



Sustainable Innovations for Wet Markets and Protective Foods

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Sustainable Innovation for Wet Markets and Protective Foods¹

1 The importance of protective foods

Perhaps the most compelling food-related questions are “what to eat” and “where to get it”. As for the “what” question there is a growing body of evidence that the best foods for supporting human health are what can be termed ‘protective foods’ (EAT Lancet Commission, 2019; Harvard University, 2011; Slavin and Lloyd, 2012). These are foods such as whole grains, fruits, fish, vegetables, legumes, seeds, and nuts that support health and protect humans from diseases (Flor, 2019). In recognition of this, Harvard University’s Healthy Eating Plate Model indicates that half of what we eat should be comprised of protective foods (Fig. 1).

And where should we look for these protective foods? One convincing answer is to look right in our own familiar, life-affirming local communities – shaped by our cultural endowments, culinary habits and the changing colour of our seasonal harvests and the produce they bring. Indeed, our local wet markets can be hard to beat for finding excellent protective foods. Particularly in the developing world and economies in transition, these markets provide between 60% and as much as 90% of the ingredients for our daily meals (Gomez & Ricketts, 2013).

¹ The authors wish to acknowledge the precise editorial contribution of Dr John de la Parra Manager, Global Food Portfolio, Food Initiative (The Rockefeller Foundation), the expert advice of Sir Gordon Conway Professor of International Development (Imperial College London) and the research support of George Taylor (Imperial College London) and Frederick Saunders (Imperial College London).

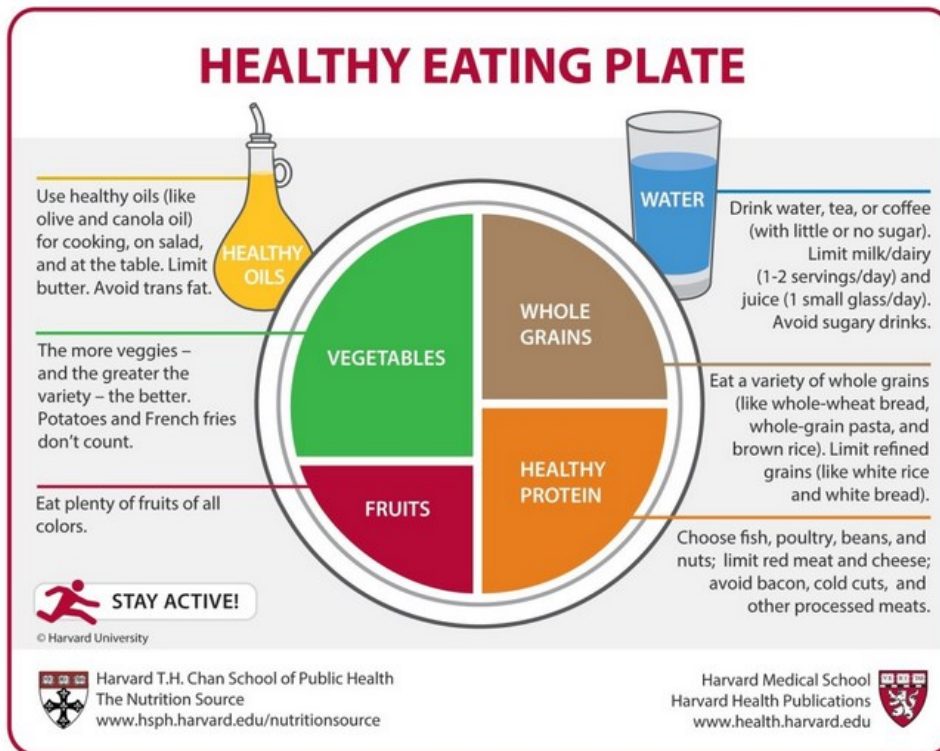


Figure 1. The Harvard Healthy Eating Plate³⁰

Source: Copyright © 2011, Harvard University. For more information about The Healthy Eating Plate, see The Nutrition Source, Department of Nutrition, Harvard T.H. Chan School of Public Health, www.thenutritionsource.org and Harvard Health Publications, www.harvard.health.edu

Why are protective foods obtained from local wet markets particularly important at this moment in history? Human civilisation is in the paradoxical situation where both excess and scarcity sit uneasily side-by-side. We have created a world where both the most economically advanced countries and those that are the most economically challenged are trending in the wrong direction when it comes to our relationships with food. This paradox is precisely why it is time for a new Food Revolution with wet markets as a leading vanguard in the sustainable transformation of our food systems.

The Western diet, which is often thought of as an aspirational goal around the world, has caused diet-related chronic diseases to become the single largest causes of morbidity and mortality (Cordain et al., 2005). Diet-related diseases are epidemic in contemporary Westernized populations and typically afflict 50–65%² of the adult population. In addition, as dietary patterns shift around the world to mimic those of the West, low- and middle-income countries are experiencing sharp

² Cordain, L. et al. 2005. Origins and evolution of the Western diet: health implications for the 21st century. *The American Journal of Clinical Nutrition*, 81(2), pp. 341–354. doi: [10.1093/ajcn.81.2.341](https://doi.org/10.1093/ajcn.81.2.341). at Page 350.

increases in diagnosed diabetes.³ Between 2010 and 2030, the number of adults with diabetes in developing countries is expected to grow by 69%, compared with a 20% increase in high-income countries.⁴ In other words, diets high in processed foods, sugar, salt and fat, are increasingly killing and disabling the world's population.

On the flip side, 2 billion people suffer from malnutrition worldwide. 815 million people⁵ cannot guarantee their next meal and yet globally 50%⁶ more food is produced than needed. Countries in the Global North and Global South (where populations are rapidly urbanising) share growing adverse health impacts of the Western diet. For example, China and India have 151 million⁷ and 72 million⁸ people (respectively) with diet-related diabetes. Aside from the serious adverse health impacts diabetes drains household incomes in India by 27-34%.⁹ In East Africa, malnourishment is on the rise with 80 million people affected—at the same time that obesity has doubled with poorer urbanites consuming cheap, ultra-processed foods.¹⁰ Much further along this fatal path, in the United States, for example, 10% of the population has been diagnosed with Type 2 diabetes, and by 2030, 1 in 3 newborns will grow up to be diabetic.¹¹ In 2017, costs associated with diagnosed diabetes in the USA alone amounted to \$327 billion.¹² On the bright side, shifting dietary patterns towards protective foods alone can prevent 30-40%¹³ of pre-diabetics from becoming diabetic and enable those with uncontrolled diabetes (33 million people) to achieve normal blood sugar levels, avoiding over \$5,000 in medical costs per person, annually.¹⁴

We feel that it is important to bend the curve of this growing burden of diet-related disease by incentivizing a shift toward protective diets consisting of sustainably grown protective foods. This is increasingly important as protective foods are dramatically under-consumed due to systemic forces that suppress demand and constrain production and supply (Fig. 2).

³ [CSIS](#), 2018

⁴ [IPES-Food](#), 2017

⁵ Protective Foods, The [Rockefeller Foundation](#), 2020, <https://www.rockefellerfoundation.org/initiative/protective-foods-usa/>

⁶ *ibid.*

⁷ [American Diabetes Association](#), 2018; [WHO](#), 2016

⁸ [International Diabetes Foundation](#), 2019; [The Lancet](#), 2018

⁹ *Ibid.*

¹⁰ The three largest obese populations in East Africa are Tanzania, Ethiopia and Kenya; “Food insecure” indicates the undernourished population in these countries [Deloitte analysis of UN and WHO data].

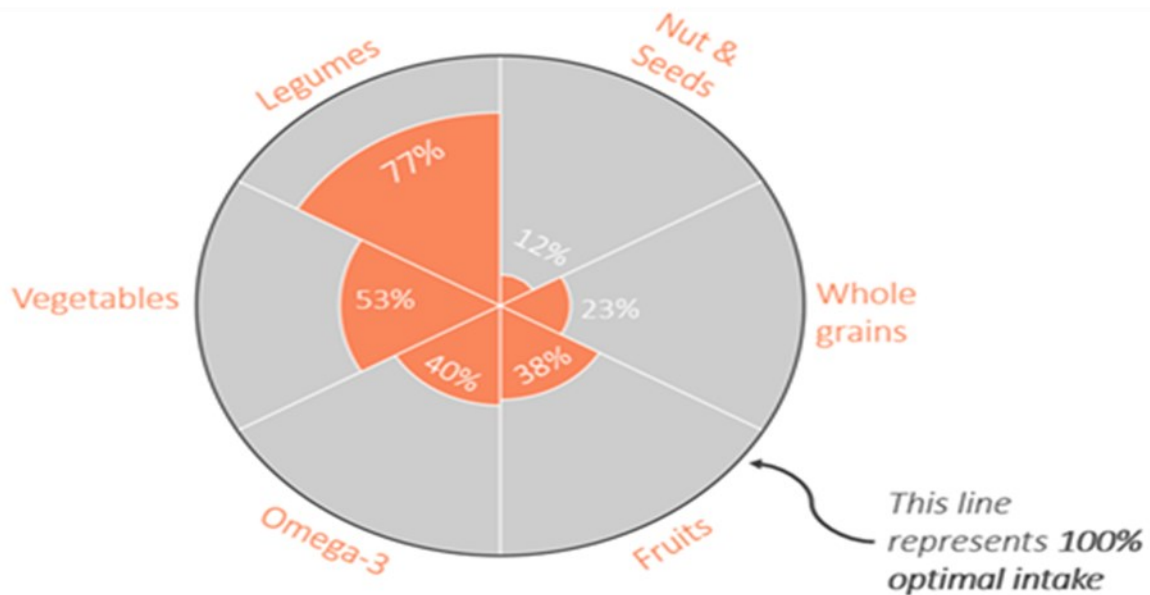
¹¹ [The Sustainable Food Trust](#), 2013

¹² [American Diabetes Association](#), 2018

¹³ Interview with Dr. Dariush Mozaffarian, 2019

¹⁴ [Journal of Managed Care & Specialty Pharmacy](#), 2017

Global Gap in Consumption of Protective Foods (Optimal vs. Actual), 2017



Source: [IHME – GDB, The Lancet](#) 2019

Source: The Rockefeller Foundation’s Circle of Protective Foods. ^{15, 16}

What would change if we dialled back Western dietary habits and promoted a more sustainable diet rich in protective foods? Globally, the adoption of optimal dietary intake levels by 2030 can save an average of four million lives per year between 2030 and 2050.¹⁷ At the same time, widespread adoption of a largely plant-based diet is generally considered the most powerful lever to prompt more sustainable food production.¹⁸ It is increasingly clear that promoting dietary patterns high in protective foods is critical to nourishing a growing population in a sustainable manner. As wet markets are responsible for feeding so many people on our planet, this also means innovating new ways of expanding their contribution to healthier, protective diets.

¹⁵ Pie chart diagram of the optima vs. actual consumption of protective foods, using original data from the IHME Global Burden of Disease, as presented in ‘*Health effects of dietary risks in 195 countries, 1990- 2017: a systematic analysis for the Global Burden of Disease Study 2017*’ DOI:[https://doi.org/10.1016/S0140-6736\(19\)30041-8](https://doi.org/10.1016/S0140-6736(19)30041-8). Reused with permission. Courtesy of The Rockefeller Foundation.

¹⁶ Murray, C. J. L. *et al.* 2020. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, 396(10258), pp. 1223– 1249. doi: [10.1016/S0140-6736\(20\)30752-2](https://doi.org/10.1016/S0140-6736(20)30752-2).

¹⁷ IHME 2019; By way of examples, the authors indicate that over 190 thousand lives in the United States and over 65 thousand lives in East Africa can be saved annually.

¹⁸ [The Lancet Commission – Global Syndemic 2019](#)

2 Challenges and Opportunities for wet markets

In this sub-section we identify some of the main challenges for wet markets and their corresponding opportunities.

Wet market infrastructure: Wet markets are normally very conveniently located for consumers, vendors and other actors, and are therefore important institutions in the retail food supply chain. As such, they would benefit from well-planned technical designs for multifunctional infrastructures and facilities that also support safe handling of food and general hygiene as described in this Handbook. The development of weighing, transport, and storage infrastructures are also important as some markets for staple foods require this infrastructure. Supporting well-planned wet market infrastructure is also the perfect response to rapidly urbanising populations that are also wet market customers.

Management and organization: Wet market user registration processes and simple contractual arrangements managed by experienced staff make such markets efficient and legitimate in the eyes of government and other key private and public stakeholders.

Sanitation, waste management and energy systems: With the right leadership and the cooperation of staff with essential expertise and training capacities, sanitary measures regularly applied and checked will reduce hygiene concerns to a minimum. In countries where tap water is not available, markets can harvest rainwater. Finally, cost effective energy and waste management measures will, if properly designed, create net benefits for the environment.

Food quality and safety risks and traceability: With on-site training of farmers and other producers with the cooperation of cooperatives and other farm organisations, sustainable production of produce, fish and meat will substantially remove product quality and safety concerns. Simple traceability mechanisms can accompany user registration systems.

Removing high produce losses: Well-designed and operated wet markets should feature cost effective cold storage facilities that can be powered by renewable energy. Low-tech, efficient dry storage facilities should also be built into wet market infrastructure design and paid for with nominal user fees.

Covid-19 related factors: With the right leadership, virtually all wet markets can develop and implement policies to address Covid-19 physical distancing measures. The right 'track and trace' systems for both wet market products as well as on-site users should ameliorate these concerns and those that might come with future zoonotic diseases. Contamination or other adverse health events should be

more capable of management on this basis— provided that the right relationships exist between wet market operators and responsible government authorities

Building a relationship around wholesale markets: Though we address this point in greater detail later, wet markets have an unrealised potential to expand their market opportunities on both the producer and buyer sides of the commercial equation. With the right regulatory strategy, wholesale market actors can expand the demand for wet market produce/products and can be physically co-located if not functionally integrated with wholesale food terminals. Wholesale markets attract larger buyers including those that have regional, national and international markets in mind. Improved business education and stakeholder understanding will make this vision possible as it already happens elsewhere.

3 The importance of wet markets in relation to sustainability and food systems

Today's food system produces abundant ultra-processed, calorie-dense yet nutrient-poor, cheap foods. High intake of these convenient foods is taking a growing toll on human health (e.g., 821 million undernourished and 1.9 billion overweight or obese worldwide),¹⁹ the environment (e.g., 14-29% of global greenhouse gas emissions come from the food system),²⁰ and communities (e.g., small-scale farmers and rural communities often experience poverty and food insecurity).²¹

Globally, thousands of sellers and consumers rely on wet markets and therefore they are incredibly important for smallholder urban food retailers in developing countries. Despite the rise in 'supermarketisation' of food systems in urban developing settings, wet markets retain a considerable market share of fresh produce (Schipmann & Qaim, 2011). For example, in New Delhi the number of fresh fruit and vegetable (FFVs) wet markets are proportionally lower than that of more modernised outlets, but account for up to 75%²² of all FFVs sold (Minten et al., 2010). A study by Gomez & Ricketts (2013) found that 90% of all FFVs are purchased through more traditional food value chains in Kenya, Zambia and Nicaragua. In Thailand and Mexico, nations with greater supermarket adoption, traditional food markets share remains high at 63% and 72.5% respectively.

¹⁹ [FAO](#), 2018

²⁰ [CDC](#), 2018

²¹ [The Lancet Commission – Global Syndemic 2019](#)

²² Minten, Bart; Reardon, Thomas; Sutradhar, Rajib. 2010. Food Prices and Modern Retail: The Case of Delhi. *World Development*. 38 (12): 1775–1787

Smallholder farmers generally sell their produce to wet or informal markets and so rely on them for their livelihoods (Gomez & Ricketts, 2013).

Continued reliance on wet markets for produce is in part based upon the consumers view that wet market produce is fresher, better tasting, and healthier than perishable goods sold in supermarkets (Zhong et al., 2020). Furthermore, there are cultural and social sustainability reasons as to why consumers prefer wet markets (Zhong et al., 2020). This evidence shows the high global reliance on wet markets for the sale and acquisition of food, and so they hold a key position within a sustainable food transition.

For a food system to be sustainable, it must ensure the health of those dependent on it. As described earlier, 'protective foods' are foods that protect against the development of negative health implications, i.e., fruits, vegetables, fish, legumes, seeds, nuts and whole grains (Flor, 2019). Such foods are commonly sold at wet markets (Kogen et al., 2019). In this regard, they are advantageous over more modern forms of food retail which often sell produce that is high in fats, sugars, and preservatives with low nutritional content (Gorton et al., 2011). In theory then, produce from wet markets can promote nourishing food systems for a growing population (The Rockefeller Foundation, n.d.).

Informal wet markets dealing in the sale of protective foods can be considered environmentally sustainable for several reasons. Firstly, the produce is sourced from local value chains which are reliant on smallholder farmers for their sustainable livelihoods (with smallholder family farms numbered at some 570 million globally) (European Commission Joint Research Centre, 2020). Regional, national, and international food supply chains are reliant on long distance transportation and so are much more greenhouse gas (GHG) intensive (Rizet et al., 2010). Secondly, fresh produce in wet markets are not packaged in single use plastics. They are sold in open market stalls with consumers relying on their own robust, reusable forms of packaging (Buchanan, 2019). Lastly, enormous amounts of food are wasted because it does not fit certain cosmetic requirements of supermarkets. This issue is less prevalent within wet markets which do not have to adhere to such standards. In addition, independent smallholders in wet markets can sell their unsold fresh produce as other sellable products such as juice or livestock feed, instead of being wasted as per the norm in supermarkets (Global Panel, 2018a).

The convoluted nature of global supply chains means that adapting agricultural practises to improve sustainability is extremely challenging (Giddings, 2016) but can be better accomplished in the short supply chains that we find in wet markets. Relationships between producer-seller-consumer are much closer within wet markets and so have the advantage of flexibility over modern food systems (Fickling, 2020). They are cultural; built on trust, observations, and experiences. Through NGO or private sector support, these relationships can be utilised to enhance the sustainability of farming practises at a faster rate than global commercial supply chains, either through improved irrigation; natural pesticide use; or any other

sustainable farming method. This would result in foods that maintain organic freshness with better overall quality.

Finally, protective food-based wet markets can be environmentally economic. They are often independently run by smallholder vendors, who source their produce from local farmers or wholesalers instead of being reliant on global, GHG intensive supply chains. These shorter value chains can also ensure inclusive economic development (Lutz & Tadesse, 2017). Informal wet markets are relied upon for food security and livelihoods throughout the developing world. Such systems are more focused on inclusivity as they function for the benefit of all those involved. Formalising the existing markets to a greater degree would ensure inclusive, sustainable growth. This is because they are building on existing cultural norms and networks of suppliers, sellers and consumers (Zhong et al., 2020). This would reinforce, upgrade and improve the existing market and lead to more rapid and inclusive proliferation.

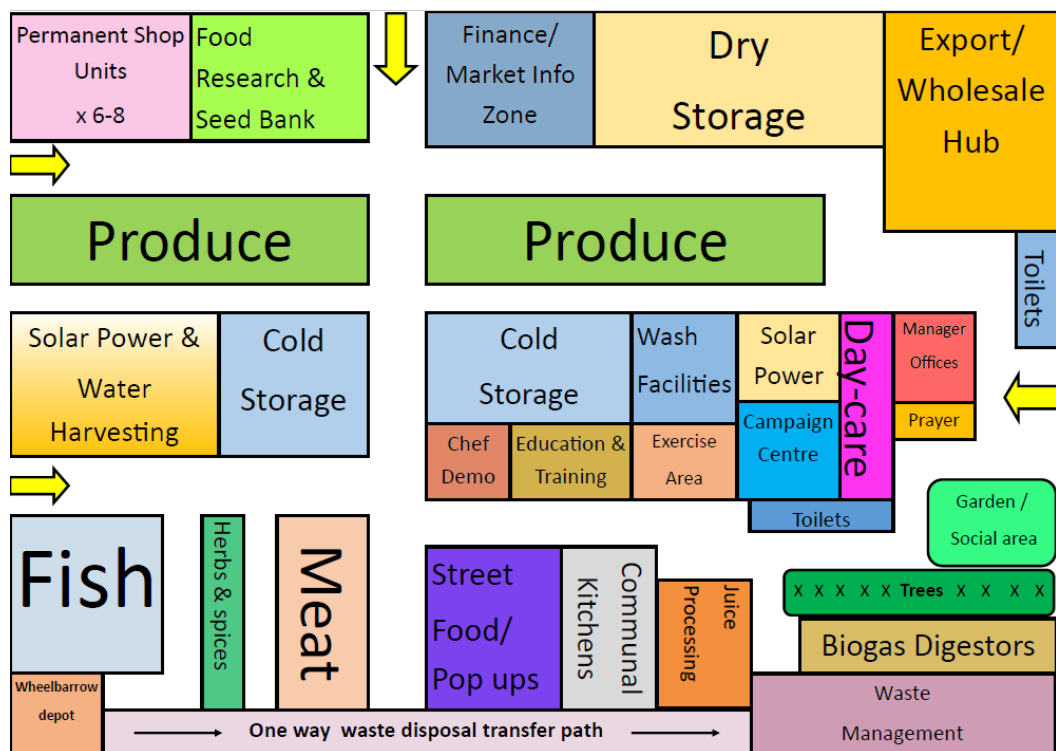
4 On-site innovation opportunities for wet markets

Multi-functionality is at the core of a well-designed, modern wet market. Accordingly, the following diagram (Fig 3) identifies the possible functions of a comprehensive 21st century wet market²³ immersed in food culture for climate resilient sustainability.²⁴

²³ The diagram is not to scale. Not all functions are required for a given wet market. Function selection is at the discretion of the operator/owner ideally acting in consultation with stakeholders.

²⁴ **Additional rationale for location of selected uses:**

South side: The location of the fish and meat markets separated by the herbs and spices is deliberate. The intention is for the herbs and spices stalls to provide a natural odor buffer to avoid the fish and meat smells mixing. Fish and meat stalls will produce the most waste and offal, which needs to be properly disposed of to mitigate against disease and pests. As such, there is a “waste disposal transfer” route directly to the “waste management area” so sellers can properly dispose of their waste throughout the day. There will be wheelbarrows that can be hired to expedite this process. Sellers who fail to properly dispose of their waste will be warned, fined and finally expelled by management. Similarly, the tree line in the east corner is to provide a visual and odour barrier against the “waste management area”.



Finance/market info zone will feature a televisual/social media unit that “markets the wet market”, calling attention to the market features and advertising on behalf of vendors. This will also enable sellers and buyers to know what prices to expect to sell and buy at. This zone will feature a series of ATMs and credit lenders to help sellers and farmers secure loans that they can use to upgrade their operations. Closely aligned with this function is the **Campaign Centre** which will be devoted to expanding the interests and influence of wet markets as well as food health, food culture and related sustainability causes throughout civil society.

Food Research & Seed Bank hub will provide a laboratory and modest seed bank used to research and demonstrate protective foods and related health research opportunities for advancing the roles of wet market stakeholders. It will be connected to a major university with aligned interests.

Solar power area will be a designated space for on-the-ground solar panels to supply the energy needs of the wet market, notably cold storage units. They will be fenced off and off-limits to non-authorized personnel.

Water harvesting/ collection area will leverage the best available technology in rainwater and ‘ambient-air’ overnight water harvesting in order to satisfy as much of the freshwater needs for the wet market. This will also include technology that recycles the moisture produced in the cold storage units and channels into collection tanks.

Chef demonstration area will bring skilled professionals in to showcase recipe ideas and new cooking techniques to encourage greater participation in the market. Management will work with chefs to ensure they are using produce that is in high supply, to then drive demand and minimise any possible waste for produce with which people are unfamiliar. Key Ingredients on recipe digital/paper sheets will be locationally identified at the numbered stalls in the wet market for ease of purchase. Aligned with this food concept, **Street Food / Pop Ups** will provide cooked food dishes representing the produce sold at the wet market and may have the option to introduce healthful international foods. The ‘Makati Vendors Programme’ (Philippines) is an example where women entrepreneurs that pre-cook and sell meals to schools or at transport hubs can join the wet market scene.

The creche/day care centre will provide childcare to empower women to participate in the market activities and therein redress gender inequality present in rural agricultural while enabling social mobility.

Education/ training will provide the wet market vendors with workshops on various topics from basic financial skills through to recommendations on growing techniques for different produce and how to combat their respective pests and diseases. Farmers and customers can participate in lessons in core skills such as: agricultural inputs, agroecology, business literacy, nutrition, seasonal meal preparation for sustainability and waste minimisation. This hub will also employ people from the existing pool of extension agents, with a view to bring on more practitioners/experts in these fields.

Permanent shop units will provide a small restaurant, café, produce, meat, fish, bakery, corner shop and related essential shopping services to customers on an extended hour basis to maintain ongoing interest in the wet market and serve as a point for essentials for consumers unable to visit the market at more typical hours.

4.1 Innovative Services and Wet Markets

In addition to the above-mentioned functions, innovation in services should be a feature of the 21st century wet market.

Market the Wet Market – Many of us grew up in the powerful marketing and advertising presence of major food conglomerates. Singing the remarkably effective advertising jingles of leading television commercials was the norm as we integrated fast food, TV dinners and ready meals into our ‘modern’ way of life. These firms and their products are ubiquitous, including in supermarkets, conveying a sense of prestige and normalcy to life in our consumer world since the latter half of the 20th Century. In all that time, can any of us recall similar advertising, marketing and communication drives for protective foods or wet markets? This Handbook has

familiarised the reader with the critical importance of wet markets to our diets, our health, our livelihoods, our economies, and, indeed, our very existence.

As such, we propose major media campaigns that convey these fundamental messages in relation to the importance of both protective foods and wet markets as a fundamental part of the health infrastructure of society (WHO,2006 – Strong and Healthy Me Campaign; NHS 2020 5 a Day Campaign; WHO Fruit and Vegetable Promotion) with past examples to be updated and presented with the full array of social media devices and strategies. As such wet market owners, operators and other stakeholder beneficiaries will be drawn together to create and implement strategic planning, creative services, brand activation, media planning & buying (traditional and digital), internal campaign development and social media activation aimed at promoting their wet markets and food sales. For reasons of financial aggregation, a national network of wet markets could generate significant financial and expert resources for this common purpose noting that government support should also be elicited for public health reasons.

Education and Training Campaigns - Further to these efforts, education and training, seminars with health, culinary, sustainability, climate resilient agriculture will be a feature of what wet market networks do with facilities on site for this purpose. Wet market management and leadership will work with stakeholders particularly on the supply side to advertise and promote protective foods and related products and services, mirroring the many uses featured at wet markets. In this regard, public-private strategies to fund and promote protective foods and wet markets in societal food, health, and sustainability initiatives will feature with on-site media centres and advertising, marketing and related communication resources related to such campaigns.

Cooking Skills and Recipes for Food Health - In order to draw further attention and customers to wet markets and their vital role in promoting food security, food culture and sustainability, we suggest that wet market operators draw upon the knowledge and experience of organisations such as the World Vegetable Centre to develop and promote recipes on-site and on-line (<https://avrdc.org/publications/recipes/>). A simple format would identify a range of culturally representative meals including dishes of the day, with customers being directed to their main ingredients and their locations on-line or in named aisles and stalls at the wet market itself. Shanghai markets have such an example of on-site cooked and prepared food offerings (<https://culinarybackstreets.com/cities-category/shanghai/2015/ask-cb-14/>) though the proposal made here of on-site chefs preparing dishes and meal programmes appears to be unique.

Mothers and Children - Women play a fundamental role at wet markets as sellers, staff, managers, and customers. Given these novel and important roles why not provide a creche, nursery service? This is of fundamental importance to the

wet market and the communities that it supports. That is why we propose this use at wet markets. It is already happening in Kenya (<https://allafrica.com/stories/202009080250.html>) and children that grow up in a healthy food cultural environment are likely to develop good eating habits.²⁵

Fitness Facilities - as diets become Westernised and urbanisation accelerates, people need a place to stay fit as part of the healthy lifestyles that accompany protective food consumption and wet market community culture. That is why it makes sense to have fitness facilities on site. That is also what is happening at the Nakuru, Kenya market.

(<https://www.youtube.com/watch?v=aAXKineXO6o>)

In addition to the above suggested multi-functional design and service innovations, other technical innovations are presented in this sub-section. Their relevance to wet markets and possible solutions are provided for each innovation.

Cold hub and cold storage solutions - Inadequate cold chain management across the supply is common, particularly in developing countries, and remains a critical barrier to reducing food loss, especially in countries with higher average temperatures (Heard and Miller, 2016). As countries develop, cold chain management can expect to expand. For example, it grew 50% from 1998-2008 in India (Yahia, 2009).

To limit unintended environmental consequences of expanded cold storage, refrigeration facilities must be renewably powered. The high levels of natural sunlight make solar-powered solutions the most appropriate choice particularly for developing countries in the tropics. The following are a sample of some innovative off-grid solar-powered cold storage solutions:

- <http://www.coldhubs.com/>
- <https://energy-base.org/projects/sustainable-energy-in-agriculture-in-colombia/>
- <http://www.solarfreeze.co.ke/impact/>
- <https://solarcoldbox.com/high-cost-food-waste-cold-storage-solution>
- <https://www.brookings.edu/blog/future-development/2019/10/16/how-off-grid-cold-storage-systems-can-help-farmers-reduce-post-harvest-losses/>

²⁵ American Heart Association. "Healthy eating behaviors in childhood may reduce the risk of adult obesity and heart disease." ScienceDaily. ScienceDaily, 11 May 2020. Available at: www.sciencedaily.com/releases/2020/05/200511092923.htm. (Accessed: 11.05.20)

Solar drying - Drying crops reduces the moisture content and therefore slows decay from insect infestations, enzymatic decay, and micro-organism growth – facilitating longer term storage (Muhlbauer, 1998; Tomar et al., 2017). Nutritionally, fibre, protein and energy content are retained after the drying process. Solar drying usually involves the enclosure of crops within layers of transparent plastic. With indirect sunlight exposure it provides a more consistent and efficient drying environment such that solar drying is comparatively (i) faster, (ii) more efficient (iii) hygienic and (iv) incurs lower crop losses (Tomar et al., 2017; Karim and Hawlader, 2004). This method is simple and affordable, with estimated cost of materials at \$195USD.²⁶ Financial and technical efforts to raise adoption of existing systems is needed (Udomkun et al., 2018).

The design is so simple that there are few commercially available options since the unit relies on the assembly of just a few basic, widely available materials. The first link provides such instructions.

- <https://horticulture.ucdavis.edu/information/solar-drying-adds-value-crop-surplus>
- <https://www.lleaf.com.au/>
- <https://www.solardryingsystem.com/>

Reducing food loss – pre-consumption at wet market level - According to YieldWise studies conducted by The Rockefeller Foundation, 10-17% of food loss occurs at fresh markets. Moreover, this means that the food has been grown, processed, packaged and transported successfully to market by the producer and then is unable to be sold – constituting wasted effort, lower incomes, and a known environmental impact. What can be done differently?

- Simple pricing information can be sent through to the mobile phones of smallholders via the mobile internet networks that are expanding across sub-Saharan Africa. This ensures farmers can receive a fair price for their goods and are not wasting crops based upon poor sales demand information.
- The impact of greater digitalisation and financial technology (FinTech), and overall financial inclusion of food producers in the market essentially lowers cost barriers arising from imperfect information and transaction costs. It was found to enhance synergies between environmental and social sustainable development goals (SDGs) (Hinson et al., 2019). Ultimately, these technologies empower producers to participate in markets with more confidence, transparency, and assurances—therefore wasting much less of what is grown.

What about packaging waste? While packaging solutions may be effective, they are nonetheless environmentally impactful. A promising alternative is packaging

²⁶ Adelaja, A. O. and Babatope, B. I. 2013. Analysis and Testing of a Natural Convection Solar Dryer for the Tropics. *Journal of Energy*, 2013, p. e479894. doi: [10.1155/2013/479894](https://doi.org/10.1155/2013/479894).

derived from coconut fibres, a waste product of coconut cultivation, which is normally burnt - <https://www.fortunacools.com/>

Finally, cold storage facilities at the marketplace are critical to ensuring the food brought to be sold maintains its quality and that farmers and sellers can receive a good price. A simple invention building on cold storage units is a market stall with an integrated solar panel on the roof that powers a cold storage unit integrated into the stall - <https://africasustainabilitymatters.com/meet-18-year-old-graduate-greening-informal-food-stalls/>

Waste management contiguous with commercial activities - Any solutions posed for wet markets and their sellers need to ensure there is adequate provisioning of waste management based upon circular market systems. These will keep products and materials in use and help design systems that reduce waste. There is not one but several promising solutions that seeks to address this challenge should be explored.

- *Black Soldier Fly (BSF)*: An insect with a life cycle of a few week that consumes up to 50 times its body weight. These insects eat food market by-products that are particularly strong smelling and difficult to deal with such as manure, meat and fish offal, kitchen waste. Once grown, they can be harvested and provide a nutritious protein-rich feed for aquaculture and livestock, and potentially for human consumption too (Nyakeri et al, 2017). BSF can even have applications as a blended biodiesel found to deliver improved performance at lower emissions (Rehman et al., 2018).
 - <https://agfundernews.com/protenga-roslin-technologies-invests-in-protenga-novel-black-soldier-fly-production.html>
 - <https://www.eatcrickster.com/blog/black-soldier-fly#:~:text=A%20black%20soldier%20fly%2C%20or%20Hermetia%20illucens%20is,can%20actually%20be%20put%20to%20use%20by%20humans.>
- *Biogas Digestors* could be a feature at every fresh food market. They provide both high-quality energy and fertilizer, reducing reliance on fossil fuels and charcoal, as well as expensive chemical fertilizers. Community owned biogas digestors that use a wide range of organic feedstocks are needed to raise their viability and lower the risk barriers to adoption. Examples are found here:
 - <https://www.biogasworld.com/news/small-scale-anaerobic-digestion-using-agricultural-waste-when-technology-and-science-team-up-for-the-environment/>
 - Larger unit suitable for a farming cooperative or wet market model - <https://blog.anaerobic-digestion.com/biogas-digester-design-fertilizer-cost-reduced/>
 - Smaller unit that could be more accessible on an individual level or amongst a handful of market participants - <https://blog.anaerobic-digestion.com/homebiogas-domestic-biogas-plant/>

Water management and water harvesting solutions - Many countries are areas of increasing water insecurity. This is likely to only worsen with climate change. To safeguard developing country water and food security, a more comprehensive approach to water management and water harvesting needs to be employed.

- Water collection can be difficult and physically demanding. This solution aims to make that process easier - <https://hipporoller.org/>
- More sophisticated medium-scale rain harvesting for community buildings such as cooperative - <http://ecosoftt.org/water-wastewater/rain-water-harvesting-2/>
- Low water usage mushroom cultivation units that empower women especially - <https://www.agrilinks.org/post/fungiculture-and-success-malawi>
- Despite access to piped water rising from 36 to 46% in Kenya²⁷, there is no monitoring and so the utilities companies can get away with underdelivering on the quality of service. An IOT powered start up is trying to change this <https://iotbusinessnews.com/2020/04/24/91544-kerlink-and-french-startup-citytaps-deploying-lorawan-network-in-kenya-to-help-bring-running-water-into-homes/>
- Technology oriented to help governments better manage water at catchment areas via satellite data and machine learning - <https://satsure.co/>

5 New business approaches for wet markets

Integrating Wet Markets into Wholesale Markets – In many nations, older regulations can impede the ability of markets to transform food systems and food security. They have also stood in the way of wholesale markets. Further to our analysis (above) on challenges and opportunities for wet markets, it is fundamental to build a relationship with wholesale markets. Developing these actors will scale up sales from wet markets and help to support and aggregate agricultural producers into a sophisticated business-smart force of entrepreneurs. For example, in London, wholesale and fresh market functionality has existed side-by-side with major markets at Billingsgate, Smithfields and Spitalfields. These markets (which specialise individually in fish, meat, or produce) are planning to come together on one site to act as the major wholesaler and retailer for these products <https://wholesalemarkets.co.uk/>.

Wet market advocates should look to the potential of this functional integration as a means of understanding a way to open sellers up to regional, national

²⁷ IOT Business News, 2020 <https://iotbusinessnews.com/2020/04/24/91544-kerlink-and-french-startup-citytaps-deploying-lorawan-network-in-kenya-to-help-bring-running-water-into-homes/>

and international buyers and the associated business opportunities. In the London version, most ‘tenants’ are small businesses. Functional integration of these market opportunities will provide vendors with a digital platform with 5G connectivity, electronic ordering and other high-tech options. This includes new waste and energy strategies as well as new solutions for transport and logistics. This example could be easily within the reach of wet markets an aligned with the cost-efficient technology options we have proposed here.

Diversified customer opportunities for wet markets - In addition to being the go-to location for local residents, wet market vendors should also be supported in expanding their customer bases. This expansion can be driven by wet market finance information and education. Trainings for these vendors can provide business market strategy, standard form contracts, and access to citizens/business legal advice. The development and presence of wholesale markets either near major cities and/or key produce, fish, meat production hubs will provide opportunities to access supermarkets, restaurants, and many other institutions as new customers. This vision can in turn be replicated at the regional, national and international scales.

Vouchers for Wet Markets – Though the range of possible public policy measures that could support protective food provision at wet markets is potentially infinite, policies should address local customer demand for healthful foods as well. To ensure that demand remains for protective foods sold in wet markets, and to compete with supermarket marketing campaigns, governments need to maintain consumer awareness. In Mozambique, a nutritious foods vouchers scheme is being introduced, supplied by local small enterprises and supported by NGOs. The vouchers are distributed through health centres by municipalities or through direct sales involving the wet market smallholder (GAIN, 2015).

A Public-Private Governance Initiative - In Nanjing, China, a public-private hybrid model of governance has been found to ensure food security. It allows for wet markets that sell produce from local supply chains, whilst introducing food safety policies. This model provided rent reductions to informal vendors and investment in storage infrastructure. The result is relatively easy and equitable provision in a healthy, local food system (Zhong et al., 2019).

Innovative Public-Private Partnership Contracts – Land ownership can be prohibitively expensive around the world. Therefore, novel contractual arrangements between municipal governments and private sector wet market operators should be considered for public lands. In addition to lease agreements for the use of land for a prescribed period, ‘concession contracts’ can be formed. These would allow for the design and building of the market and its use for a prescribed concessionary period (e.g., 25-30 years) and offer the opportunity of a return on investments. Finally, a variation on the concession contract the [“Build-Operate-Transfer (BOT) contract”] allows the operator ownership of the wet market for the duration of the contract. This arrangement dispenses with the need for constant

consultation with the municipal government on site-related operational decisions. The Mandaluyong City Market is an example of such a BOT contract (<https://ppp.worldbank.org/public-private-partnership/library/summary-mandaluyong-city-market-rebuilding-bot-basis-undp>)

Online Platform for Wet Markets - We intend wet markets to satisfy the purchasing needs of consumers in their totality. An online platform would have two-way functionality and as such would serve to inform and signal to both producers and buyers in a variety of ways. It will serve as a central hub for individual customers, as well as a wholesale outlet that can then supply the larger volumes required of restaurants, schools, hospitals – both regionally and internationally. The platform would show a stock of the available inventory, which then would allow all types of consumers to view, purchase and arrange delivery of their chosen goods in a timely, safe and cost-effective manner.

An online platform would help farmers market directly to consumers, cutting out the middlemen, and providing customers with an alternative to supermarkets (O’Hara and Low, 2020). Such a platform could provide additional employment for delivery services, the cost of which could be viable if conducted as part of a cooperative. Aggregating the data from all their members, the platform would be able to flag up specific produce that is either in high or low demand – allowing farmers in cooperatives to best time their sales and receive better prices. Over the years, such a platform would be able to provide annual estimates of produce demand, and so in the case of a local drought or disease, they could coordinate with other regional platforms to better balance supply and demand. Moreover, farmers could share updates about external shocks in certain regions (e.g., locust plagues or other well-known chronic pests specific to certain crops) and exchange suggestions for remedies to build up the participants’ collective knowledge base.

Chg	%Chg	Vol	Bid	Offer	Vol
0.00	0.00%	20,709,800	6.45	5.50	42,815,900
+0.00	+0.29%	1,267,100	9.25	9.30	1,242,100
+0.00	+16.36%	354,100	6.35	6.40	168,400
+0.01	+0.88%	2,144,400	1.14	1.15	7,206,100
0.00	0.00%	4,302,745,000	0.04	0.05	5,448,146,400
+0.03	+2.83%	1,547,600	1.09	1.10	12,735,100
-0.02	-0.77%	23,545,800	2.56	2.58	8,524,100
+0.13	+7.88%	1,206,000	1.78	1.79	459,700
0.00	0.00%	12,178,200	10.30	10.40	4,427,000
+0.00	+4.55%	1,719,300	13.80	13.90	1,415,700
1.61		Vol/Value(K)	High/Low	Ceil/Floor	
+0.03(+1.90%)		28,233,400	1.62	2.04	
		45,083	1.57		

For our proposed market information and financial inclusion zone of the wet market a system of digital payments could record market sales volumes from the market transactions. This would enable producers to receive up-to-date inventory information via an online platform. Since most people have mobile phones such facilities are within reach. This zone could also include digital message boards, using solar powered efficient LEDs, for bulletins relevant to traders and customers - e.g., Sale on mangos, go to “zone 12”. This could then link up with the education hub, such that easy to follow instructions are given to advise people how to make the most use of produce that is in season. This board could even display accurate market prices for produce such that the parameters of sale are better

defined, and producers and consumers can make more informed transactions (Fig 4).

Micro-business support for wet markets and their vendors - In Brazil (as elsewhere) micro-business formation has pulled many people out of poverty. Small businesses have joined taxation initiatives set out by the government, voluntarily. In return, they receive access to social protection and business development services. This could apply to wet markets. Smallholder farmers and other small businesses can sign up directly to municipalities in return for a small tax and in return they get access to a market space (ILO, 2014). Whilst formalisation may be beneficial for governments and corporations, great care must be taken to ensure they remain in line with green growth strategies. This is where institutions and NGOs can provide support and advice.

6 Twin roles for wet markets and supermarkets

Supermarkets play an important role in the development and delivery of food systems and offer a convenient business model for governments and municipalities. Public and private investment often goes to supermarket chains that have less risk associated with them than wet markets. This often means that smallholders cannot afford to purchase infrastructure to increase yields such as more advanced farming equipment or storage facilities. However, supermarkets that compete with smallholder wet market vendors through price often do not offer protective foods with the same sustainable qualities (GRAIN, 2018). As such, it is in the interest of such governments from a sustainability perspective to uphold wet markets alongside supermarkets. Consumers will also appreciate diversity in their food purchasing options.

In this table we consider the benefits of wet markets and supermarkets. This suggests that their offerings can work alongside one another:

Wet Markets	Supermarkets
Food safety is established through local trust. Local knowledge of market vendors directs purchasing choices.	Produce must follow strict food safety guidelines and there is greater accountability.
Wet markets are often perceived to have fresher foods with greater nutritional value, especially with fruits and vegetables.	Supermarkets normally have better storage infrastructure, which is particularly important for produce that can make individuals unwell if it spoils. Example: meat, fish and dairy products.

Shorter food supply chains make produce that is essential to a healthy diet - such as vegetables and fruit - more affordable. This is especially important to the urban poor.	Longer food supply chains increase the range of food offered, thus can provide nutrition from food groups that otherwise might not be in regular supply.
Shorter supply chains where vendors are close to the market make it easier to check for sustainable farm practices.	Supermarket buying power can be used to positively influence the environmental sustainability of supply chain actors.
Wet markets generally offer an alternative to processed and high-energy-low-nutrition foods.	Processed food can be prepared quicker in accordance with consumer tastes and time constraints.
Informal system at wet markets are better for smallholder sellers as a hedge against larger scale institutional corruption or other barriers to upscaling.	The supermarket economic system is more attuned to the formal, highly regulated economy, and therefore more beneficial to the national macroeconomic model and development.
If citizens are using wet markets primarily to gain their produce, then they are less likely to be faced with misleading marketing information on the nutritional benefits of food.	Additional benefits to the economy such as employment of staff including those working suppliers that are providing goods to supermarkets.

In view of the benefits and disbenefits of both commercial offerings a sensible strategy integrates wet markets alongside supermarkets. Indeed, this is what customers already do to diversify the food cultural experience for positive health reasons. In many Western nations (for example Spain and Italy), wet markets function alongside supermarkets and are a preferred choice for those seeking healthful foods.²⁸ It does not have to be a case of either/or.

The emergence of supermarkets has been described as a “double edged sword” for development. On the one hand, supermarkets can lower food prices and provide opportunities for farmers and processors to access differentiated food markets. They can also contribute to influencing consumer behaviour through strategic display of fruits and vegetables. On the other, the emergence of supermarkets creates challenges for smallholder retailers and farmers who are not equipped to compete and provide similar services to modern supermarkets. The

²⁸ Achón, M.; Serrano, M.; García-González, Á.; Alonso-Apperte, E.; Varela-Moreiras, G. Present Food Shopping Habits in the Spanish Adult Population: A Cross-Sectional Study. *Nutrients* 2017, *9*, 508. CBI Ministry of Foreign Affairs, Which trends offer opportunities or pose threats on the European fresh fruit and vegetables market?, 2019 <https://www.cbi.eu/market-information/fresh-fruit-vegetables/trends>.

promotion of fresh, protective foods can also be difficult as supermarket customers continue to demand the Western dietary menu with accompanying ill health effects. Treating wet markets and supermarkets as an integrated food system offering can blunt the sword with the shield of protective foods as we transfer to a more peaceful, nutritious relationship with what we eat.

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