUBLIC OF KENYA

KENYA INDUSTRIAL RESEARCH & DEVELOPMENT INSTITUTE

SolCoolDry Research, Innovation and Business Hub

Intervention Partners

With support from

Federal Ministry of Food, Agriculture and Consumer Protection

by Decision of the German Bundestag

Project Manager

Federal Office for Agriculture and Food

K.M.F.R.I. — Kenya Marine and Fisheries Research Institute

Technical University of Mombasa

INNOTECH Ingenieursgesellschaft mbH

Fraunhofer ISE

Project Title

Development of Milkfish (Chanos chanos) and Kimarawali (Stolephorus delecatulus) Solar Drying-Cooling Technology, Value Addition and Quality Assurance (SolCoolDry Project)

Thematic Area

Agri-Industrial enterprises development

Background Information

Mariculture is gaining prominence in Kenya as natural fish stocks (e.g., tilapia in Lake Victoria) dwindle, a situation that has pushed Kenya to import fish. Milkfish (Chanos chanos) is currently being produced in culture ponds by farmers at the Coast of Kenya. Fishermen also harvest a local sardine called Kimarawali (Stolephorus delecatulus). Milkfish farmers depend on fluctuating and seasonal wild stocks of milkfish fingerlings from local mangroves and therefore must maximize their productivity and returns during periods of abundance. Kimarawali catches are also seasonal with high swarming occurring in the months of March to July.

However, the fisher folk lack appropriate technologies to process their fish and are therefore forced to sell their produce when fresh to dealers at uneconomical prices. The farmers also practice poor handling techniques that negate the prospects of accessing high-end markets. This scenario offers an opportunity to Kenyan institutions to partner with German Institutes and private firms to develop a technology package to utilize the latest advances in photovoltaics and drying technologies.

Ice Storage Cold Room

The project developed a solar cooling-drying system for fish. The project introduced a containerized, stand-alone solar technology package consisting of a 100% cooling and drying system, for cooling technology.

The SolCoolDry system consists of two tunnel dryers that 2m wide and 24 meter long. One of the tunnel dryers is integrated to a hot water system for night time performance.

To produce high quality dried fish of premium nutritional value, texture and flavour, drying is done under standard conditions. Fish farmers will be trained on processing and quality assurance. Fraunhofer ISE and Innotech will partner with KIRDI, Kenya Marine and Fisheries Research Institute (KMFRI) and Technical University of Mombasa (TUM) to design, develop and transfer the proposed technology package.

Processing fish for drying at SolCoolDry Research, Innovation and Business Hub

Justification

Food insecurity among rural communities of the coastal region of Kenya requires urgent intervention that can be supported by the marine fishery resources. Milkfish (Chanos chanos) and a local sardine called Kimarawali (Stolephorus delecatulus) are caught along the sea shores of Kwale and Kilifi Counties. Fisher folks depend on fluctuating and seasonal availability with high swarming occurring in the months of

SolCoolDry System

SolCoolDry System installed at Mwazaro, Kwale County.

Hygienic Fish Drying using the SolCoolDry System

Hybrid Solar Drying of Seaweed

March to July. Milkfish and Kimarawali are generally under-utilized fish species. Kimarawali are low social status owing to its small size and brittleness when dried. Fisher folk in the region lack appropriate technologies to process and add value to fish therefore they sell their produce fresh to dealers at uneconomical prices.

This scenario offers an opportunity for KIRDI to develop a technology package that can utilize the latest advances in solar driven cooling utilizing innovative energy storage materials and technologies such as phase- change materials (PCM), drying and food processing technologies to process and add value to Milkfish and Kimarawali.

In addition, one of the foci of the Sustainable Development Goal (SDG) is to end poverty in all its forms everywhere. The project is designed to develop and disseminate a solar powered cooling and drying system to improve income and livelihood of smallholder fisher folks.

Project Outputs

(i) Model solar powered hybrid cooling-drying platform
(ii) Fish handling and processing center
(iii) Quality system and recommended production practises

Collaborators

(i) Fraunhofer Institute for Solar Energy Systems (ii) Kenya Marine and Fisheries Research Insitute (KMFRI), (iii) Technical University of Mombasa (TUM), (IV) Innotech Ingenieursgesellschaft mbH

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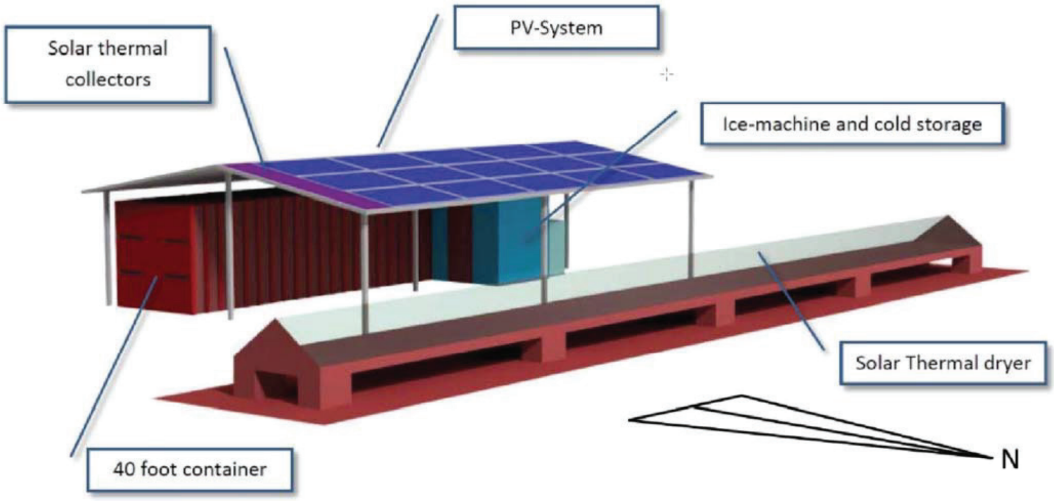

SolCoolDry System Design


SolCoolDry System Product


Drying of Orange Fleshed Sweetpotato chips for
making wheat-sweetpotato composite bread

General Objectives

Introduce a technology package for 100 % off-grid solar powered cooling and drying to improve quantity, quality and value of Milkfish and Kimarawali

Specific Objectives

1) Develop a model solar powered hybrid cooling-drying system
2) Establish fish handling and processing centres
3) Establish a quality system and recommended good production practises
4) Produce longer shelf-life milkfish and kimarawali for coastal and inland markets

Methodology

The project carried out a baseline documentation of the local milkfish processing technologies and capacity in order to adapt the proposed technology package to the needs of the target communities.

The project undertook SolCoolDry system design and energetics evaluation of the solar- cooling concept. This involved the design of integrated photovoltaic driven cooling through ice production and solar thermal energy-suported drying.

The project undertook a technology needs assessment in Kwale, Kilifi and Kisumu Counties to design the SolCoolDry components. This led to a shift in technology design and focus from a solar-powered cold room to a solar-powered ice-making system.

Expected Impact

(i) Longer shelf-life (at least 3 months) milkfish in Coast and Inland Markets
(ii) Reduce post-harvest fish losses by up to 25 %
(iii) Improve income of fisher folk

Project Activities

(i) Project planning meeting
(ii) Baselines Survey
(iii) Profiling fish value chain
(iv) Preliminary evaluation of KIRDI Solar-Biomass Hybrid Dryer for improvement
(v) Site selection for SolCoolDry system installation
(vi) Water analysis for the design of solar-powered ice-making system
(vii) Energetics evaluation and design of solar powered fish handling system
(viii) Importation of the SolCoolDry System
(ix) Setting up of the System at Mwazaro in Kwale
(x) Completion of installation of the SolCoolDry System
(xi) System tests and evaluation
(xii) Capacity building
(xiii) Production of ice and fried products

Annex VI. Newspaper article on the SolCoolDry project.

THURSDAY, FEBRUARY 9, 2023 The Standard
COUNTIES 21

New facility to reduce post-harvest fish loss

- The solar cooling and drying project targets small-scale fishermen in remote areas who operate from small sites.
- The project will assist fishermen in Mombasa, Kilifi, Lamu, and Kwale counties.

JOACKIM BWANA, MOMBASA

Two state agencies and a German company yesterday unveiled a solar drying-cooling system for small-scale fishermen along the coast to help them reduce post-harvest losses.

Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Industrial Research and Development Institute (KIRDI), Innotech and Fraunhofer from Germany, and the Technical University of Mombasa TUM are leading the project.

The project will assist fishermen in Mombasa, Kilifi, Lamu, and Kwale counties in selling their catch at a profit because they will be able to store the fish for an extended period of time while looking for markets.

Around 48 Beach Management Units (BMUs) ranging from Lamu to Vanga and LungaLunga will benefit.

To produce ice and dry fish, a portion of the project has already been installed in Mwazaro, Pongwe-Kidimu, and Lunga Lunga Kwale County.

The solar cooling and drying project, according to KIRDI's lead researcher, Linus K'Osambo, is completely off the grid and targets small-scale fishermen in remote areas who operate from small-scale landing sites.

With a fish deficit of over 300 tonnes in the country, no fish should go to waste, said K'Osambo, adding that the project will aid in preserving the harvest.

"The project was designed to intervene and prevent post-harvest losses of fish, especially given that we are having a fish production deficit. So we're not supposed to lose any fish that we farm or catch," K'Osambo said.

According to him, the project is intended to produce ice to assist farmers and fishermen in preserving fish as they are caught, as well as shelf-stable fish that can reach inland markets through high-quality drying.

"The goal is to have systems that can be installed in areas where our power grid cannot reach. We plan to build 48 BMUs from Lamu to Vanga on Kenya's South Coast," said K'Osambo.

Fish preservation through a solar drying and cooling technology system at Mwazaro Beach Management Unit. [Robert Menza, Standard]

He added that the project would also focus on capacity building and fish handling, both of which are necessary for Kenyan fish to be sold in high-end markets.

"We must produce high-quality fish that adheres to quality standards. So this project is doing onsite capacity building, producing ice, drying fish, and marketing it," K'Osembo added.

Dr James Mwaluma, the KMFRI's Director for Oceans and Coastal Systems in Mombasa, said the project will benefit Tana River fishermen who have a bumper harvest of bronze and snappers.

Mwaluma said during the peak season, Tana River fishermen suffer massive post-harvest losses.

He said the project would be beneficial as they seek to introduce mariculture farming (ocean fish farming), with a hatchery already established in Shimoni.

"The main challenge for mariculture production has been a lack of seeds. So, in our strategy, the project will be useful when there are a lot of harvests because it will help farmers preserve the fish so that they can reach a wider market," Mwaluma added.

He said the project would also help to dry up seaweed farming in the shorelines of Kibuyuni and Nyumba Sita, as well as add value to the resources.

Dr Albert Esper, the Managing Director of Innotech Company, said the solar-powered system would keep fish for more than a year and guarantee zero food losses during harvest.

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