UNIVERSITY OF NAIROBI

From the Lab to the Land: Solutions for Food Loss & Waste Reduction for the People and the Planet

The 50th Professorial Inaugural Lecture of the University of Nairobi

27th September 2024

PROF. JANE AMBUKO

PROFESSOR OF HORTICULTURE

DECLARATION

This booklet contains an original narration of my academic journey to become a Professor of Horticulture at the Department of Plant Science and Crop Protection, University of Nairobi. The content as laid out in this booklet has not been published on any other platform.

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DEDICATION

This inaugural lecture is dedicated to my late mum, Reverend Sarah Velma Ambuko whose tough motherly love and guidance helped me to stay the course in my academic journey.

SALUTATION

- **The Vice Chancellor of the University of Nairobi (Ag) –** *Prof. Margaret J. Hutchinson*
- **The DVC, Academic Affairs (Ag) –** *Prof. Ayub Gitau*
- **The DVC, Research Innovation and Enterprise (Ag) –** *Prof. Francis Mulaa*
- **Dean of the Faculty of Agriculture -** *Prof. Moses Nyangito and other Deans Present*
- **The Chairman Department of Plant Science and Crop Protection –** *Prof. James Muthomi and other heads of departments present*
- **Members of the University of Nairobi Senate Present**
- **All Professors and other academic staff from FOA and entire UoN present**
- **All the non-academic staff present from FOA and entire UoN present**
- **All the Students from FOA and the entire University of Nairobi**
- **My beloved Family – those present and others following from various locations**
- **All my funding and research partners – those present physically and online**
- **My dear friends – those present physically and online**

Good afternoon and thank you very much for honouring me with your presence during this special occasion in my academic career.

PROFESSIONAL BIOGRAPHY

Jane Ambuko begun her academic journey at Mulwakhi Primary School in Mulwakhi village of Vihiga County where she sat her Kenya Certificate of Primary Education (KCPE). She then proceeded to Bunyore Girls High School and thereafter to the University of Nairobi. Her first choice of the degree program was medicine, but by divine design, she ended up at the Faculty of Agriculture to study BSc Agriculture. She struggled in the first year to adjust to studying Agriculture instead of her preferred degree program but by the time she was in second year she had adjusted and put her best foot forward. Upon competition of the BSc Agriculture (Crop Science Major), she was awarded the highly competitive University of Nairobi scholarship for staff development to study a Master of Science (MSc) in Horticulture. Upon graduation with an MSc in Horticulture in 2001, she joined the University of Nairobi as a tutorial fellow under the staff development program. In 2004, she won the competitive Japanese Government Scholarship (MEXT) to pursue doctoral studies at the University of Tsukuba in Japan. She graduated with Doctor of Philosophy (PhD) in Agricultural Sciences (Pomology and Postharvest Major) in 2008. Upon return to the University of Nairobi, she was promoted to the position of Lecturer in 2008. In 2014, she was promoted to Senior Lecturer and 5 years later (2019) she rose to the position of Associate Professor and then to Professor of Horticulture in 2023 (October).

Over her 15-year tenure at the University of Nairobi as a full academic, Prof. Ambuko has dedicated her career to advancing the field of postharvest management, with a particular emphasis on reducing food loss and waste. Since completing her doctoral studies in 2008, she has secured over 3 million USD in research and development funding through approximately 30 projects. Her efforts have been supported by a range of national and international organizations, including the Rockefeller Foundation, United States Agency for International Development (USAID); the Food and Agriculture Organization of the United Nations (FAO), the UN World Food Program (WFP); the Foundation for Food and Agriculture Research (FFAR), United Kingdom Research & Innovation (UKRI), National Research Fund (NRF-Kenya); the National Commission of Science, Technology and Innovation (NACOSTI). Additionally, her work has been supported by various agri-food industry players such as JUATECH, AGROFRESH, SIOVALLEY TECHNOLOGIES, and MRM-Safal Group, highlighting her role in both research and outreach within the sector.

During her career at the University of Nairobi, Prof. Ambuko has significantly contributed to the academic and research community. She has mentored 40 MSc and 8 PhD students to completion, with an additional 30 graduate students currently advancing their research in various fields. Her collaborative research efforts have resulted in over 80 peer-reviewed journal publications and over 130 conference presentations. Additionally, her team's work on evaporative cooling solutions has led to the registration of two utility models and one innovative cold storage technology under intellectual property protection.

Prof. Ambuko has made significant contribution in raising awareness and addressing food loss and waste issues in Kenya and Africa at large. She co-convened the inaugural All Africa Postharvest Congress and Exhibition (AAPHCE) in 2017, which was hosted by the University of Nairobi and was later adopted by the African Union Commission (AUC) in 2019 as a biennial event. The congress, now in its 5th cycle, has become a major pan-African platform for discussing postharvest challenges and innovations. In addition, Prof. Ambuko has played a pivotal role in promoting the United Nations' International Day of Awareness of Food Loss and Waste (IDAFLW) at the national level. Since the day's inception in 2020, she has led the University of Nairobi in collaborations with various stakeholders to organize the national IDAFLW, thereby enhancing awareness and fostering solutions to tackle food loss and waste.

Prof. Ambuko has demonstrated extensive commitment and leadership both within and outside the University of Nairobi. At the university, she has contributed to various committees at the departmental, faculty, college (former), and university levels. Beyond the university, she serves on multiple local and international boards, commissions, committees, consortia, and task forces. Notable roles include membership in the Micronutrient Forum (MNF) Board; the 3D Commission on Data, Social Determinants, and Better Decision-Making for Health; the United Nations High Level Panel of Experts (HLPE) on Food Security; the Regional Advisory Board for the Innovation Lab for Horticulture, Feed the Future (USAID). She is the Regional Coordinator for the International Society of Horticultural Science (ISHS) for East Africa and a member of the Kenya Bureau of Standards Committee for Fresh Horticultural Produce. She served as the lead expert for Kenya during the development of the Post Harvest Loss Reduction Strategy for IGAD (Intergovernmental Authority on Development) in 2020. She has also served as a lead consultant in the development of a Postharvest Management

Strategy for Kenya which has been spearheaded by the Ministry of Agriculture and FAO.
Prof. Ambuko has received prestigious fellowships such as the Norman Borlaug Fellowship (2014) and the AWARD Fellowship (2013). In recognition of her work and achievements, she has received several awards and recognitions including Top fellow ('Influencer') by AWARD (2015); Innovation Champion under the Feed the Future, Kenya Innovation Engine (2017); National Diversity and Inclusion Awards and Recognition (2018); The top 28 people globally impacting postharvest loss reduction, by FoodTank (2018); University of Nairobi Merit Award (2022).

Prof. Ambuko is an active member of various professional bodies including the International Society of Horticultural Science (ISHS); the Horticultural Association of Kenya; African Women in Science & Engineering (AWSE); the Kenya National Young Academy of Sciences (KNYAS); African Women in Agricultural Research and Development (AWARD); and the Kenya Professional Association of Women in Agriculture and Environment (KEPAWAE). She is a past member of the American Society of Horticultural Science (ASHS) and Japanese Society of Horticultural Science (JSHS).

Prof. Ambuko proudly identifies herself as a Food Loss and Waste Reduction Champion of Sustainable Development Goal 12 (3), reflecting her dedication to advancing sustainability and addressing local and global challenges in the food systems.

A JOURNEY OF RESILIENCE, HOPE AND FAITH IN GOD

After completion of high school in 1990 and while waiting to commence university education, Jane was belatedly diagnosed with end-stage renal failure. She then started to undergo peritoneal and later haemodialysis twice a week at the Kenyatta National Hospital (KNH). When the time to join the University of Nairobi came, she had given up hope because of her ill health. However, her parents, Lay leader Jonathan Ambuko and the late Rev. Sarah Ambuko encouraged her not to give up but take up the opportunity especially being the first girl in the village to join University. Therefore, against all odds, she reported to the Upper Kabete campus and reluctantly started her journey in the BSc Agriculture program. Given her ill health, she was convinced that she could not manage to study agriculture, which at the time she imagined that it entailed hard labour at the University farm, typical of smallholder farmers in Kenya. Therefore, she consulted the Faculty Dean at the time, Prof. Daniel Mukunya to seek his help to transfer to the Faculty of Medicine. Prof. Mukunya enlightened her that BSc Agriculture had nothing to do with farm work and that it was the science of food production and utilization. He encouraged her to pursue the BSc agriculture and aspire to be like him – a Professor of Agriculture and even Dean of the Faculty. Jane reluctantly accepted to stay but still explored the alternative degree programs. Throughout the first year her life was divided between lecture theatres, KNH and the student health services. By the grace of God, she sailed through first year without supplementary examinations. Her health was slowly but surely deteriorating as dialysis started to take a toll on her. As she witnessed her fellow dialysis patients lose the battle during or in between dialysis sessions, she knew that even for her, it was no longer a question of IF but WHEN she would also lose the battle. The doctors at KNH advised her family that the only hope for her was a kidney transplant. Her brothers and sisters willingly availed themselves for assessment of their compatibility as kidney donors. Only one of the sisters, Winfred Opisa was cleared as a potential kidney donor. By the grace of God and because of her great love, Winfred willingly accepted to donate one of her kidneys to save Jane's life. The Faculty Dean then rallied the University community and friends to raise funds for Jane's kidney transplant. Out of their great love and care for one of their own, the renal team of doctors at the UoN School of Medicine waived the surgery fees. This helped to save the proceeds of the fundraising for the post-transplant medication. On 12th January 1993 while waiting to join the 2nd year of study, Jane and her twin sister (Winfred) underwent the life-saving surgery that would bind them together for life. Jane is eternally grateful and indebted to her twin sister for her sacrifice of love that gave her a new lease of life.

Jane is sincerely grateful to her family for their loving care and enormous sacrifices when she was on dialysis and immediately after the transplant. She is indebted to her late mother, Rev. Sarah Velma Ambuko who sacrificed all comforts to nurse her during the initial days of dialysis. She thanks her dear dad, Lay Leader Jonathan Ambuko, who believed in her and together with her late mother, they encouraged her to report to the University and commence her academic journey, despite the ill health. She thanks her siblings for their unconditional love and support all through.

Her gratitude also goes to her doctors from the KNH renal doctors led by Prof. Joshua Kayima and Prof. Seth Mcligeyo and the nursing team led by Matron Musumba (retired), for their loving care during period on the dialysis and the continued care after the kidney transplant.

Jane will never forget the great support that she received from her classmates at the University (class of 96) during her struggles in 1st year. She missed many lectures and practical sessions because of dialysis but the classmates always ensured that she had lecture notes. She has special gratitude to her roommate at the time, Mrs Alice Kainyu Miano, who became her voluntary resident caregiver. She was always on standby whenever Jane's health deteriorated and she needed to be rushed to KNH or to the students' clinic, sometimes in critical condition, during the wee hours of the night. The prayers and encouragement of many and especially brethren from the Upper Kabete Campus Christian Union kept her strong.

Jane is grateful to her loving husband, Prof. Willis Owino (JKUAT), the resident mentor and personal G.O.A.T on matters postharvest. He is her life and professional partner who has stood by her in good and bad times. She is also indebted to her mentors Prof. Margaret Jesang Hutchinson, Dr. Lusike Wasilwa, Prof. Linus Opara and Dr. Lisa Kitinoja who have held her hand in her career growth and pointed her to opportunities for growth. She is sincerely grateful to Ms. Betty Kibaara, Director at the Food Initiative of the Rockefeller Foundation. Betty challenged Jane to stop talking in conferences about applicable technologies for food loss/waste reduction and demonstrate their practical application – from the Lab to the Land.She sincerely thanks her multi-disciplinary research team that includes students and faculty members who have been part and parcel of her academic journey. A special mention for

Mr. Emmanuel Amwoka, current PhD student who joined the team as a final year undergraduate student and has worked hand in hand with Jane in many projects – doubling as a student and research assistant.

All in all, it has been a journey of resilience, hope and faith in God. When God granted her a new lease of life through the kidney transplant, Jane embraced it with so much gratitude and appreciation. She prayed to God to help her live a life of purpose and service to Him and humanity. Indeed, God has been faithful thus far and she says EBENEZER, thank you Lord. He has opened doors for her and granted her access to the unexpected, beyond her dreams. By the grace of God, she has risen from a frail and hopeless first year student in 1992 to a Professor of the University of Nairobi in 2023 – 31 years of divine favour.

Join her in acknowledging and appreciating the faithfulness of God in her life – **'See what the Lord has done'.**

SYNOPSIS

Food loss and waste (FLW) poses a significant challenge to global food security and environmental sustainability. Globally, 14% of food produced for human consumption is lost between harvest and retail, and an additional 17% is wasted from retail to consumption. In Kenya, available data shows that 30% of food produced is lost or wasted along the supply chain. A recent study on food waste (between retail and consumption) revealed that every Kenyan wastes approximately 141 kg of food annually. As so much food goes to waste globally, more than 800 million people worldwide suffer from hunger and 3 billion people cannot afford a healthy diet. The wasted food represents not just a loss of the edible food but also the squandered resources used in its production, including water, land, energy, labor, and capital. Moreover, food waste contributes significantly to greenhouse gas emissions, exacerbating environmental issues and threatening food security of future generations. Addressing FLW is crucial for achieving sustainable food systems and meeting the United Nations Sustainable Development Goal 12 (SDG 12), which aims to halve per capita global food waste at the retail and consumer levels and reduce postharvest losses by 2030 (SDG target 12.3). In recognition of the importance of FLW reduction, the United Nations General Assembly designated September 29 as the International Day of Awareness of Food Loss and Waste (IDAFLW). The IDAFLW aims to raise awareness about the problem of food loss and waste and its negative impacts – social, economic and environmental. In addition, possible solutions to address food loss and waste at all levels are highlighted. During observance of IDAFLW, a call to action is made for public and private entities to take action to reduce food loss and waste towards transforming agri-food systems to contribute to the achievement of the 2030 agenda.

This inaugural lecture will be presented in two parts. The first part will serve as an advocacy and call to action, aligning with IDAFLW 2024. I will emphasize the critical need for collective efforts by agri-food sector stakeholders including practitioners, policymakers, researchers, development partners, and civil society to tackle FLW for the benefit of both people and the planet. The second part of the lecture will highlight several initiatives that I have led in my academic career as part of my contribution to the efforts towards FLW reduction. The initiatives to be highlighted include adaptive research on food FLW reduction technologies; capacity building of various actors in the food supply chain; and community engagement & outreach activities to promote the adoption of research-based solutions for FLW reduction. These initiatives reflect a commitment to translating scientific research into practical solutions and scaling them – 'from the Lab to the land'.

At the end of the lecture, I hope to have enhanced awareness of the FLW problem and showcased practical solutions derived from research to address the problem. I encourage all stakeholders in the agri-food sector to take proactive steps, both individually and collectively towards reducing food loss and waste, thereby contributing to food security and environmental sustainability.

PART 1

ADVOCACY AND CALL TO ACTION

STOP FOOD LOSS AND WASTE.
FOR THE PEOPLE. FOR THE PLANET.

BACKGROUND: UNDERSTANDING FOOD LOSS AND WASTE

1.1. DEFINITIONS AND DELINEATIONS

Food loss and waste (FLW) refers to decrease in mass/quantity and quality of food that was originally intended for human consumption (FAO, 2019). Food loss and waste happens along the food supply chain from the time food is harvested to when it is consumed or utilized. For the sake of measurement, and considering the contributing factors, FLW has been divided into two, based on the stage of the supply chain where it occurs. Food loss (FL) refers to food that gets spilled, spoilt or otherwise lost, or incurs reduction of quality and value prior to the retail stage of the supply chain. Thus, FL results from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers. Food Waste (FW) refers to food of good quality and fit for consumption that doesn't get consumed, it is deliberately discarded. FW takes place from the retail to consumption stages in the food supply chain and is a result of decisions/actions by retailers, food service providers and consumers. The distinction between food loss and food waste and the stage of the food supply chain where they occur is depicted in Fig. 1.

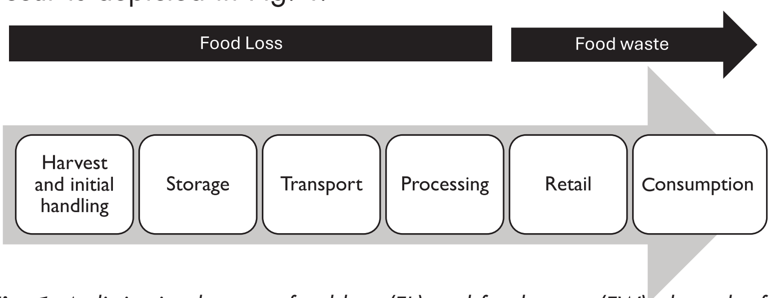


Fig. 1: *A distinction between food loss (FL) and food waste (FW) along the food supply chain*

Apart from the quantitative loss, there are qualitative losses which results from a decrease in quality attribute of food (nutrition, safety, etc.) which occur at all stages of the food supply chain from harvest to consumption.

1.2 EXTENT OF FOOD LOSS AND WASTE

Reliable data on the extent of FLW is scarce. The most cited statistics on FLW and which most countries have adopted as a baseline are based on a 13-year-old report on food lost and waste (FAO, 2011). According to the report, 30% (or one third) of the food produced is lost or wasted along the supply chain. This is equivalent to 1.3 billion metric tons of food lost or wasted cumulatively long the food supply chain. Although this report was the most comprehensive study on FLW, it was based on estimates and made major assumptions. According to the report, while the total amount of food loss/wasted is comparative across continents (26% and 36%), disaggregation by stage of the supply chain differs significantly. For example, in developing counties in SSA, most of the losses (FL) occur upstream at the production, postharvest handling and storage stages. On the contrary, more developed countries in Europe and North America grapple more with food waste (FW) which occurs between the retail and consumption stages. This assumption has since been debunked with recent reports showing that food waste is equally high in the developing countries in SSA.

The causes and drivers of food loss (upstream) and food waste (downstream) differ significantly. Therefore, measurement of FL and FW has been separated into two components with different indicators. The food loss index and the food waste index are under the custodianship of the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP) respectively. Based on this distinction, the most recent report by FAO estimates food loss (between harvest and the retail stage of the supply chain) to be 14% (FAO, 2019). The extent of losses varies across the regions/continents (Fig. 2) and commodity groups (Fig. 3).

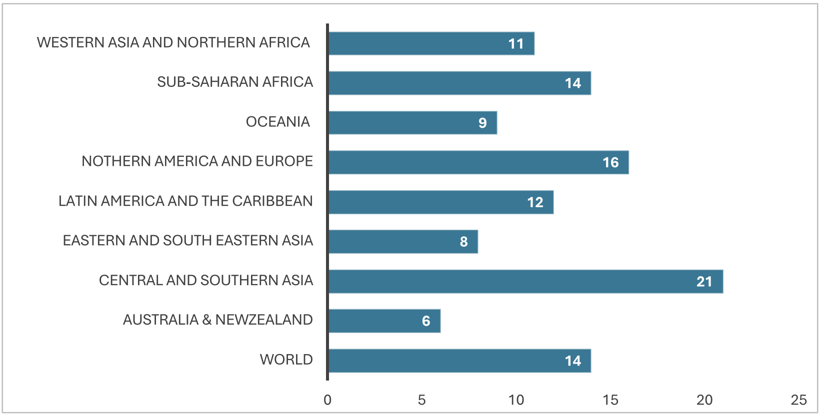


Fig. 2: *Disaggregation of Food Loss by continent (Adapted from FAO, 2019).*

Some commodity groups are more prone to spoilage and subsequently FLW than others. In the less perishable commodities such as cereals and pulses, FL is estimated to be about 8%, which is much lower compared to the more perishable fruits & vegetables (22%) and roots & tubers (26%), (FAO, 2019).

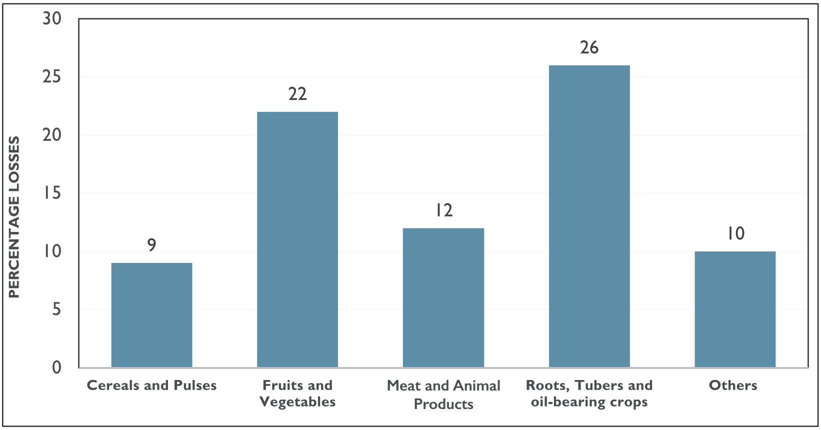


Fig. 3: *Disaggregation of food loss by commodity groups (Adapted from FAO, 2019).*

A study by UNEP, the custodians of the food waste index, revealed that 17% (931 million metric tons) of the food produced for human consumption is wasted between the retail and consumption stages of the supply chain (UNEP, 2019). Of this amount, 61% is wasted at the household level while retail and food service stages contribute 11% and 28% respectively to the wastage. Closer home, it is estimated that every Kenyan wastes approximately 141 Kg of food every year, of which 99 Kg (70%) happens at the household. This figure is way above the global average (120 Kg) and that of some developed countries like the United Kingdom, 98 Kg (Fig. 4). These figures debunk previous assumptions that food waste is a problem of the more affluent developed countries while food loss is a problem of the less developed and technologically challenged countries.

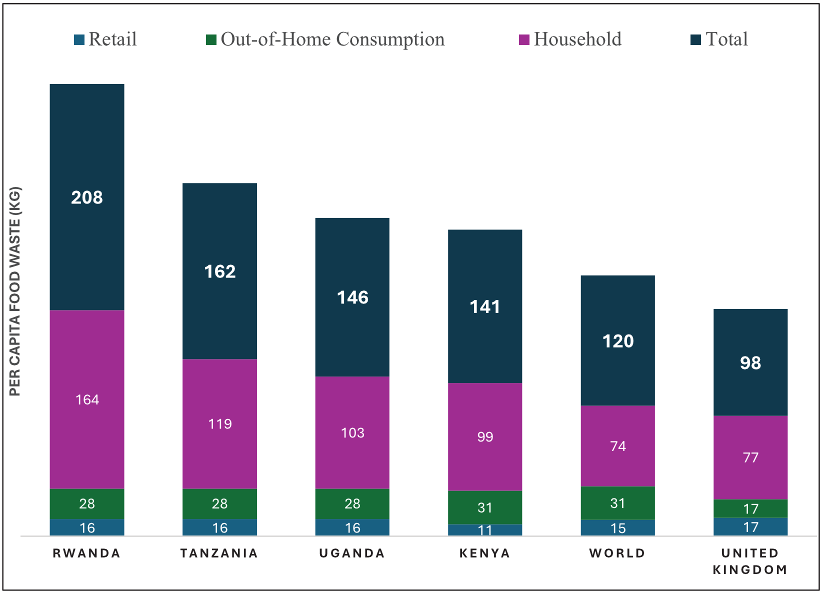


Fig. 4: *Per capita food waste for selected countries (Source; https://ourworldindata.org/food-suppl*

1.3 CAUSES AND DRIVERS OF FOOD LOSS AND WASTE

Identification of causes of FLW is critical in selecting and prioritization of effective interventions to tackle it. As indicated in the definitions, FLW occurs along the supply chain as food moves from the point of harvest to the point of consumption/utilization. Each node/stage in the supply chain accrues some loss/waste due to various causes which are interrelated. Actions (or lack of action) at one stage could drive losses/waste at a different stage or in the whole chain. Therefore, the food supply chain must be viewed as a conveyor belt with closely interrelated steps. Subsequently, FLW reduction interventions should be wholistic and not isolated to the apparent causes at a single stage (HLPE, 2014).

For a deeper understanding of the causes, various approaches have been used in the categorization. The simplest categorization being direct versus indirect causes of FLW. Direct causes refer to the factors that can be observed as leading to the food being lost or wasted. Direct causes can be attributed to actions (or lack of action) of individual actors at the stage where FLW occurs. Indirect causes are more systemic and concern the economic, cultural and the political environment of the food system under which the actors operate, and which may influence their decisions that lead to FLW (Delgado et al. 2021).

Causes of FLW can also be categorized into three levels as micro, meso and macro level causes depending on the level of control of the actors (HLPE, 2014). Micro-level causes refer to causes at each stage of the supply chain which result from actions (or lack of actions) by individual actors at that stage in their response to external factors. Meso-level causes refer to secondary or structural causes leading to FLW at the same stage or a different stage. Meso level causes relate to organization and relationships of actors in the chain, the state of infrastructure supporting the actors etc. The meso-level causes are often singled out as the ones driving losses at the micro-level. Macro-level causes are at a higher level and relate to systemic issues that drive FLW including lack or poor policies, dysfunctional food systems, poor institutional capacities, poor or lack of requisite investments. Macro-level causes drive losses at the meso and micro-levels as depicted in Fig 5.

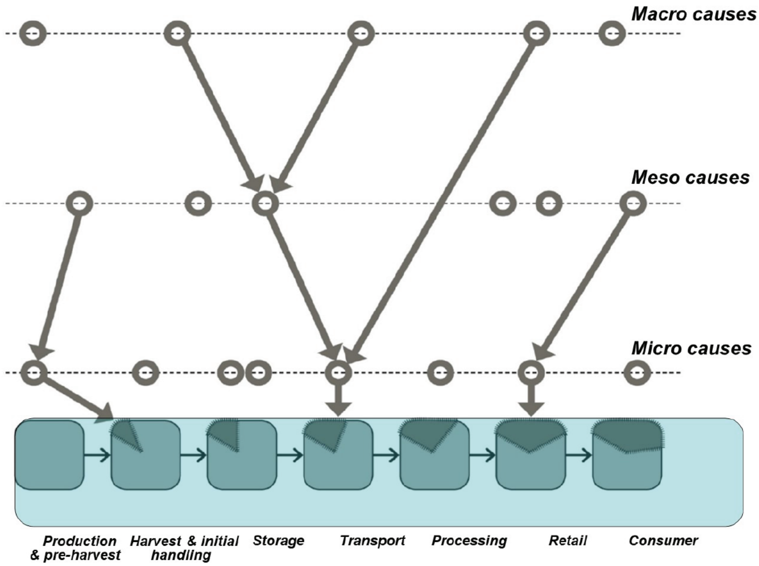


Fig. 5: *Depiction of micro-meso-macro level causes of FLW (HLPE,2014).*

1.4 THE IMPACT OF FOOD LOSS AND WASTE: SOCIAL, ECONOMIC AND ENVIRONMENTAL

The quote "We need to be reminded that food discarded is in a certain sense stolen from the table of poor and starving" by Pope Francis, captures the weight of the social impact of FLW. The fact that 1.3 billion MT of food can go to waste in a world where more 800 million people go hungry and more than 3 billion cannot afford a healthy diet should be an inditement of our conscience. It is estimated that the food that goes to waste could feed up to 2 billion people globally. Closer, home, according to the Global Hunger Index (2022), Kenya's score for hunger averaged 23.5 with the hunger situation categorized as 'serious'. This means that 20 – 30% Kenyans (about 14% of the population) experience significant food insecurity. At the same time, 30% of the food produced in Kenya goes to waste. By extrapolation, the food wasted in Kenya could feed close to 14 million hungry Kenyans.

There is an enormous economic value attached to FLW that is often overlooked. Lost food means lost income for all the actors involved. At the global level, the value of the food that goes to waste is estimated to be up to 1 trillion USD, annually! In SSA, the value of grains lost along the supply chain is estimated to be over USD 4 billion every year. This exceeds the value of grain imports into Africa every year and the total food aid received in SSA over the last decade. In Kenya, the value of FLW represents around 10% of the GDP. Overall, at the macro level, FLW contributes to unrealized economic efforts including returns on public investment in agriculture and infrastructure. As more resources are invested in fruitless efforts, less of the resources are available for other sectors. Therefore, reducing FLW has benefits for actors in the supply chain and society at large as available resources are used more efficiently.

The negative footprint of FLW on the environment can be categorized into three – the carbon, land and water footprints. The carbon footprint is the contribution of FLW to greenhouse gas emissions and is estimated to be 4.4 Gtonnes of carbon dioxide (CO_2) equivalent or 8-10% of the GHGs. The land footprint is attributed to the pressure on limited land resource with 1.4 billion hectares (30%) of arable land being used to produce food that is wasted. The water footprint refers to the pressure on water resources with 250 KM^3 of blue water used to produce food that goes to waste. In Kenya, the land footprint is estimated to be 15% (or 82,890 sq KM) used to produce food that goes to waste. Kenya's FLW carbon footprint is estimated to 21% of total greenhouse gases attributed to FLW (WRI, 2024).

A sustainable food system is one that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised (HLPE, 2014). Reducing postharvest losses is a critical component of sustainable food systems (Stathers et. al. 2020). Food losses and waste which speak to unsustainability of food systems have a negative impact food and nutrition security.

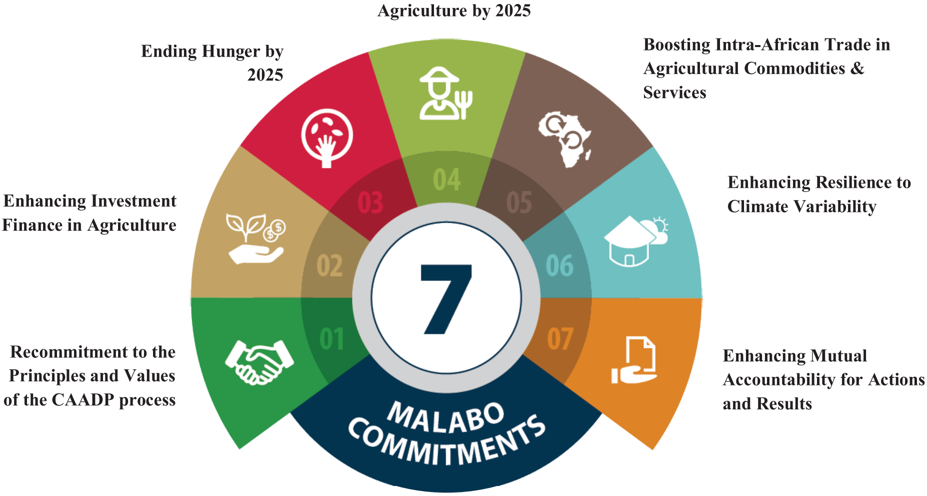
1.5. COMMITMENTS TO FOOD LOSS AND WASTE REDUCTION

1.5.1. Sustainable Development Goals (SDG 12.3)

Recognizing the urgent need to reduce FLW and measure progress, a target has been set under the United Nation's Sustainable Development Goal 12 on sustainable consumption. The third target SDG 12.3 it to 'halve per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains (including postharvest losses) by 2030'.
Many FLW reduction initiatives (public and private) have adopted the SDG 12.3 target as their guide.

15.2. Malabo 2014 Commitments

At the continental level, in June 2014 at the African Union Summit, African heads of state and government adopted the Malabo Declaration on 'Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods'. The 2014 Malabo Declaration has seven specific commitments to achieve accelerated agricultural growth and transformation for shared prosperity and improved livelihoods. These commitment areas are summarized in the figure below:



Among the seven commitment areas, the commitment area related to FLW reduction is 3 on ending hunger by 2025. The target to halve the 2014 levels of postharvest losses by 2025 is target 3 of this commitment area. The African governments were expected to cascade this commitment in the relevant programs. Subsequently, in Kenya, in the previous government, this commitment was anchored in the 'Big Four Agenda' under the Food Security and Nutrition pillar. A target was set to reduce postharvest losses from the estimated 30% to 15% by 2022.

So far, little progress has been made on the set targets at global, continental and national level.

1.6 GUIDES TO FOOD LOSS AND WASTE REDUCTION INITIATIVES

1.6.1 The Food Loss and Waste Hierarchy

Efforts towards FLW reduction are guided by the food loss and waste hierarchy also referred to as the food waste pyramid. The hierarchy provides a framework on priority and structured actions towards FLW reduction – from the best (most preferred) options to the worst (least preferred) options. It emphasizes prevention of FLW as the top priority, followed by minimization, valorisation and then recycling. Disposal of food into landfills is the least preferred option (Fig. 6).

Prevention: Prevention of FLW from occurring in the first place is the most effective and sustainable approach to tackle it. This entails addressing the causes/drivers of FLW at all stages of the supply chain.

Redistribution: This is an effort to minimize FLW by ensuring that food that would otherwise go to waste is eaten by humans, first and foremost. In this regard, surplus food from commercial food operations, including grocery retailers, restaurants, processors and other food handlers, and which is still fit for consumption, should be supplied to food banks and other charities who will then make it available to hungry people.

Valorisation and Recycling: When measures to prevent or minimize FLW cannot be effected, the next best option is extraction of the maximum good from the waste. This could be achieved through conversion of food waste into energy, composting into organic nutrient sources for the soil, use of the food waste for animal feed production, biochemical conversion into food/feed products or ingredients.

Disposal: All efforts must be made to ensure that landfills are the last destination for food. Even then, disposal should be done responsibly to minimize environmental impacts.

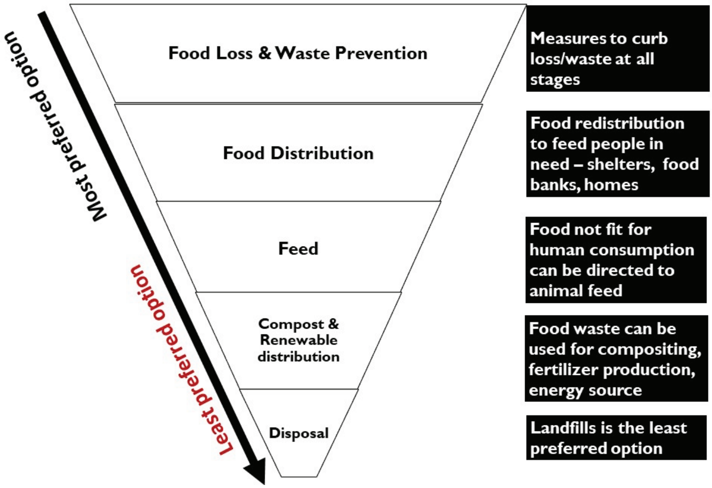


Fig. 6: *Food Loss and Waste Hierarchy (Pyramid)*

1.6.2 Categories of Food Loss and Waste Reduction Solutions

The complexity of causes and drivers of FLW calls for well-thought through interventions which can also be organized into levels. Some of the solutions are at the individual actor level (micro-level) while others (meso and macro level solutions) require action and coordination of all actors within the supply chain with support from other actors who may be external to the supply chain. According to HLPE (2014), FLW reduction solutions (at the three levels) can be loosely categorised as follows:

- Appropriate technologies/innovations
- Good practices
- Behavior changes
- Coordination inside value chains
- Valorization of food/ food byproducts
- Targeted investment
- Coordination of policies and action

Implementation of these interrelated solutions requires concerted and complementary efforts of all actors in the agri-food sector, individually and collectively.

1.7 A CALL TO ACTION FOR AGRI-FOOD SECTOR ACTORS

Reducing food loss and food waste is a shared responsibility from actors in the agri-food sector. The categories of actors include:

- Governments (national and sub-national)
- Private sector
- Civil society
- Development agencies
- Research and academic institutions*
- Consumers*

The responsibility of each of these categories of agri-food sector actors is spelt out very well in various publications/documents from the Food and Agriculture Organization of the United Nations (FAO). The short time provided for this inaugural lecture is not sufficient to delve into the role of each of the different categories of stakeholders. Therefore, I will focus my call to action to only two categories of the actors – consumer and researchers/academia. The focus on consumer is because all of us are consumers and have a responsibility to reduce our individual FLW footprint, especially with respect to food waste at the household. I will then spotlight the responsibility for researchers/academia because I am researcher and many listening to this inaugural lecture fall in this category.

1.7.1 A Call to Action for Consumers

All of us can take deliberate action to reduce our individual waste which is estimated to be 141 Kg per person per year. We can all set a target for food waste reduction based on our current food waste.

Fig. 7: *Food waste on the plate – a common site at social events where food is served in a buffet, at restaurants, in households*

At our individual level we can contribute to the bigger goal by taking the following small actions:

Change habits that encourage FLW

- Plan meals to avoid excess meal preparations
- Prepare a shopping list to avoid over shopping
- Manage your food stock in the house – watch out for expiry dates
- Donate surplus food to those who need it – directly or through established organizations or food banks

Reduce your plate waste

- Minimize wastage by serving smaller portions and top up only when necessary, especially at buffets
- At restaurants and eateries, ask for a 'doggy bag' to carry left overs that can be eaten later or fed to pets
- Re-use leftovers in new meal recipes

Raise awareness about FLW and lead by example

- Among peers, friends, family
- Join initiatives aimed at awareness creation
- Share stories of impact/achievement to inspire others

I would like to challenge each one of us to take stock of your current individual or household to food waste. Estimate the amount of food you waste individually or as a household per day, week, month or year. Thereafter set a target to reduce the wastage by a certain percentage within a specified period – targets create ambition. Motivate yourself (your household) to work towards the set target for food waste reduction by implementing some of the tips described above. Be sure to share your stories on impact/ achievement to inspire others to act.

1.7.2 A Call to Action for Researchers and Academia

Researchers have a critical role to play in the efforts to reduce FLW. The contribution of researchers can be summarized as follows:

Context-appropriate Research

- To identify food loss and food waste hotspots, the extent of losses and the causes/drivers of losses in various contexts
- To address FLW data gaps and provide the evidence required to track and advance progress towards FLW reduction

Develop practical solutions for FLW reduction in a sustainable manner

- Innovative technologies/processes for FLW prevention, redistribution, recycling and food waste management

Build the business cases for reducing FLW

- Quantify the potential benefits for food security, healthy diets and the planet
- Quantify the potential trade-offs

Generate the evidence required to influence policy towards FLW reduction

- Social impact, environmental and economic impact of FLW
- Impact of FLW reduction interventions – social, environmental and economic

Package and disseminate research fundings for various audiences and communication channels

- Scientific journals and conferences for researchers
- Translate research evidence for lay audiences and application of such research on FLW reduction - facts sheets, figures, infographics to promote better understanding

Capacity building and consumer education

- Develop and implement training programmes to enhance the capacities of varying stakeholder groups
- Guided by consumer behavior studies, develop targeted education and campaigns to reduce food waste among consumer

PART 2

FROM THE LAB TO THE LAND

CONTRIBUTION TO FOOD LOSS AND WASTE REDUCTION

As a researcher in the agri-food sector, my responsibility extends beyond academic achievement to include a commitment to societal transformation. The University of Nairobi's vision, "To be a globally competitive university transforming society," serves as a guiding principle for my work. In my research at the University, which I refer to as 'the Lab,' I am dedicated not only to achieving citation scores as expected of an academic but also to ensuring that my research contributes meaningfully to societal change. My focus is on bridging the gap between theoretical research and practical application, ultimately fostering transformation in the agri-food sector.

The complexity of the FLW problem requires a multi-disciplinary approach where natural and social scientists complement their knowledge and skills for better outcomes. Therefore, I lead a multi-disciplinary team, dubbed the University of Nairobi Postharvest Research Team. The team is composed of horticulturists, agronomists, food scientists, animal scientists, nutritionists and agricultural economists, drawn from the different departments at the Faculty of Agriculture. Our faculty-wide team is complemented by colleagues from the Faculty of Engineering, specifically from the Department of Environmental and Biosystems Engineering. The team members include academic staff, technical staff and graduate students (MSc and PhD).

In response to the urgent call for action on food loss and waste reduction, my team has concentrated their efforts on three key areas: adaptive research, capacity building, and community engagement/outreach. In the sub-section below, I endeavour to outline collaborative initiatives undertaken in the three areas.

2.1. ADAPTIVE RESEARCH

In response to the call for context-appropriate research on food loss and waste (FLW), our multi-disciplinary team has developed a range of innovative solutions. The innovative solutions described below address some of the main causes/drivers of FLW and offer practical solutions for sustainable reduction of FLW.

2.1.1. Innovative Cooling and Cold Storage Solutions

Poor cold chain management has been flagged as one of the drivers of food loss and waste in perishable food commodities such as fruits and vegetables. It is reported that the rate of deterioration of perishables increases two to three-fold with every 10^0 C increase in temperature (Kitinoja, 2013). Therefore, cold chain management entails maintaining low (safe) temperature during handling of the commodities right from harvest to the end user, is critical for the preservation of their quality and reducing postharvest losses. Fruit and vegetable production in Kenya is dominated by smallholder farmers, majority on less than 2 acres. For their scale of production, investment in high-tech cold storage and cold chain management solutions is not economical. These farmers require low-cost alternatives to the conventional cold storage and cooling solutions. Over the years, our team has conducted adaptive research that has yielded several off-grid and on-grid cold storage technologies described below.

- **The Coolbot Cold Room**

A Coolbot cold room is a walk-in cold room that serves as a low-cost alternative to a conventional cold room. It is made up of 3 main components: a compatible air conditioner, a Coolbot™ controller and an insulated room. The Coolbot™ is an electronic gadget which

Fig. 8: *A Coolbot Cold Room – with stored mango fruits*

upon connection to a compatible air conditioner (AC), it overrides the thermostat and causes the AC to achieve temperatures lower than the set temperatures (about 16^{0}C). The Coolbot™ is an innovation by a smallholder farmer in the USA, Ron Khosla, the founder of StoreitCold Ltd. Through the USAID's Feed-the-Future Program, the Kenya Innovation Engine and in partnership with the Horticulture Innovation Lab at University of California, Davis, our team introduced the Coolbot technology to Kenya. Working with Kawala Horticultural Farmers in Makueni County, the first Coolbot Cold Room was installed in 2014. Locally available materials were used to fabricate the insulated room, which was then fitted with a locally available AC, compatible with the Coolbot. Subsequently, on-farm studies were conducted to evaluate the efficiency of the Coolbot cold room to preserve quality and extend the shelf life of mango fruits (Ambuko et.al 2018; Ambuko et. al 2018b). In addition, several conference presentations and TEDex talk (https://www.youtube.com/watch?v=z3qjxc4_ fNA&ab_channel=TEDxTalks) contributed to the dissemination and awareness creation about the Coolbot technology. We used these opportunities to not only create awareness about the Coolbot technology but also highlight challenges and opportunities, especially in smallholder horticulture. The publicity and awareness created led to additional funding from NRF-Kenya to scale up the technology and establish a demonstration unit for potential users of the technology.

While working with the smallholder farmers in Makueni County, we realized that reliable electricity was a major challenge in rural areas where most of the horticultural production occurs. With the regular power outages, the benefits of the on-grid Coolbot Cold Room were reduced because the power outage would result in higher postharvest losses for the farmers. The situation took our research team back to the drawing board. We needed to explore off-grid alternatives for cooling as an option for rural farmers without electricity or where electricity is unreliable. This led the team to explore evaporative cooling technologies as an off-grid alternative.

- **Evaporative Cooling Technologies**

Evaporative cooling is an old and time-tested method for temperature regulation, leveraging the physical process of water evaporation. When water evaporates, it absorbs a significant amount of heat from its surroundings. This process requires 2,260 kJ of energy per kilogram of water, known as the latent heat of vaporization. This substantial heat absorption during evaporation makes evaporative cooling an effective cooling method. In evaporative cooling systems, water is held in an inert, porous medium. This medium can be charcoal, sand, or other materials with high water retention capacity. When dry or hot air passes over or through this wetted medium, the water evaporates, absorbing heat from the air and thereby cooling it. The overall effect is cool and humid air inside the chamber as depicted in figure 9.

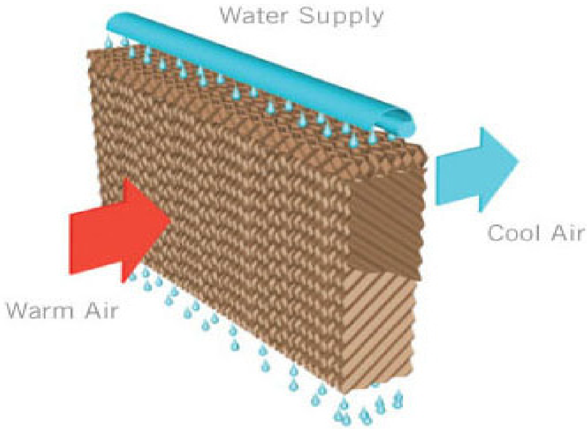


Fig.9: *The working principle in evaporative cooling*

The Biosystems engineers in our team have led us to fabricate and validate three types of evaporative cooling technologies which are briefly described below.

- **Zero-energy Brick Cooler (ZEBC)**

This evaporative cooling option which is also referred to as the zero-energy cool chamber (ZECC) is an innovation first developed in India in early 1980 and tested in various commodities (Roy and Pal, 1980). It was developed as a low-cost solution to reduce postharvest losses in fruits and vegetables especially in rural areas in India where electricity was a challenge. The original design is made up of a double brick wall structure covered with a straw mat (Fig.10).

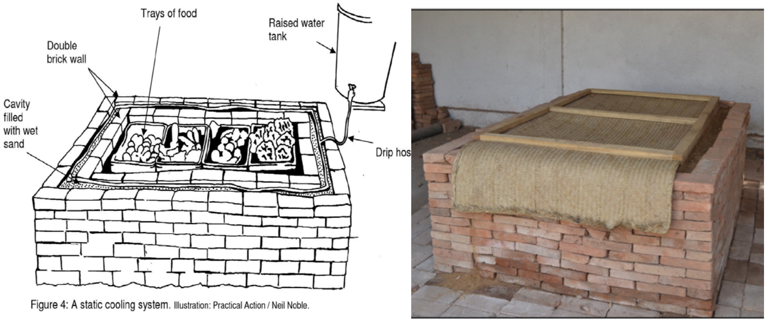


***Fig. 10:** The original zero energy cooling chamber developed in India – made of brick walls and a cover made from dry grass and wood*

Our team first introduced the ZECC to Kenya in 2015. We renamed it zero energy brick cooler (ZEBC) to distinguish from other forms of evaporative cooling. Initial adaptive research on the ZEBC were conducted on-station at the Upper Kabete Campus Field Station in 2015. The ZEBC was fabricated from locally available materials including locally sourced earthen bricks, riverbed sand, sisal sacks, sisal waste, fiber board, water tank, and water drip lines. The bricks were arranged to make a double wall measuring 220 × 200 cm and 60 cm high with riverbed sand sandwiched between the two walls. Water in the sand was replenished through a drip line connected to a water reservoir. The top cover of the ZEBC was made from fibreboard and sisal gunny bags stuffed with sisal waste.

On-station studies were conducted to establish the effectiveness of the ZEBC. The studies showed that the ZEBC could achieve a temperature difference that ranged between 10^{0}C and 100^{0}C depending on the ambient air temperature. In addition, the relative humidity inside the ZEBC was near saturation (95 – 99%). The cooler temperature and high relative humidity inside the chamber were shown to be effective in preserving the quality of the stored Amaranthus vegetables. Storage in the ZEBC extended the shelf life of Amaranth vegetables by 5 days compared to the vegetables that were stored at ambient room conditions (Ambuko et. al. 2017). These findings enabled the project team to promote the ZEBC as a simple, cheap and effective cooling options for smallholder farmers, especially in hot and dry areas.

The performance of the first generation ZEBC and feedback from the users challenged our team to improve the original structure. The wooden frame was prone to rotting and attack by termites. Therefore, in the second generation ZEBC, the wooden frame was replaced with galvanized aluminium to address the challenge of termite attack and rotting.

Fig. 11: *The 1st and 2nd generation ZEBC at the Upper Kabete Campus Field Station*

The 2nd generation ZEBC was scaled-up through a research for development project under the Rockefeller Foundation's YieldWise initiative, 2016 – 2018. On-farm studies were conducted with the Karurumo smallholder horticultural farmers to validate the 2nd generation ZEBC and complementary technologies (Amwoka et al. 2021; Amwoka et al. 2022).

Further feedback from the users of the 2nd generation ZEBC led to development of the 3rd generation ZEBC referred to as the Improved Zero Energy Brick Cooler. The Improved ZEBC is registered for protection as a utility model developed by our team (KE/UM/2020/1454). Features of the improved ZEBC include the special bricks with a cavity to hold sand, replacing the double wall of bricks used in the original design. The improved version is also reinforced with steel rods that ensure long-term stability of the structure. This was necessitated by the fact that the bricks used to build the ZEBC are simply interlocked with no cement to hold them in place. With continued pressure from bulging sand, because of constant wetting, there was a tendency for the bricks to bulge out of frame. Ultimately, the ZEBC structure would fall apart, unless the bricks were forced back. The reinforced ZEBC can remain stable and in good shape for long with little maintenance compared to the original ZEBC and 2nd generation ZEBC.

Fig. 12: *The 3rd generation Improved ZEBC at the Cold Storage Technologies Demonstration Hub*

Through a community engagement project supported by the World Food Program (WFP), our team introduced the 3rd generation ZEBC to small-scale traders in Kalobeyei Market, Turkana County.

Feedback from users regarding the size led the project team to rethink the size of the ZEBC. Subsequently, a resized ZEBC was conceptualized as part of research for a Master of Science degree in Biosystems Engineering. The ingenuity of the engineers yielded a brand-new innovation, the resized ZEBC, the first of its kind in Kenya (and globally). The resized ZEBC measuring 4 M x 4 M and 2 M high is a walk-in chamber with a larger storage capacity compared to the standard ZEBC. It is fitted with solar powered micro-fans to improve air circulation and can therefore achieve better cooling efficiency than the standard ZEBC. There are ongoing studies to compare the efficiency to preserve quality and extend the shelf life of various fruits and vegetables.

Fig. 13: *The Resized ZEBC – under construction and the finished product at Cold Storage Tech Hub*

- **Evaporative Charcoal Cooler (ECC)**

The charcoal cooler is perhaps the most familiar and widely adopted evaporative cooling technology in Kenya. The medium that holds water for evaporative cooling in this case is charcoal. In the typical design, the charcoal is sandwiched between chicken wire and wooden frames used to hold the structure in place (Fig. 14).

As already described in the ZEBC, the wooden frame is prone to termite attack and rotting. To address this challenge, the research team came up with an improved modular design (2nd generation) whose frames are made from galvanized aluminium. In addition, the rust prone chicken wire was replaced with expanded mesh made from galvanized aluminium. Modularity of the design makes it possible for the improved charcoal cooler to be resized to a larger or smaller size according to the needs of the users.

Fig. 14: *The original charcoal with a wooden frame and the improved version with galvanized aluminium frame*

Feasibility studies aimed at introducing the charcoal cooler to Northeastern Kenya, a region that experiences extreme climatic conditions informed the need for a structure that can withstand extreme weather. The improved charcoal (3rd generation) is reinforced with fibreglass which encases the expanded aluminium mess that is filled with charcoal (Fig. 15). Fibreglass not only enhances durability but gives the charcoal cooler a finer finish and is easy to maintain and clean.

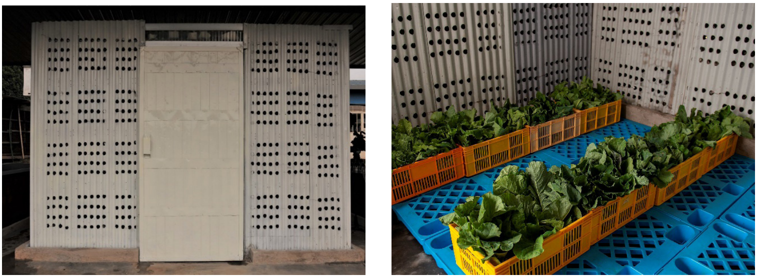


Fig. 15: *The improved charcoal cooler with fibreglass encasing – the appearance outside and inside*

The Refrigerated Box on Wheel

Cold chain management entails handling of harvested produce at low (but safe) temperatures from harvest to the point of utilization. There has been great emphasis on cold storage and the complementary cold chain management at the farm level. However, during transportation of the perishable produce from the farm to the target market, the cold chain is broken. In most cases, the produce for domestic market is transported in open tracks, pick-up, lorries, passenger vehicles, motorbikes and other means with no temperature control thereby making on-farm cold storage a zero-some effort. This scenario necessitated research to find low-cost alternatives to the conventional refrigerated tracks associated with fresh produce destined for export market. Such tracks require colossal investment and are generally beyond reach for most small-scale practitioners in the domestic market.

The idea of the refrigerated box on wheels was conceptualized through a partnership between Brunel University (UK) and Phase Change Materials Limited (PCM Ltd) under the SolCool Project supported by United Kingdom Research and Innovation (UKRI).

The refrigerated box combines the use of solar panels and phase change materials (PCMs) to harness, store energy and release thermal energy. PCMs store and release thermal energy during the processes of melting and freezing. The refrigerated box features an inbuilt battery that serves as reserve for solar energy and recharges the system to ensure continued cooling at the right temperatures during transit. The unit can achieve temperatures as low as 0^0c and below. The refrigerated box which was developed on pilot scale can accommodate 10 bread crates of fresh produce and can be pulled by an average capacity vehicle. The unit can be used for high value produce that is prone to fast deterioration due to breaks in the cold chain from the farm to market. Although the concept was never out to test because of premature termination of the project during the COVID period, the idea/concept remains viable and ready for validation.

Fig. 16: *A refrigerated box on wheels – a possible low-cost alternative to refrigerated tracks*

Fig. 17: *The cold storage technologies hub at Upper Kabete Campus – used for research, training and demonstration*

All these cold storage and cooling solutions described in section 2.1.1. can be found at our research, training and demonstration Hub located at the Upper Kabete Campus Field Station. The Hub has been effective in promoting and showcasing innovative technologies and practices for cold storage. It has hosted many benchmarking delegations from within and outside Kenya who come to not only see the technologies in practise but also take stock of lessons learnt to improve their own adoption process. Some of the external delegations that visited the Hub including the HortiFuture Project team from Jordan and Muni University Research team from Uganda have since adopted the Coolbot Technology in their countries.

2.1.2. Complementary Shelf-life Extension Technologies for Fresh Produce

To complement the cold storage and cooling solutions discussed in section 2.1.1, our team has conducted extensive research on other postharvest technologies for shelf-life extension in fresh produce. Some of the adaptive research studies have been conducted in partnership with private sector companies or the technology developers/innovators. Examples of these innovative technologies for shelf-life extension in fruits and vegetables are described below.

- **1-Methylcyclopropene (1-MCP)**

Ripening of climacteric fruits is characterized by an increase in ethylene production which is associated with desirable and undesirable changes. Elevated ethylene production leads to increased ripening rate associated with reduced shelf life and marketing period (Satekge and Magwaza (2022). It is therefore important to take control of ethylene in postharvest handling of climacteric fruits to extent their shelf life and maintain quality. 1-methylcyclopropene (1-MCP) is an innovation that has been used widely to extend the shelf life of horticultural produce. The beneficial effects of 1-MCP have been reported in various fruits (Blankenship and Dole, 2003; Watkins, 2006). Our team has conducted studies to validate application of 1-MCP in various fruits including mango fruits (Githiga et. al. 2014) and passion fruits (Ambuko et. al. 2014). In a recent partnership with AGROFRESH Ltd, the mother company that developed 1-MCP, our team has optimized the dosing range for various 1-MCP formulations in mango fruits (Chomba et. al. 2024) and avocado fruits (Ademba et. al 2024). The team has also conducted studies on 1-MCP application in tomatoes and banana fruits.

- **Hexanal**

Hexanal is volatile aldehyde which occurs naturally in plants. It is known to inhibit action of enzymes such as lipases and lipoxygenases which catalyse the degradation of cell membranes leading to softening and subsequent deterioration of fruits and vegetables after harvest. Through collaborative research between our research team and Guelph University in Canada, the effective dosing range for hexanal has been established in banana (Yumbya et al. 2018; Hutchinson et. al. 2022) and papaya (Hutchinson et al. 2018).

- **Modified Atmosphere Packaging (MAP)**

Modified Atmosphere Packaging (MAP) entails alteration of the gas composition of the air surrounding packaged food commodities. Typically, oxygen (O_2) levels are reduced to levels below the atmospheric level (21%) while carbon dioxide (CO_2) levels are increased within the package. The final gas composition depends on commodity and the type of materials used for MAP. The altered gas composition (low O_2 and high CO_2) slows down metabolic and physiological processes that require O_2 and/or are inhibited by high CO_2. The packaging also creates a barrier to moisture exchange. Subsequently, if the choice of the packaging material is well matched with the physiology and properties of the packaged commodity, MAP can significantly extend the shelf life. Generally, MAP works best under appropriate cold storage conditions, thereby achieving better results compared to either technology alone. Our team has conducted extensive research to demonstrate the beneficial effects of various MAP products such as Extend® and Activebag®. The achievable shelf-life under various storage conditions has been established for various fruits and vegetables including mango (Githiga et al. 2014; Ambuko et al. 2018), passion fruits (Owino et. al. 2016; Yumbya et al. 2014), kales (Kathambi et. al. 2022) and black nightshades (Kathambi, 2024).

- **Mango Wax**

Application of wax or edible coating on harvested produce, is an eco-friendly solution for postharvest quality preservation in fruits and vegetables (Fawole, 2023). The coatings form a barrier to water, gas and microorganisms. The coating therefore reduces moisture loss, controls gas exchange and microbial contamination. Therefore, the waxed/coated produce maintain their firmness and remain fresh for long (Fig 16). Our research team has conducted research on a special wax (mango wax), developed by UPL especially for commercial use in mango fruits. Our team has elucidated the effectiveness of mango wax to extend the shelf life of apple mango fruits under different storage conditions (Maina et. al. 2020).

Fig. 18: *Unwaxed versus waxed mango fruits – 'apple mango' variety*

2.1.3. Small-scale Processing Technologies and Innovative Products from Fruits and Vegetables

Perishability of fruits and vegetables predisposes them to high postharvest losses after harvest. The losses are aggravated by seasonality of these commodities with the surplus during peak seasons contributing to high losses. Simple processing technologies can be applied to transform perishable fruits and vegetables into shelf-stable products thereby reducing postharvest losses during the peak season. To support small-scale processors of fruits and vegetables, our team has conducted research to optimise parameters for processing of various products from fruits and vegetables. Examples of innovative products where wet processing parameters have been optimised through research include mango nectar, mango wine, mango-enriched yoghurt, moringa-enriched mango juice, mango jam and mango chutney. Our team has also optimized dry processing parameters for mango chips, mango flakes and mango rolls (Nyangena et. al 2020; Jumbale et al. 2023; Sikwaya et al. 2023). In addition, drying parameters for selected vegetables (tomato, kales, cowpeas, black nightshades) have been optimized (Kirakou et al. 2017; Mbondo et al. 2018; Gitau et al. 2022). The comparative advantage of different drying technologies including Tunner Solar Dryer(Fig. 19), Dehytray (Fig.20) Dehytray (Fig.17) and Open-air drying for selected vegetables has been documented (Wambui et al, 2023).

From the adaptive research, the challenges and opportunities in small-scale processing of fruits and vegetables as an intervention for food loss and waste reduction have also been documented (Owino and Ambuko, 2021; Ambuko and Owino, 2023)

Fig. 19: *Tunnel Solar Dryer - loaded with mango chips*

Fig. 20: *Dehytray™ - loaded with tomato slices and blanched leafy vegetables*

2.1.4. Valorisation of waste from mango processing

Processing of fruits and vegetables generate a significant amount of waste, mostly from the non-edible parts. For example, in mango the seed and the peel which constitute 15 – 30% and 5 – 15% of the whole fruit respectively are discarded during processing. If the processing waste is not put to good use, it ends up in the landfills resulting in a negative footprint on the environment. To address this challenge, our team has explored the use of the waste from mango processing to develop diets for layer and broiler chicken, from the peel and seed respectively. The dried waste has been used to supplement maize in well-calculated and optimized ratios that do not compromise productivity and quality of the chicken meat and eggs. The research revealed that in fact inclusion of the dried peel into the layer diets can significantly improve the egg quality (Nawiri et. al. 2024). Similarly, inclusion of the dried mango seed into broiler chicken diet resulted in improved quality parameters of the carcass (Jepkurui et. al. 2023)

2.2. CAPACITY BUILDING INITIATIVES

2.2.1. Future Researchers in Postharvest Management

The research activities described in 2.1. have involved training and building capacity of approximately 40 MSc and 7 PhD students (completed) and 30 more graduate students ongoing at different stages of their research. The students have worked alongside established researchers (mentors) in multi-disciplinary research projects that cut across horticulture, agronomy, food science and nutrition, agricultural economics and agricultural/biosystems engineering. This has enabled the students to cross-learn and expand their knowledge beyond their specific disciplines. The graduates thereof are well equipped with theoretic and practical skills through hands-on experiential learning and community engagement activities. Upon completion of their degree programs, some of the graduates have proceeded to pursue careers in academia at local or international universities. Others are currently leading research teams in their own institutions while others (MSc) have proceeded to enrol in PhD programs locally and internationally. Therefore, we have contributed significantly to growing the requisite critical mass of experts with the knowledge and skills required to address FLW in horticultural and other value chains.

2.2.2. Food Supply Chain Practitioners

Some studies have cited poor postharvest handling practices as one of the major factors that contribute to high postharvest losses in perishable commodities. Therefore, capacity building of food supply chain practitioners on good harvest and postharvest handling practices is an important component in food loss and waste reduction initiatives. Over the years our team has conducted tailor-made training for various actors in the agri-food sector including producer/farmers, aggregators, transporters and traders. The cold storage technologies demonstration and training Hub established through funding from the National Research Fund (NRF-Kenya) has been used for hands-on practical training sessions for practitioners in horticultural value chains. The Food processing hub which was established with support from the Rockefeller Foundation has not only been used to build capacity of processors but also serves as an incubator to entrepreneurs in food processing.

Besides the food supply chain practitioners in Kenya, our team trained over 70 food supply chain practitioners from 11 countries across Africa and beyond. This was made possible through the CABSFOODS (Capacity Building in Food security for Africa) project funded by the United Kingdom Research & Innovation (UKRI).

2.2.3. Extension Officers – County Focal Persons for Postharvest Management

The Food and Agriculture Organization of the United Nations (FAO) recently supported our team to train focal persons for postharvest management in all the 47 Counties in Kenya. This initiative is aimed at addressing capacity gaps on FLW interventions and reporting. It is one of the key interventions to address FLW data gaps as highlighted in Kenya's national strategy for postharvest management towards FLW reduction. The focal persons were equipped theoretic and practical skills in postharvest management towards FLW reduction. They have been tasked with providing leadership and guidance in FLW reduction and related programs in their respective counties. They will also report on FLW initiatives and data to the national focal person for FLW reduction at the MOALD. It is expected that with the County focal persons, there will be better coordination and reporting on FLW reduction activities at the County and National level to help address the FLW data gaps.

2.3. COMMUNITY ENGAGEMENT AND OUTREACH INITIATIVES

Researchers/academia in our team have endeavoured to debunk the myth about 'academia living in ivory towers'. Each of the innovative solutions for FLW reduction that have been described in section 2.1 have been inspired by real challenges facing practitioners in the agri-food sector. The team has adopted the 'Hub and Spoke model' to scale up innovations from research (the lab), hence the phrase 'from the lab to the land'. The University serves as the Hub where innovations are created and/or refined while the end users (including farmers, farmer groups, traders, processors and entrepreneurs) are the spokes. The spokes are centres where other practitioners can see and learn from those who have adopted various innovations and practices from research at the Hub. In a reiterative manner, the Hub works with the spokes to identify challenges that face practitioners in the food supply chains and then develop innovative solutions through research. The sub-sections below describe examples of the spokes that have benefited from our community engagement initiatives.

2.3.1. Kawala Small-scale Horticultural Farmer's Group

This group was our multi-disciplinary team's first community engagement. They were the first beneficiaries of Coolbot Cold Room which was fabricated onsite in 2010 https://2012-2017.usaid.gov/news-information/frontlines/grand-challenges/kenyas-crop-innovators-moving-needle-food-security The group has over 100 members of all genders and age. They mainly produce mango fruits for the domestic market with a small percentage being exported. The Coolbot cold room served to help the group members to aggregate their produce for better market access. After installation of the Coolbot, the group has benefited from other programs from various development partners. The group's chairlady, Mrs Teresia Benjamin is 'star farmer' who has been featured in various programs including Shamba Shape-Up on citizen TV.

2.3.2. Karurumo Horticulture Self-help Group

Through the YieldWise Initiative supported by the Rockefeller Foundation, this self-help group was the first real showcase of the concept of 'From the Lab to the Land'. Through this community engagement, we tested the concept of zero-loss centers for food loss and waste reduction in the mango value chain, as envisioned under the Yieldwise initiative. The group benefited from evaporative coolers (zero energy brick cooler and charcoal cooler); the Coolbot™ cold room, small-scale juice processing line, Tunnel solar dryer and produce preparation area (for sorting, grading, washing and packaging). The Karurumo aggregation and processing center was officially launched by the County governor, Hon. Martin Wambora in 2017.

Fig. 21: *Commissioning of the zero-energy brick cooler, the small-scale juice processing line and the Tunnel solar dryer at the Karurumo Center in 2017 by the governor of Embu County, Hon. Martin Wambora*

In partnership with Technoserve Kenya, the group members received training on good production and orchard management practices to ensure high quality fruits at the time of harvest. The members were also trained on good harvest and postharvest handling practices to minimize on-farm losses. They have received training on small-scale processing of various products from fruits and vegetables. Our team has helped the group to receive KEBS (Kenya Bureau of Standards) certification for some of their products.

It was envisaged that all the fruits (or other fresh produce) that was delivered to the center would be put into use and that none would end up in land fills hence the name ‘zero loss center’ (Ambuko 2020; Ambuko et al. 2022; https://www.businessdailyafrica.com/bd/corporate/enterprise/embu-fruit-farmers-reap-big-from-value-addition-plan-2198184

In a bid to create a ready market for the group’s products, our team had engaged Embu County government with a proposal to contract the group to supply read-made mango juice for Embu schools. The idea is to pilot the program in selected early childhood development (ECD) schools in Embu County as part of the County’s school feeding program. Lessons from the pilot would be used to scale-up the program in other ECD schools and possibly to primary schools in the County. Such an initiative would not only create a ready market for mango processors in the County but also improve nutrition in school meals. Our study in a separate project revealed that most government-sponsored school meals (for day scholars), mostly contain maize and beans (githeri). Most schools cannot afford fruits and vegetables as part of the meal provided to learners. Therefore, inclusion of nutritious mango juice would help to enrich the meals for learners and contribute to better nutrition outcomes for the County.

2.3.3. Masii Horticulture Cooperative Society

This group was the second beneficiary from the Yieldwise Initiative. Their main commodity is mango, but they also produce citrus, avocado and papaya. Since the group’s premises did not have electricity, we used them to showcase options for smallholder farmers in rural areas without electricity. The group benefited from off-grid cooling technologies (the charcoal cooler and zero energy brick cooler) and a Tunnel solar drier. The group has been successful in aggregating fresh produce (mainly mango) for local and export markets.

Fig. 22: *The zero-energy brick cooler and the Tunnel solar dryer at the Masii Horticultural Cooperative*

2.3.4. Jitahidi Farmers Women Group

This progressive group is engaged in various agribusiness activities including production and value addition of horticultural commodities such as banana and African Leafy Vegetables. They are beneficiaries of a technology scale up project funded by the National Research Fund (NRF-Kenya). Our team installed a zero-energy brick cooler (ZEBC) to help them to aggregate their produce for the market. The ZEBC has been complemented by a charcoal cooler installed under the National Agricultural and Rural Inclusive Growth Project (NAGRIP), implemented by KALRO and Egerton University.

Fig. 23: *The zero-energy brick cooler at the Jitahidi group premises; a capacity building session in progress*

2.3.5. Kisumu Young Agriprenuers (KIYA)

This is a group of approximately 300 ambitious young farmers who are mainly engaged in vegetable farming as a business. Our team has been linked to them through a project that is supported by FAO. Our team recently installed a charcoal cooler for the group to help them aggregate their produce (mainly vegetables) for better market access. The long-term plan is to link them to diverse market beyond Kisumu with the goal of enhancing profitability of their farming business. Through the project, the group has also benefited from a training on postharvest handling of vegetables to reduce FLW.

Fig. 24: *The newly installed charcoal cooler for Kisumu Young Agriprenuers in Kisumu County*

2.3.6. Small-holder Farmers in Kisii and Kakamega Counties

In a new collaborative project with KALRO and the North Carolina State University which is by USAID through the Feed-the-Future Innovation Lab for Horticulture at UC, Davis, our team will engage with small-holder farmers of African Indigenous Vegetables (AIVs) in Kakamega and Kisii Counties. Our team is in the process of installing a charcoal cooler for the group in Kakamega to complement a solar-powered cold room that will be installed under this project. Both groups are expected to use the cold-storage facilities to aggregate their AIVs for better market access. The groups will be linked to profitable market outlets within and outside their Counties.

2.3.7. Small-scale traders in Turkana, Wajir and Marsabit Counties

In partnership with the World Food Program (WFP), our team has introduced the evaporative cooling technologies to traders in the hot and dry Counties of Turkana, Wajir and Marsabit. Introduction of cold storage and/cooling facilities at the market is important especially for small-scale traders. It is expected that with cold storage at the market, the small-scale traders will not only save the time that is spent on daily sourcing logistics but will store fresh produce that is not sold at the end of each trading trade for later sales thereby reducing food waste at the market.

Fig. 25: *Zero energy brick cooler and charcoal cooler at Kalobeyei Market in Turkana County*

2.3.8. Fresh Produce Aggregation and Distribution Hub

Research has shown that one of the key drivers of FLW in fruits and vegetables is poor market linkages. Because of the scale of production and poor market information, most rural farmers are at the mercies of middlemen and brokers. The brokers source from individual farmers often at very low prices, making farming unprofitable for many. In bid to address this challenge, the concept of on-farm aggregation by smallholder farmers who organized in groups was tested under the Yieldwise project. While on-farm aggregation was possible, linkage to profitable market became a challenge because most traders were not willing to pay for the value added through aggregation. To address this challenge, the idea of an Urban Aggregation and Distribution Hub was conceptualized by our team. The idea recently came to fruition through an Academia-Industry partnership between University of Nairobi and Mabati Rolling Mills. The Hub established through this partnership seeks to establish market linkages for smallholder farmers. Through the Hub, smallholder horticultural farmers will be connected to various market outlets including supermarkets and other outlets. There is also great potential for export market destinations for selected horticultural produce.

Fig. 26: *The Urban Aggregation and Distribution Hub at the Upper Kabete Campus Field Station*

The concept is in its initial phase on a pilot scale targeting smallholder farmers of African Indigenous Vegetables (AIVs). The first beneficiaries are the AIVs farmers Kakamega and Kisii Counties through the KALRO-led project. Under the project, the smallholder farmers will be trained on good production practices, postharvest handling and linked to markets to enhance profitability and reduce losses. Also set to benefit from this market linkage initiative is the Kisumu Young Agriprenuers (KIYA).

2.4. AWARENESS CREATION AND DISSEMINATION PLATFORMS

Lack of awareness has been singled out as reason why we continue to lose and waste large volumes of food. Awareness about the extent, the causes and the negative impact of FLW on food security and the environment is a key step in the efforts to address the problem. In addition, many of the practitioners in the food supply chain are not well-informed about the available solutions or interventions for FLW reduction. To address the awareness gap, our team has been at the forefront of organizing various platforms for awareness creation on FLW and the dissemination of knowledge and innovative solutions for FLW reduction. Some of the platforms where our team has contributed significantly are described below.

2.4.1. The All-Africa Postharvest Congress and Exhibition (AAPHCE)

The idea of the AAPHCE was conceptualized during the 1st International Conference for Postharvest Management in Rome, Italy in 2015. During the conference, the delegates from Africa felt the need to cascade the conference back to Africa where the problems and solutions that were being discussed in the Rome conference had direct relevance. Subsequently, a multi-stakeholder consortium with representation from local and international institutions spearheaded the organization of the 1st AAPHCE.

Fig. 27: *Images from the 1st AAPHCE at Safari Park Hotel, Nairobi, Kenya and the 2nd AAPHCE at the African Union Headquarters in Addis Ababa, Ethiopia*

The event was co-convened by the University of Nairobi and the World Food Preservation Center. The event was supported by various development partners led by the Rockefeller Foundation as the strategic partner. After a successful convening in Kenya in 2017, there was a call to expand the reach and make the AAPHCE a biennial pan-African convening that would serve as a platform for African Countries to showcase FLW reduction initiatives in their efforts to achieve the set targets under the Malabo 2014 declaration and in line with SDG12.3. During the 2nd AAPHCE, the University of Nairobi handed over the convening of the AAPHCE to the African Union Commission (AUC). The AUC has continued to convene the AAPHCE, including the 3rd AAPHCE (2021) and the 4th AAPHE (2023). The AUC team has been supported by a multi-institutional and international technical committee drawn from research, academic and development institutions in Africa and beyond. The AAPHCE has served as an important platform for knowledge sharing, showcasing innovative solutions and strengthening of partnerships in the efforts to reduce FLW in the African context.

2.4.2. The International Day of Awareness of Food Loss and Waste (IDAFLW)

The International Day of Awareness of Food Loss and Waste (IDAFLW) was designated by the 74th United Nations General Assembly. The designation was in recognition of the fundamental role that sustainable food production and consumption (SDG 12) plays in promoting food security and nutrition. Subsequently, a target has been set to halve the per capita global food waste at the retail and consumer level and reduce post-harvest losses along the food supply chain by 2030 (SDG 12.3). The IDAFLW which is marked annually on 29th September serves to raise awareness about FLW and its negative impact on the people and the planet. The IDAFLW provides an opportunity to call to action all actors in the agri-food sector (public and private) to prioritise action to reduce food loss and waste towards restoring and building back better and resilient food systems.

In response to this call, our team has convened and coordinated the national IDAFLW observance platforms in partnership with other stakeholders with an interest in FLW reduction. In 2020, 2021 and 2022, the convening was online because of the Covid-19 related restrictions. In 2023, the University of Nairobi hosted an impactful physical convening for IDAFLW at Taifa Hall. The event featured various activities to raises awareness about FLW including themed skits, radio and TV talk shows, exhibitions and expert presentations. The event also featured cooking demonstrations on how to re-use left over food that would otherwise end up in the dustbins and ultimately the landfills https://www.youtube.com/live/T_xDC9YL31M?app=desktop&feature=share

Fig. 28: *Publicity Poster for the IDAFLW 2024 which was organized by various partners in Kenya's agri-food sector who have an interest in FLW Reduction*

The University of Nairobi continues to spearhead observance of IDAFLW in partnership with other partners and stakeholders in the agri-food sector. This inaugural lecture is part of the awareness creation about FLW in the lead up to the IDAFLW 2024 on 29th September.

2.4.3. Other awareness creation and dissemination platforms

Our team also co-organizes and participates in several local and international convenings where they share knowledge and show-case solutions for FLW reduction. Examples of these include the Nairobi Innovation Week (hosted by University of Nairobi), The University of Nairobi Research Week, the Annual Fruits, Vegetables, Herbs and Spices Conference, which is spearheaded by the Horticulture Industry actors, the All-Africa Horticultural Congress (AAHC) among others. Apart from exhibition of our innovations as these events, our team has presented over 140 peer-reviewed papers in local and international conference. In addition, more than 30 expert presentations from our research and development activities have been delivered at non-academic stakeholder convenings.

In a bid to reach the non-academic public, our research has been demystified and published in industry magazines and daily newspapers. We have participated in TV productions aimed at educating the public on innovative solutions for FLW reduction. Examples of this include Shamba-Shape Up (Citizen TV) https://shambashapeup.com/series/season-10/ep-24-post-harvest-losses-cattle-production-electric-pressure-cooker/, Smart Farm (Citizen TV), Food Friday (NTV), Farmer TV, KTN morning show/spice FM. Our work has also been featured on international TV, CNN (Market Place Africa) https://www.cnn.com/videos/business/2021/03/18/marketplace-africa-kenya-informal-produce-sector-cold-chain-spc.cnn and the Inquiry on BBC https://www.bbc.co.uk/programmes/w3csytfv

In 2016, I was invited to do a TEDx talk focusing on the Coolbot technology https://www.youtube.com/watch?v=z3qjxc4_fNA&ab_channel=TEDxTalks

In partnership with Wageningen University and Research (WUR), we produced an educative documentary on Postharvest Losses in Mango – the causes, extent, impact and solutions https://youtu.be/Zk_624eEwVA?si=8b3UxcOTBMH3nAej

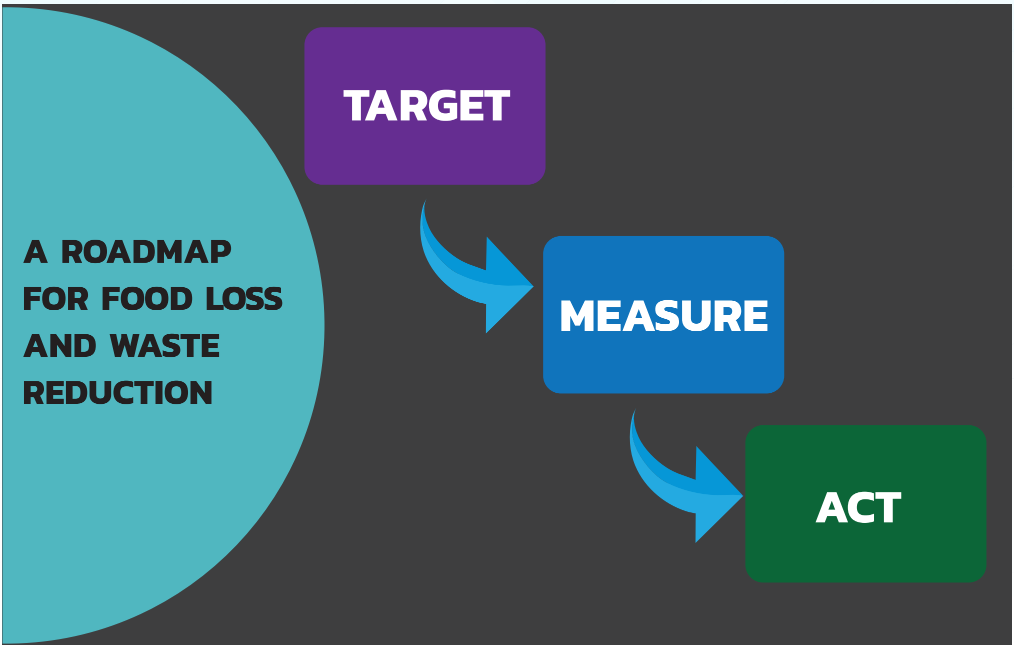
A feature interview by the University of Nairobi's UNCTV spotlighting Women in Research has also featured our work on FLW reduction https://youtu.be/r_Tb-QdSrLQ?si=pSb8PqJHvAibk-DJ.

A short video prepared during the practical training under the CABSFOODS Project titled 'Virtual Training on Postharvest Loss Reduction is still readily available on Youtube https://youtu.be/v0AamwxgKQM

I have been invited to contribute teaching modules in international short courses on FLW, mainly to showcase our research and innovative products. Examples of the international short courses where we have made contribution are hosted by Wageningen University Research (WUR), University of California, Davis, Postharvest Research Center and the Volcani Institute in Israel. Overall, I have been at the forefront not only to raise awareness about FLW as a problem to sustainability of our food systems but also champion interventions to address the problem. I can proudly say that when the subject of food loss and waste is mentioned or discussed in Kenya, my name will somehow be mentioned.

PART 3

RECOMMENDATIONS AND FUTURE INITIATIVES TOWARDS FOOD LOSS & WASTE REDUCTION



The recommendations outlined in this section are mainly guided by our team's years of experience in FLW reduction initiatives in horticultural value chains. They are not exhaustive enough to cover all the necessary interventions to the complex problem of FLW.

3.1. ADDRESS DATA GAPS ON FOOD LOSS AND WASTE

There are serious gaps in the available food loss and waste data. Many stakeholders still refer to the FAO report of 2011. Without reliable data, we cannot inform policy on FLW reduction for the people and the planet. There is need for reliable and verifiable evidence that investments in FLW reduction initiatives can positively contribute to other initiatives aimed at addressing food and nutrition security in sustainable food systems. Similarly, without reliable evidence on the contribution of FLW to the greenhouse gases and ultimately climate change, we cannot tap into available funds for climate change mitigation and adaptation. Does FLW in fruits and vegetables affect access and consumption and therefore poor nutrition? Is there any evidence to support this claim?

3.1.1. A Roadmap to address FLW data gaps

Since FLW measurement is a costly and time-consuming exercise, there is need to select priority or representative value chains at the national or subnational (County) or company level. The selected value chains would serve to estimate FLW in related value chains in similar contexts. An innovative approach for FLW measurement and monitoring progress is the Target-Measure-Act approach. This approach was proposed by champions for SDG 12.3 (Champions 12.3) and is being implemented by various companies in several countries.

In Kenya, World Resources Institute (WRI) is set to implement this approach in selected value chains. The key steps in Target-Measure-Act approach is summarised in the figure below:

Target

- Governments, Counties, Companies and other entities are encouraged to **set targets** for FLW reduction which are aligned to the SDG 12.3 target of halving FLW by 2030. The entities can also set their own targets after the initial measurement to establish the current losses
- **Targets create ambition** which will motivate action towards FLW reduction.

Measure

- Each entity should **measure** FLW in their operations using appropriate FLW measurement tools
- Quantifying FLW within the target entity's operations helps to identify the hot spots/critical loss points, the causes/drivers of the losses
- This evidence-base provides a solid foundation for targeted and prioritized FLW reduction interventions. It is also key for monitoring progress towards achieving the set targets
- **What gets measured, gets managed**

Act

- **Action/interventions** towards FLW reduction guided by evidence on the causes/drivers of the losses measured.
- Such interventions could be technological, better practices, behavioral changes, implementation of existing guidelines
- All interventions should be context-specific taking into consideration the socio-economic dynamics for each situation.
- Effective actions require partnerships between public and private sector organizations in a shared vision that engages all actors in the supply chain – from farmers to consumers.

3.1.2. Ongoing activities to address FLW data gaps by our research team

- FLW measurement in selected African Leafy Vegetables (cowpeas and black nightshades) along the value chains. The study is part of a project that is supported by USAID Feed the Future, Innovation Lab for Horticulture at University of California, Davis.
- FLW measurement in selected fruit value chains (mango, avocado and banana). The study is funded by the World Resource Institute (WRI). In the same initiative WRI is also supporting FLW measurement in other value chains including maize, potato and fish.
- Evaluation of quality and drivers of FLW in value chains that are linked to the homegrown school meals program. The study was supported by FAO and targeted two Counties (Kajiado and Kitui).

3.2. PARTNERSHIPS TO CO-CREATE AND SCALE-UP FOOD LOSS & WASTE REDUCTION INTERVENTIONS

3.2.1. Take stock of applicable FLW reduction technologies, practices and other interventions

There are proven interventions for FLW reduction including technologies and practices. Examples of these interventions have been described in section 2 of this inaugural lecture. However, there are many more technologies and practices for FLW reduction which remain largely unknown to the potential users.

There is need to take stock of all the available and possible interventions for FLW reduction in various value chains and respective contexts. Our team has previously taken stock of available technologies and practices to reduce FLW in fruits and vegetables. The desk study that was supported by the CABSFOODS Project focused only on the participating countries namely Kenya, Ghana and South Africa. The unpublished report shows that there are over 200 proven and applicable technologies for FLW in fruits and vegetables. However, less than 10% of them have been applied commercially.

More comprehensive studies are required to document the applicable and context-appropriate interventions for priority value chains. Factors that would affect adoption (positively or negatively) should be documented to guide the required changes or adaptive research to promote applicability and adoption.

3.2.2. Innovate to address the technology/innovation gaps

In cases where there are no context-appropriate innovations/ technologies, there is need to innovate. There is need to depart from the current trend where researchers develop technologies in hope that they will be adopted by the target users to address the problem identified by the researchers. This approach is part of the reason many technologies remain unadopted or they have not achieved the desired impact.

It is important to co-create the interventions together with the target users. Therefore, the researcher-industry linkages and partnerships are critical. Support from the industry can transform the researchers' ideas into practical solutions in a win-win situation – addressing the industry's pain points while advancing research. Partnership between the University of Nairobi and Mabati Rolling Mills is a case in point.

The upcoming Kantaria Agricultural Technology and Innovation Center (KATIC) located at the Upper Kabete Campus provides a good opportunity for research/academia-industry partnerships to co-create and scale up solutions to address challenges in the agri-food sector and enhance productivity.

Similarly, an innovation park is set to be established under the Big Five transformative agenda of the UON Chancellor, Prof. Patrick V. Verkooijen. The innovation park will provide a great platform where innovations to drive growth and productivity in the agri-food sector can be co-created and up-scaled through academia-industry partnerships. It is envisaged that the innovation park will grow into a 'Silicon Savannah' for entrepreneurship and technological innovation

3.2.3. Partnership to scale up research outputs

There are many innovations from research which have potential to address the causes/drivers of FLW. Some of the innovations require pilot studies to test their applicability in various contexts. On the other hand, some of the innovations are market-ready but remain in the 'lab' at various research institutions. There is need for partnerships to move these innovations from 'the lab to the land'. Therefore, we call upon agri-food sector partners including private sector, development partners, civil society organizations, community-based organizations and others to support efforts to scale up the proven FLW reduction solutions from research (the Lab) to benefit the target end users (the Land).

The KATIC and Innovation Park described in section 3.2.2 provide opportunities for such partnerships.

As part of the efforts to scale up the innovations, economic analysis including the cost-benefit-analysis, return on investment and the impact (social, economic and environmental) of adoption of the various technologies is critical.

3.3. PARTNERSHIPS IN AWARENESS CREATION AND DISSEMINATION

Low adoption of market-ready technologies for FLW reduction is in part attributed to lack of awareness. Conferences, webinars, seminars, exhibitions and other traditional awareness creation/dissemination platforms should be complemented by other innovative dissemination options.

Digital and social media platforms such as YouTube, blogs, LinkedIn, Facebook, X(Twitter), extension bulletins, fact sheets should be embraced by researchers in their bid to increase awareness. Partnership with the media houses is key in the dissemination efforts because of the massive reach.

To breakdown the scientific jargon and communicate better to the general public, it is important that researchers embrace retooling in science communication. This will enable them to appropriately package their research and innovative ideas for various audiences including policy makers, practitioners in the agri-food sector, private sector, consumers, funding agencies and others.

3.4. CONCLUSION AND PARTING SHOT

The need to address food loss and waste has never been urgent as it is now. Our collective efforts in minimizing food loss and waste will not only enhance sustainability but also address pressing issues of food security and resource efficiency. I have endeavoured to unpack the multifaceted nature of the problem and some solutions to address it. It is evident that every actor in the food supply chain from production to consumption, has a role to play in the efforts to reduce FLW. Moving forward, let us embrace a holistic approach to FLW reduction that combines various interventions including technology/ innovation, capacity building, and behaviour change in an enabling policy environment. By leveraging new technologies, fostering collaborations between stakeholders, and empowering all actors with knowledge, we can drive meaningful change. Our commitment to reducing food loss and waste reflects our values of stewardship and sustainability.

As we conclude today's discussion, I urge each of you to reflect on the insights shared and consider how you can contribute to this global effort. Whether through research, advocacy, or everyday actions, every effort counts. Together, we can forge a path towards a future where food is valued, waste is minimized, and resources are used wisely – for the people and the planet.

Thank you all for your attention and God bless you.

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REFERENCES

Ambuko J., Yumbya P. Shibairo S. and Owino W (2014). Efficacy of 1-Methylcyclopropene in Purple Passion (*Passiflora edulis*Sims) Fruit as Affected by Dosage and Maturity Stage. International Journal of Postharvest Technology and Innovation. Vol. 4: 126-136

Ambuko Jane, Esther Karithi, Margaret Hutchinson, Lusike Wasilwa, Britta Hansen and Willis Owino (2018). Postharvest shelf life of mango fruits stored in a Coolbot™ cold room. *Acta Horticulturae 1225*:193-197

Ambuko Jane, F. Wanjiru, G. N. Chemining'wa, W.O. Owino and Eliakim Mwachoni (2017). Preservation of Postharvest Quality of Leafy Amaranth (*Amaranthus spp*) Vegetables Using Evaporative Cooling. Journal of Food Quality. Article ID 5303156, https://doi.org/10.1155/2017/5303156

Ambuko Jane, Florence Wanjiru, Esther Karithi, Margaret Hutchinson, George Chemining'wa, Eliakim Mwachoni Britta Hansen, Lusike Wasilwa, Willis Owino and Ngoni Nenguwo (2018). Cold chain management in horticultural crops value chains: options for smallholder farmers in Africa. *Acta Horticulturae 1225: 85-91*

Amwoka, E.M., Ambuko, J.L., Jesang, H.M. and Owino, W.O. (2022). Comparative evaluation of the effectiveness of selected storage technologies to preserve postharvest quality of mango fruit. Acta Hortic. 1348, 43-50 https://doi.org/10.17660/ActaHortic.2022.1348.6

Benson Maina, Jane Ambuko, Margaret Hutchinson and Willis Owino (2020). The effect of waxing options on shelf life and postharvest quality of 'ngowe' mango fruits under different storage conditions. Advances in Agriculture. Volume 2019, Article ID 5085636, 9 pages. https://doi.org/10.1155/2019/5085636

Blankenship, S.M., and J.M. Dole. 2003. 1-Methylcyclopropene: A review. Postharvest Biology & Technology 28(1):1–25. doi: 10.1016/S0925-5214(02)00246-6.

Emmanuel M. Amwoka,1 Jane L.Ambuko , HutchinsonM. Jesang', and Willis O.Owino (2021). Effectiveness of Selected Cold Chain Management Practices to Extend Shelf Life of Mango Fruit. Advances in Agriculture https://doi.org/10.1155/2021/8859144

FAO. 2011. Global food losses and food waste – Extent, causes and prevention. Rome

FAO. 2019. The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO

Fawole Amos Olaniyi (2023). Recent Advances in Improvement of Postharvest Application of Edible Coatings on Fruit in Recent Advances in Improvement of Postharvest Application of Edible Coatings on Fruit. Ibrahim Kahramanoglu (Ed). Taylor & Francis Group, LLC. CRC Press 2385 NW Executive Center Drive, Suite 320, Boca Raton FL 33431

Gitau K, Ambuko J, Chemining'wa G and W Owino (2022). Effect Of Harvest Stage And Nitrogen Fertilization On The Postharvest Shelf Life Of Black Nightshade (Solanum Nigrum L.) And Collard (Brassica oleracea var. acephala L.). Afr. J. Food Agric. Nutr. Dev. 2022; 22(6): 20737-20751 https://doi.org/10.18697/ajfand.111.22085

Githiga Ruth, Ambuko Jane, Margaret Hutchnison and Willis Owino. (2014). Effect of Activebag® Modified Atmosphere Packaging on the Postharvest Characteristics of Mango Fruits, Mangifera indica L, Cultivar Tommy Atkins. Journal of Applied Biosciences 83:7535– 7544

Hutchinson, M. J., Ouko, J. R., Yumbya, P. M., Ambuko, J. L., Owino, W. O., & Subramanian, J. (2022). Efficacy of Hexanal Field Spray on the Postharvest Life and Quality of Papaya Fruit (Carica papaya L.) in Kenya. Advances in Agriculture, 2022.

Isaac O. Nyangena, Willis O. Owino, Jane Ambuko and Samuel Imathiu (2020). Moisture sorption properties of two varieties of dehydrated mango slices as determined by gravimetric method using Guggenheim—Anderson—de Boer model. Journal of Food Processing and Preservation. https://doi.org/10.1111/jfpp.15041

Jane Ambuko and Willis Owino (2023). Towards Sustainable Transformation through Post-Harvest Management: Lessons from the Mango Value Chain in Kenya. In Breisinger, Clemens, ed.; Keenan, Michael, ed.; Mbuthia, Juneweenex, ed.; and Njuki, Jemimah, ed. 2023. Food systems transformation in Kenya: Lessons from the past and policy options for the future. Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896294561 - 534 pages.

Jane Ambuko, Esther Karithi, Margaret Hutchinson and Willis Owino (2018). Modified atmosphere packaging enhances the effectiveness of Coolbot cold storage to preserve postharvest quality of mango fruits. Journal of Food Research, Vol 7 (5).

Jane Ambuko, Esther Karithi, Margaret Hutchinson and Willis Owino (2018). Modified atmosphere packaging enhances the effectiveness of Coolbot cold storage to preserve postharvest quality of mango fruits. Journal of Food Research, Vol 7 (5).

Karen Wambui, Jane Ambuko, George Chemining'wa and Willis Owino. Effect of Blanching and Drying techniques on quality characteristics of Collard (Brassica oleracea var. acephala) and Black night shade (*Solanum nigrum*). Presented at the 4th All Africa Postharvest Congress & Exhibition, 19th to 22nd September 2023, Addis Ababa, Ethiopia

---

Kathambi J, Ambuko J, Hutchinson M and W Owino (2022). Effect Of Coolbot ™ Cold Storage And Modified Atmosphere Packaging On The Shelf Life And Postharvest Quality Of Collards. Afr. J. Food Agric. Nutr. Dev. 2022; 22(6): 20668-20686 https://doi.org/10.18697/ajfand.111.22075

Kirakou P. Stanley, Hutchinson J. Margaret, Jane Ambuko and Willis O. Owino (2017). Efficacy of blanching techniques and solar drying quality of cowpea leaves. Afr. J. Hort. Sci. 11:18-34

Kitonoja Lisa (2013). Use of cold chains for reducing food losses in developing countries," Postharvest Education Foundation (PEF) White Paper no. 13-03, 2013.

Margaret Jesang Hutchinson, John Robert Ouko, Jane Ambuko, Willis Omondi Owino and Jayasankar Subramanian (2018). Effects of hexanal dip on the post-harvest shelf life and quality of papaya (*Carica papaya* L.) fruit. Tropical Agriculture Volume 95, 1: 43-70

Mbondo, N. N., W. O. Owino. Ambuko, J., and Ndaka, S. D. (2018). Effect of drying methods on the retention of bioactive compounds in African eggplant *(Solanum aethiopicum L.)*. Food Sci Nutr. 2018:1–10.

Naum Jepkirui, Joyce G. Maina, Judith Atela, Jane Ambuko, Benjamin Kyalo. Effects of Graded Levels of Mango Seed Kernels in Broiler Diets on Growth and Carcass Characteristics. Presented at the 4th All Africa Postharvest Congress & Exhibition, 19th to 22nd September 2023, Addis Ababa, Ethiopia

Owino W. O. and Ambuko, J.L. Mango Fruit Processing: Options for Small-Scale Processors in Developing Countries. Agriculture 2021, 11, 1105. https://doi.org/10.3390/agriculture 11111105

Peninah Mueni Yumbya, Margaret Jesang Hutchinson, Jane Ambuko, Willis Omondi Owino, Alan Sullivan, Gopinadhan Paliyath and Jayasankar Subramanian (2018). Efficacy of hexanal application on the post-harvest shelf life and quality of banana fruits (*Musa acuminata*) in Kenya. Tropical Agriculture Volume 95, 1: 14-35

Stathers, T., Holcroft, D., Kitinoja, L. et al. A scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia. Nat Sustain 3, 821–835 (2020). https://doi.org/10.1038/s41893-020-00622-1

S. K. Roy and R. K. Pal, "A low cost zero energy cool chamber for short term storage of mango," Acta Horticulturae, vol. 291, pp. 519–524, 1991

Thabiso Kenneth Satekge & Lembe Samukelo Magwaza (2022) Postharvest Application of 1-Methylcyclopropene (1-MCP) on Climacteric Fruits: Factors Affecting Efficacy, International Journal of Fruit Science, 22:1, 595-607, DOI: 10.1080/15538362.2022.2085231

Vishweshwaraiah Prakash, Jane Ambuko, Walter Belik, Jikun Huang and Toine Timmermans (2014). Food Losses and Waste in the Context of Sustainable Food Systems. High Level Panel of Experts – HLPE Report No. 8

Watkins, C.B. 2006. The use of 1-methylcyclopropene (1-MCP) on fruits and vegetables. Biotechnology Advances 24 (4):389–409. doi: 10.1016/j.biotechadv.2006.01.005.

Willis Owino, P. Yumbya and S. Shibairo J. Ambuko. (2016). Effect of 1-MCP and Modified Atmosphere Packaging on the shelf life of Purple Passion (Passiflora edulis Sims). Acta Horticulturae, 1120:85-89

World Resources Institute, WRI-Africa. Consultative workshop on developing food loss and waste protocol and guidelines, Best Western Hotel, Nairobi, November 14, 2023, in Nairobi.

Yumbya P., Ambuko J., Shibairo S., Owino O. W. (2014). Effect of Modified Atmosphere Packaging (MAP) on the Shelf Life and Postharvest Quality of Purple Passion Fruit (Passiflora EdulisSims). Journal of Postharvest Technology, Vol.2 (01): 025-036.

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