The Sustainability Benefits of Smart Fresh Markets

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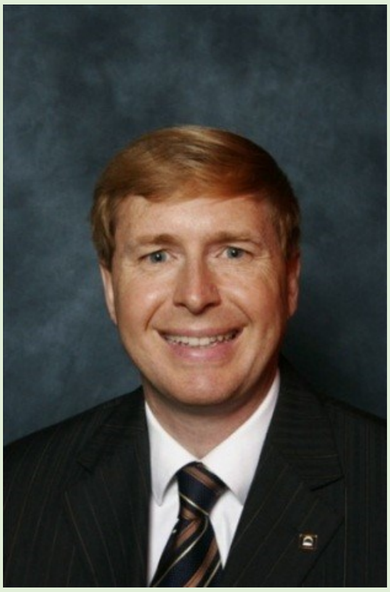

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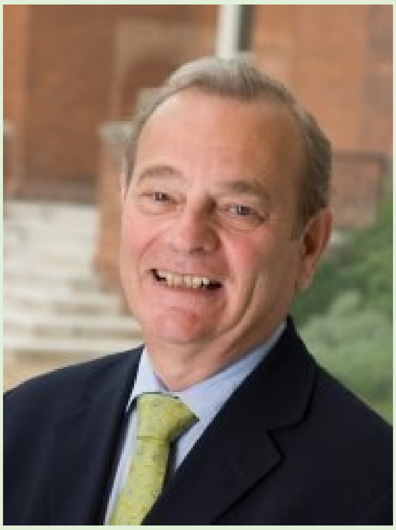

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1. Introduction

This report is aimed at the overseas development assistance, philanthropic foundation, commercial and blended finance sectors in addition to those with an interest in the benefits of Smart Fresh Markets (also identified as SFMs). Its overarching purpose is to provide an objective basis for understanding the added value and inherent stability of investing in SFMs.

As such, we identify and analyse a series of benefits from SFMs. The benefits are divided into economic, environmental, and social pillars with accompanying criteria in relation to each pillar. We structure the report systematically by identifying and explaining each criterion. Then, we provide a rationale for characterising the benefit. Then, we compare the benefit understood as a SFM Market benefit in contrast to a traditional, local fruit and vegetable produce market. Finally, where a quantitative assessment is possible, then we calculate or otherwise estimate the numerical nature of the benefit. Where a qualitative assessment based upon evidence is more appropriate then, we provide such an assessment.

What the report reveals is the numerous advantages of investing in SFMs and the promise that they hold for advancing healthy communities, local through to national economies and their accompanying climate resilient environments.

In this report we define SFMs as integrated multifunctional markets that are fit to meet current and future sanitary food needs. An SFM is a fresh market that is economically, socially, and environmentally sustainable, affordable, supports healthy diets, and uses digital technologies. Achieving 'smart' fresh markets is likely to require improved cold storage facilities, sanitation and waste management, the use of renewable power generation, digitalisation of sales data, improved transport infrastructure, and increased opportunities for additional business creation. Restorative and regenerative by design, SFMs are likely to provide lower GHG emissions, reduced food waste, greater incomes for smallholders and traders, improved data and revenue collection, improved water and waste management, healthier diets, and more associated employment.

SFMs should be suited to local contexts, and therefore, there should be no "one size fits all" approach. Rather, the basic concept should be applied sensitively to diverse local needs, designed by or in accountable consultation with local stakeholders and end users.

2. Economic Benefits

In this sub-section, we identify the economic benefits that are potentially associated with SFMs. They can be understood broadly as macroeconomic, microeconomic, and stakeholder-specific benefits as relevant.

2.1 Employment Increase (EC1)

The creation of new business opportunities associated with the multifunctional design of SFMs will lead to an increase in market-related employment.

2.1.1 Rationale

SFMs will be designed to be multifunctional, offering many different business opportunities beyond the current single market function. This increase in businesses will drive growth in employment.

2.1.2 Value-added from SFMs

Increases in employment from additional businesses will be due to the multifunctional design of SFMs. Additional employment will also be likely from construction work necessary to rebuild/retrofit or build new markets.

2.1.3 Evidence and Calculations

The total number of employees that would be linked to a multifunctional SFM with a City Market (Nairobi) size would range from 662 to 876. This is drawn from our case study of the City Market in the Report entitled *"The Economic Case for SFMs"* (Makuch, 2021). Scaling up, based upon the size of the City Market and the number of similar markets across Kenya, we project a minimum increase of 2,648,000 to 3,504,000 employment positions associated with SFMs nationally.

2.2 Increased Government Revenues (EC2)

SFMs will cause increased government revenues due to the benefits of digitized sales, as well as the increased business opportunities available.

2.2.1 Rationale

There is currently an estimated total national income stream from SFM stalls of $12.15-48.6m to municipal governments per year. From kiosks, there is an additional estimated $9.7m per year.

2.2.2 Value-added from SFMs

Increase in businesses, coupled with improved sales records due to digitization, will drive increased government revenues.

2.2.3 Evidence and Calculations

Report 2 found that the 24 (of 47) most populous counties in Kenya collected $17.18m in cess and market fees annually. Possible increases in revenue due to the projected factors above are given below.

Table 1 – Possible Government Revenue Increases

Current Revenue	5% increase in revenue	10% increase in revenue	20% increase in revenue	30% increase in revenue
$17.18m	$18.04m	$18.90m	$20.62m	$22.34m

The authors have been advised by experts at the Rockefeller Foundation (Nairobi Offices) that revenue increases are likely to reach 30% over the next 5 years. As such, we extend the table that far in percentage terms.

2.3 Increased Smallholder Earnings (EC3)

By reducing transport costs and improving customer access, smallholder farmer earnings will increase.

2.3.1 Rationale

Improved infrastructure in SFMs will allow greater buyer access to fresh produce, thereby increasing smallholder earnings. Additionally, investments in surrounding infrastructure will bring down distribution costs. If distribution methods remain as they are, we anticipate some gains from reduced distribution costs. However, we also see the potential for increased smallholder earnings from increased smallholder participation in markets directly.

2.3.2 Value-added from SFMs

There are two cases where the formalisation of small producer participation in local markets has led to higher participation rates and revenue streams. In Bihar, India, the Kaushalya Foundation[1] formalised (in financial terms) the participation of informal market sellers of fruit and vegetables. This brought 6,000 sellers into the formal economy. They have doubled their income streams by selling more and gaining higher prices for their produce. Similarly, in Kenya, enlightened Government policy broke the oligopolistic market in milk – previously controlled by a small number of sophisticated, cartelised vendors. This programme was led by the Kenya Dairy Board (KDB) to promote self-regulation, resulted in the creation of a Dairy Traders Association (DTA) in 2009. Its membership grew to over 4,000 sellers who through the benefit of a certification scheme for milk products have solved the previous dangers that attended raw milk purchasing. The DTA trains its members in all aspects of dairy hygiene and product management for the delivery of high-quality milk products to Kenyans across the nation. These market formalisation measures suggest greatly enhanced revenue streams for Government actors without the perceived barriers of exclusion that theoretically attend formalisation of market providers and sellers (the supply side).

2.3.3 Evidence and Calculations

The FAO's Smallholder Data Portrait dataset gives a median value of household income in Kenya of $3,130 in 2005 (FAO, 2019). 60.7% of that revenue was from on-farm income, amounting to a median on-farm income value of $1,990.

[1] https://www.kaushalyafoundation.org/

A report by the Kenya Markets Trust found that transport costs were the largest segment of distribution costs for a range of products, with transport reaching 48% of the distribution cost of kales (KMT, 2016).

That report also found that the average production cost for a hectare of maize was Ksh 29,980 (USD 273.3). The average maize yield in Kenya is 1.8t/ha. Therefore, the average production cost for 1 tonne of maize is $152. This is compared to a market price of $372. While the price paid to farmers may be higher than the production costs, this implies that farmers currently receive approximately 41% of the market price of maize.

To calculate the transport cost of maize, we take two approaches. First, the Kenya Markets Trust estimates transportation costs as 40% of total distribution costs. If we assume that the difference between the production cost and market price of maize is total distribution cost, then transportation costs amount to $88 per tonne of maize.

Second, we can deduce some indicative costs of transportation based on fuel costs and vehicle hire costs. One example is the transport of maize from Trans-Nzoia to Nairobi. This journey is, approximately, 400 km by the most direct route. Petrol prices in Kitale, the capital of Trans-Nzoia, are currently (as of 23/03/21) estimated at 123.73 Ksh/l by the Energy and Petroleum Regulation Authority (EPRA, 2021). The average across Kenya was 124.81 Ksh/l. Assuming fuel consumption for trucks of 20 litres per 100km, the approximate fuel costs for a return journey from Trans-Nzoia to Nairobi are 19,796.80 Ksh, or ~$180.

Having considered fuel costs, we now turn to vehicle costs. In doing so, it is important to consider the impact of cooperatives, as explored in Report 2 (Makuch, 2021b). A cooperative of smallholder farmers may choose to purchase one or more trucks to transport produce to long-distance markets. This is likely to significantly bring down vehicle costs per farmer, given the efficiency available from increased usage. However, in the below analysis, we set out the situation in the absence of a cooperative society, where a single farmer or trader transports goods to market.

Vehicle costs are calculated based on purchasing a vehicle - alternatively, vehicle hire may offer further efficiencies. Truck prices are reported on sales websites of between 2-4m Ksh (Cheki.co.ke, 2021), or between $18,000 and $36,000, for used vehicles. Spread over an assumed 10-year lifespan (and further assuming that after this period the value will be negligible), this amounts to £1800-3600 per year. If a return trip is made once a week, the vehicle cost per trip is $35-69. Combined with the fuel costs found above, this gives a total return journey cost of $215-249.

Using the dimensions of an Isuzu CXZ truck, we estimate that 200 30kg crates can be transported, meaning a total weight of 6000kg. Therefore, the transport cost per tonne of maize is estimated at $36-42.

The above analysis considered a very long journey to market – an 800km round trip. Below we set out costs for a range of distances, based on the logic set out above.

Table 2 – Transport Costs to Market for Various Distances

Roundtrip distance (km)	Fuel Cost	Total transport cost per truck	Total transport cost per tonne
20	$4.55	$40-74	$7-12
50	$11.37	$46-80	$8-13
100	$22.74	$58-92	$10-15
400	$90.95	$126-160	$21-27
800	$180.34	$215-249	$36-42

Note that these estimated costs are substantially lower than the implied cost per tonne found using the first method above. While the possibility that this 'from first principles' method has omitted some costs (e.g., repair, licensing) is acknowledged, this nonetheless appears to imply that significant savings could be made on current transport costs. Even for longer journeys, the available financial returns are some 50% beyond production costs, a profit-making opportunity indeed.

2.4 Export and wholesale market growth (EC4)

SFMs will increase the amount of produce smallholders sell to wholesale, and export markets.

2.4.1 Rationale

Digitisation and formalisation of markets allow export and wholesale market expansion by providing access to smallholders' fresh produce, providing additional income to smallholder farmers and traders.

2.4.2 Value-added from SFMs

Bringing smallholders into the export/wholesale markets increases total produce available in these markets and provides an additional revenue stream for smallholders.

2.4.3 Evidence and Calculations

In 2018, the most recent year surveyed for the Kenyan Food Balances study (KNBS, 2019) Kenya exported 167,000 tonnes of cereals, primarily sorghum; 2,000 tonnes of potatoes; 19,000 tonnes of pulses; 72,000 tonnes of vegetables; and, 98,000 tonnes of fruit. We project that – if Kenyan food security requirements are met – the proximity of the main SFMs to export and wholesale markets could mean targeted, conservative growth in exports of 1% per year for the next five years. Hence, based upon current market prices for pulses, vegetables, and fruit this represents an increase in the value of exports of $29.2m. Note that this calculation is based on the exports reported KNBS Enhanced Food Balance Sheets for 2018. Some of the data is reported in groups of products, meaning comparison with a single commodity price was not always possible. Therefore, for the product types affected an average price across products, weighted by production level, was used to calculate the export value and projected rise in exports.

2.5 Increases in dependents' wellbeing (EC5)

Increases to stallholder and farmer incomes will have a knock-on effect on dependents' wellbeing.

2.5.1 Rationale

87% of kiosk and small shop workers are smallholder farmers, upon whom their families also rely for their living circumstances.

The average Kenyan household has 3.6 people (UN DHS, 2015), meaning for every individual employed, almost three co-householders are likely to also benefit.

2.5.2 Value-added from SFMs

An increase in smallholder earnings due to the introduction of SFM reforms will increase dependents' wellbeing.

2.5.3 Evidence and Calculations

The average smallholder family size (from 2005 data) is 5.1 in Kenya (FAO, 2019). Therefore, any increase in earnings for smallholder farmers will have a further impact on their wider family. If 1 family member sees a direct increase in earnings, an average of 4.1 others will also see an uplift in their wellbeing.

Additionally, the median smallholder farm employs 0.2 labour-days of hired labour per day, the highest value in the Sub-Saharan Africa component of the FAO Smallholder Data Portrait. Increases to smallholder earnings are likely to have positive impacts on employed farm labourers, either through more hours worked or through increased pay.

2.6 Formalization increases profits & government revenues (EC6)

Formalization will allow for improved decision-making by stallholders and farmers due to price transparency and improved symmetric information. Government revenues will be increased due to the transparency of sales.

2.6.1 Rationale

Formalization of market prices will create price transparency for buyers and sellers, both across a market and potentially across all markets. This will help alleviate the asymmetric information problem, rationalising prices across markets, and avoiding price gouging.

Formalized sales will also improve government revenues by giving tax authorities greater access to sales information.

The Kenyan Revenue Authority rolled out a digital tax platform, iTax, in 2013 to improve revenue collection (IMF, 2018). Digitalization has expanded the tax base and increased tax collection (Ndung'u, 2017). This has been enabled by the growth of M-Pesa, a mobile payments platform that has rapidly boosted financial inclusion in Kenya (Ndung'u, 2017). Informal economy participants previously had to physically visit a KRA office. However, they are now able to use virtual payments (Ndung'u, 2017). Oudraeogo and Sy (2020) also find that digitalization is associated with a decrease in perceived corruption, based on Afrobarometer survey data. Such a decrease is to the benefit of both supply-side actors (producers, traders, retailers) and Government authorities as sales prices (and tax collection amounts) become greater and more certain.

2.6.2 Value-added from SFMs

The digitalisation of sales helps avoid potential corruption that could lead to inefficient prices and loss of tax revenue.

2.6.3 Evidence and Calculations

See section 2.3.2 for a discussion of case studies of the benefits of formalization.

2.7 Economic benefits from new uses - childcare (EC7)

The provision of childcare can enable more women to enter the employment market, as well as providing a business opportunity.

2.7.1 Rationale

Childcare facilities will allow more women to work in markets, increasing women's earnings. 32% of Kenyan households have female headship, and of those households headed by a woman, more than two-thirds are lone parents with children under age 15 (UN, 2017). Increases in women's income, therefore, have disproportionately positive effects on children.

2.7.2 Value-added from SFMs

We project an increase in female participation at SFMs due to the provision of day-care facilities. 32% female heads and 67% of female-headed households being a lone parent with under 15 children, potentially means 20% of people excluded – in other words, day-care means 20% can be included. Taking the total number involved in Kenyan fresh markets calculated in Report 2, this analysis will calculate the potential number of sole parent women who could be involved in SFMs, given childcare is provided. Some may be able to leave children with relatives, or 'dual-task' at the market, but that still limits their ability to work and stops relatives from working.

2.7.3 Evidence and Calculations

The estimated Kenyan population is 52,573,973 (UN, 2019). The average household size is 3.9, meaning there are approximately 13,480,506 households in Kenya.

21.44% of all households are female-headed households with a lone mother with under-15 children. This equates to approximately 2,890,220 households, and equivalently, 2,890,220 single mothers.

The total working age (15-65) females in Kenya is 15,495,185. Meanwhile, the total working-age population is 30,694,157 (UN DHS, 2019). Hence, 18.7% of working-age women, and 9.4% of the total working-age population, are women leading households in which they are the single parent to children under 15.

Given an estimated 112,500 stallholders in Kenya, 0.37% of working-age Kenyans are stallholders. If a similar proportion of single mothers were stallholders, this would equate to 10,593 women that could be stallholders, if childcare is present. Some number of single mothers will of course already be stallholders. Note that this figure only counts stallholders – there will be further employment opportunities in surrounding SFM functions, such as kiosks, food stalls and other employment roles associated with the new multifunctionality of our 21st Century SFM design.

2.8 Economic benefits from new uses – cold storage (EC8)

Cold storage is integral to the SFM concept and will provide jobs and business opportunities.

2.8.1 Rationale

We project economic benefits from either microbusiness creation or increased employment, revenues from existing businesses due to cold storage installation and maintenance.

2.8.2 Value-added from SFMs

The proposed cold storage will represent new business opportunities, either due to an expansion in existing cold storage businesses, or new businesses.

2.8.3 Evidence and Calculations

The FAO gives a median figure for food loss at the retail stage of 15.6% for Kenya (FAO, 2019). If we assume that 75% of this retail stage food loss is due to food spoilage due to lack of refrigeration, this amounts to 11.7% of food lost due to lack of refrigeration.

Using the example given in Report 1 (Makuch, 2021a), a 20 m2 cold storage unit can store 150 30kg crates. Assuming that fruits and vegetables require cold storage for one week on average (noting that some produce will be sold sooner than this), 1.7 million crates of capacity would be required across Kenyan fresh markets. This would require 11,329 cold storage units.

If we assume that 10% of fresh markets (by weight sold) already have refrigeration, this will still require an additional 10,196 units to be installed.

We assume that each cold storage unit will require the equivalent of one full-time employee to manage the operation of the cold storage facility. The additional employment from operating these cold storage businesses will therefore be between 10,196 and 11,329 additional workers nationally. The avoided food waste would also be substantial as we discuss elsewhere in this report.

2.9 Economic benefits from new uses – street food (EC9)

SFMs will foster street food businesses, providing micro-business opportunities.

2.9.1 Rationale

SFMs will include facilities to support street food businesses such as designated areas with biogas connections and waste systems in place. This will facilitate an increase in such businesses, with the potential for diversification for stallholders.

2.9.2 Value-added from SFMs

SFMs will support increases in street food businesses from current rates.

2.9.3 Evidence and Calculations

Given total stallholders of 112,500 in Kenyan fresh food markets, and an assumed average market size of 200 stallholders, we calculate that there are approximately 562 local food markets in Kenya.

We further assume that the average 200-stallholder market could accommodate between 6 and 10 street food businesses, each employing two people. This equates to 6,744 and 11,240 employees of street food businesses across Kenyan SFMs.

2.10 Economic benefits from new uses – fitness (EC10)

The management and operation of fitness facilities will provide employment opportunities.

2.10.1 Rationale

Provision of fitness areas leads to healthier lifestyles and an increase in employment and revenue due to business creation.

2.10.2 Value-added from SFMs

Fitness facilities are a new potential function of SFMs, not currently operating in local markets.

2.10.3 Evidence and Calculations

Given total stallholders of 112,500 in Kenyan fresh food markets, and an assumed average market size of 200 stallholders, we calculate that there are approximately 562 local food markets in Kenya.

Assuming two full-time fitness employees per market, this equates to 1,124 fitness employees.

3. Social Indicators

3.1 Health – reduction in air pollution (SO1)

The use of renewable energy sources instead of diesel generators will reduce air pollution in SFMs, with positive effects on health due to reduced exposure.

3.1.1 Rationale

Reduction in use of polluting power generation to reduce harmful effects of air pollution.

3.1.2 Value-added from SFMs

The provision of renewable energy sources will significantly reduce the number of pollutants, improving local air quality and reducing health impacts of air pollution.

3.1.3 Evidence and Calculations

The WHO estimates that there were 888 air-pollution attributable DALYs lost per 100,000 population. Moreover, there were 78.1 air pollution attributable deaths per 100,000 population.

To understand the exposure due to markets, we assume only those over age 15 will regularly visit markets. There are approximately 33,510,999 Kenyans over the age of 15, using CIA World Factbook estimates. Thus, potential exposure to air pollution in markets is high.

Jakhrani et al (2012) estimate consumption of 4.07 litres per diesel generator in a six-hour period. We assume a minimum operational period of 10 hours per day for Kenyan food markets, implying consumption of 6.78 litres per day. The following formula is used to calculate pollutant emissions:

$E = EF.A$

Where E = Emissions of a given pollutant, EF is the Emissions Factor, and A is the Activity rate

6.78 litres = 5.79kg (using UK Government estimates of fuel weight)

UK Government estimate of GJ per kg = 0.0453

Meaning GJ per day = 0.262

Using EMEP EEA values for Emission Factors, we, therefore, find the below values for grams of pollutant per day for one generator.

Table 3 - Pollutant Totals per Day per Diesel Generator

Pollutant	Emission Factor	Grams per day
NOx	942	247.2
CO	130	34.11
SO2	48	12.60
PM2.5	30	7.87

Table 4 - Pollutant Totals per Year per Diesel Generator

Emissions per year (kg)			
Days per year	**313 (6 days per week)**	**350 (assuming market open all week, except certain holidays)**	**365 (assuming market open every day of the year)**
NOx	46.4	51.9	77.4
CO	6.4	7.2	10.7
SO2	2.4	2.6	3.9
PM2.5	1.5	1.7	2.5

Assuming 10 generators per 100 to 150 stallholders, we find the below emissions estimate for all Kenyan food markets:

Table 5 - Pollutant Emissions per Year for Ten Diesel Generators

Kenya emissions per year (kg)			
Days per year	**313 (6 days per week)**	**350 (assuming market open all week, except certain holidays)**	**365 (assuming market open every day of the year)**
NOx	580,285 – 870,427	648,880 – 973,321	676,690 – 1,015,034
CO	80,082 – 120,123	89,548 – 134,322	93,386 – 140,079
SO2	29,569 – 44,353	33,064 – 49,596	34,481 – 51,722
PM2.5	18,480 – 27,721	20,665 – 30,997	21,551 – 34,326

As a means of understanding these emissions values, we can compare to the equivalent number of diesel vehicles. The below table gives details of current and historical EU emissions standards.

Table 6 – Emissions from Vehicles based upon Euro Standard Classifications

	Year of Entry	CO (g/kWh)	NO_x (g/kWh)	PM (g/kWh)
Euro I	1992	4.5	8.0	0.61
Euro II	1997	4	7.0	0.15
Euro III	2001	2.1	5.0	0.13
Euro IV	2006	1.5	3.5	0.02
Euro V	2011	1.5	2.0	0.02
Euro VI	2015	1.5	0.4	0.01

Source: Adapted from Reşitoğlu et al., 2015.

Therefore, 10 diesel generators operating for 10 hours per day in a market is the equivalent of approximately 10 to 12 diesel vehicles engines idling on-site at the market throughout the day if they were built under 2001 emissions standards, or 120 to 150 vehicles running on-site if they were built under 2015 emissions standards. It is noted that the average vehicle age in Kenya is 15 years (Deloitte, 2016).[2] The intensity of said emissions equals or exceeds that of busy traffic routes in the capital city of Nairobi with associated adverse impacts on human health and environmental resources (air, water and land).

3.2 Risk of disease transmission lowered (SO2)

Modernised waste management processes reduce the risk of disease transmission within SFMs.

3.2.1 Rationale

Improper waste management leads to organic matter rotting, and unbiodegradable waste build-up which can bring disease, pests and overall reduce community wellbeing (Global Dialogue on Waste, 2016). Polluted water courses can get blocked and stagnant, creating ideal spawning grounds for malaria carrying mosquitoes.

31% of all deaths due to diarrhoea in lower- and middle-income countries are due to poor sanitation (WHO, 2019). Improved sanitation can reduce rates of diarrhoeal

[2] Deloitte Touche have determined the average vehicle age in Kenya to be 15 years associated with high pollution loads and a market growing over 7% year to year (2005-2014).

disease by 32-37% (Mara et al, 2010). Nationally, 29% of people have access to improved sanitation – 14% practice open defecation, the highest risk for disease spread (Republic of Kenya, 2015). Unsafe water, sanitation and hygiene is the second leading risk factor in Kenyan mortality (Republic of Kenya, 2015).

3.2.2 Value-added from SFMs

The provision of formal waste management facilities is projected to lead to a reduction in disease transmission within markets.

3.2.3 Evidence and Calculations

To the extent that sanitary waste management facilities are in place and that our suggested approach to the use of bathroom/washroom facilities is implemented in our 21st Century SFM design then these disease transmission risk issues will be minimised to the greatest extent possible. The same applies to our suggested risk management Covid-19 procedures.

3.3 Covid-19 compliance made easier (SO3)

Formalised and controlled entrances, and managed routes through SFMs, make Covid-19 compliance easier to enforce.

3.3.1 Rationale

Management of customer flow through markets allows for one-way systems and capacity limits.

Nouvellet et al. (2021) found that strict measures to reduce mobility were associated with a reduction in transmission of Covid-19.

3.3.2 Value-added from SFMs

Control of entry and exit to SFMs can help to limit capacity – a stated aim of the Kenya Ministry of Health (MoH, 2020). Few studies currently exist on efficacy of one-way systems in reducing transmission (see Ying & O'Clary, 2020, preprint, for one example), but formalized entry/exit points would enable such strategies if required.

3.3.3 Evidence and Calculations

This is manageable provided that the suggested Covid-19 risk management procedures are applied. This is addressed in the Report 1 – *Horizon Scanning for Fresh Markets* in sub-section 2.1(Makuch, 2021a).

3.4 Safe drinking water available (SO4)

SFMs will use rainwater harvesting and water storage to provide safe drinking water.

3.4.1 Rationale

Rainwater harvesting and water storage can help even out seasonal precipitation variation. This will allow provision of safe drinking water, without placing stress on local sources (i.e., from ground sources).

In 2016, Kenya lost 1,270,053 disability-adjusted life years (DALYs) due to poor water and sanitation practices, according to the WHO. This is a rate of 2,621 DALYs lost per 100,000 population.

Much of the health impact from unsafe drinking water is due to diarrhoea. Diarrhoea causes 8% of all deaths under 5 globally, and 60% of all diarrhoea deaths are due to inadequate water supply, sanitation, and hygiene (Gomes, F. *et al.*, 2020). Ensuring safe drinking water, sanitation and hygiene can therefore drastically reduce diarrhoea mortality.

3.4.2 Value-added from SFMs

Provision of rainwater harvesting, and safe water storage facilities will reduce the likelihood of waterborne disease spread within markets.

3.4.3 Evidence and Calculations

Our water harvesting solutions provide safe drinking water and other water use requirements on site at SFMs while providing similar off-site contributions and solutions for farmers and their families. Please see sub section 2.4.7 of Report 1 – *Horizon Scanning for Fresh Markets* (Makuch, 2021a).

3.5 Improved outcomes for women (SO5)

Women are empowered to participate in SFMs due to provision of childcare.

3.5.1 Rationale

Women make up a large proportion of traders and stall holders and are therefore likely to benefit from the increased revenues projected by EC3. Furthermore, creche/day-care facilities will provide childcare to empower women to participate in the market and therein redress gender inequality present in rural agriculture while enabling social mobility.

3.5.2 Value-added from SFMs

We project an increase in women traders due to childcare facilities, which would mean an increase in total women's earnings, with additional benefits to dependents.

3.5.3 Evidence and Calculations

See EC7, above. An estimated 10,593 women who are single mothers with children under age 15 could be employed in SFMs, provided childcare facilities.

3.6 Healthier, prolonged lives (SO6)

Sale of protective foods in SFMs will promote longer, more healthy lives.

3.6.1 Rationale

Healthy diets are essential to reduce the burden of disease and ensure that people are able to live productive, contented lives. Conway et al (2021) in their Briefing Paper for the Rockefeller Foundation, find that the average child will only be 40% as productive as their potential if they received a full education and healthy diet.

3.6.2 Value-added from SFMs

Virtually all commodities sold at fresh markets contribute to healthy diets. More food sold at SFMs means more healthy food, therefore more people eating healthy foods. We simplistically define healthy foods as those that are not processed, with low sugar, salt, and fat content.

3.6.3 Evidence and Calculations

The EAT-Lancet Commission recommended adoption of the ‘planetary health diet’, which emphasises consumption of fruits and vegetables, whole grains and plant-sourced protein (EAT-Lancet, 2019). This would require a more than doubling of current fruit, vegetable, legume and nut consumption (EAT-Lancet, 2019). The Commission estimated that adopting the planetary health diet would avoid 11 million deaths per year, thanks to the reduced risk of coronary heart disease, stroke, type-2 diabetes, some cancers, and a range of other diseases (Willett et al, 2019). Therefore, the need to “drastically increase the intake of ‘protective foods’” (Flor, 2019) is clear.

Abrahams, Mchiza & Steyn (2011) report, based on WHO data, that Kenya has a mortality rate of 729 per 100,000 population due to non-communicable diseases (such as type-2 diabetes, cardiovascular diseases and cancers). Moreover, 12.3% of Kenyan women are underweight, while 25.1% are overweight or obese (Abrahams, Michiza & Steyn, 2016). An important contributor to these problems is due to diet, with underweight likely due to lack of access to food or to nutritionally beneficial food, and overweight due to lack of nutritionally beneficial foods, and lack of awareness of the benefits of protective foods.

A study for the Global Burden of Disease 2017 study found that the mortality rate due to dietary risks in Kenya was 225.4 per 100,000, while there were an estimated 4971.4 lost DALYs attributable to dietary risks (Afshin, A. *et al.* 2019.). In comparison, Western Europe saw a mortality rate due to dietary risks of 121.0 per 100,000 and lost an estimated 2441.5 DALYs attributable to dietary risks (Afshin, A. *et al.* 2019). In Kenya, 11.9% of all-cause mortality was attributable to dietary risks (Afshin, A. *et al.* 2019).

3.7 Greater youth participation (SO7)

SFMs aim to provide training and opportunities for young people through its multifunctionality and a range of employment opportunities for youths.

3.7.1 Rationale

Young people are currently disproportionately likely to be employed in food markets (FAO, 2009). The retail trade as a whole, employs a third of urban Kenyan youth (World Bank, 2016). Therefore, increased employment opportunities and formalisation of markets will lead to improved outcomes for youth employment.

3.7.2 Value-added from SFMs

Where SFMs contribute to greater smallholder earnings, that will maintain youth participation in agriculture. SFMs will be designed to include training for potential participants in SFMs or the wider agricultural sector, to advance sustainable livelihoods and make this work more economically viable. The diversifying business models due to the multifunctionality of SFMs means there will be more entrepreneurial opportunities, and more diverse employment opportunities for youth. Therefore, we expect there will be higher quality youth employment as well as higher quantity of youth employment.

3.7.3 Evidence and Calculations

Kenya has existing youth skills training, which have proved successful – increasing employment and leading to higher earnings (Ismail, 2018). For example, the Kenyan Youth Empowerment Project saw male employment increase by 14%, and women's earnings increased by 7,500Ksh.

The USAID project Kenya Youth Employment and Skills Program (K-YES) supported more than 45,540 Kenyan youth without a high school certificate to gain new or higher quality employment between 2015 and 2020 (USAID, 2020). Meanwhile, the Pan-African Youth Entrepreneur Development Program (PAYED) supported young entrepreneurs in the micro-retail sector to expand their businesses (TechnoServe, 2018). The World Bank Kenya Youth Employment and Opportunities program seeks to improve youth employability through training and work experience in the formal and informal sectors (World Bank, 2016).

These existing programs show the importance of youth training for achieving the 'youth dividend' promised by Kenya's young population (World Bank, 2016). The potential benefits of this youth dividend will only be achieved if young people receive appropriate training to achieve high quality employment (World Bank, 2016).

4. Environmental Indicators

4.1 Reduced food waste (EN1)

Cold storage and intelligent market design mean SFMs help to reduce food waste.

4.1.1 Rationale

Improved road infrastructure and access to SFMs reduces damage and spoilage to produce. In Sub-Saharan Africa, most post-harvest loss is due to production, handling, and storage challenges, with a relatively small amount due to consumption waste (FAO, 2019). Effective cold storage can extend product life by days to months, depending on the produce type, lengthening saleability. Improved data collection and pricing information through use of mobile internet is projected to produce a fairer price and lower chance of food loss due to imbalance of supply and demand.

In addition to cold storage, fruits and vegetables that are not sold as commodities can be converted to fresh juices. While some of the nutritional value will be lost, and juices can be high in sugar, we anticipate that the effect on health would be minor given the low quantities involved. Conversion of fruits and veg that would otherwise become waste into juice is a valuable alternative, taking produce out of the waste stream. There has been growth in demand for fresh fruit and veg drinks (Mwangi, 2014), creating a new opportunity for trader sales.

4.1.2 Value-added from SFMs

Cold storage facilities and smart design of markets (to exclude sun, wind from stalls) allow longer shelf life of fresh food, thereby decreasing food waste.

4.1.3 Evidence and Calculations

The FAO estimate for food loss at the retail stage is 15.6% for Kenya, the largest of any stage in the value chain (FAO, 2019). Report 2 gives estimates of a range of fruits and vegetables sold at fresh markets, totalling 2.65m tonnes of fresh produce. Therefore, approximately 489,996 tonnes of fresh produce are lost at the retail stage annually. Note that this is likely to be an underestimate, because only some fresh products were estimated in Report 2.

If it is assumed that full cold storage provision could achieve the median estimate food loss globally, at 8.7% (FAO, 2019), this would result in a 44% decrease in food loss associated with the retail stage, or 216,729 tonnes of fresh produce saved annually.

This reduction in retail stage food loss by 6.9% has a number of implications for food producers. Producers could produce 6.9% less food and maintain the amount consumed or continue to produce their current production quantity and see an increase in sales of 6.9%. Either case is highly likely to see improved revenues for food producers.

If current production levels are maintained, 1.84 million crates of cold storage capacity would be required nationally, compared with 1.70 million crates if current retail levels were maintained (as reported in EC7). Report 1 proposed a price per 30kg crate of $0.25 per day for cold storage. This amounts to an approximate storage cost of $8.33 per tonne per day, compared to current produce prices of $484 per tonne for tomatoes or $180 per tonne for mangos, as found in Report 2.

If producers chose to produce 6.9% less food, this could be achieved either by reducing the land area farmed, or farming in a less intensive way (i.e. by using fewer inputs), both of which would have positive environmental effects on local ecosystems.

SFMs, through provision of cold storage solutions, offers the opportunity to extend the saleability window of fruits and vegetables. Therefore, in addition to the environmental gains from reduced food waste, cold storage also provides social benefits in the form of increased provision of protective foods, and economic benefits to market traders from an increase in the saleable produce, through reductions to product wastage. The table below, from CRS Cold Storage (2018), gives details.

Table 7 – Cold Storage Life of Selected Fruits and Vegetables Sold at SFMs

Produce Type	Optimum Temp °*C*	Optimum humidity %	Storage life
Apples	1-4	90-95	Up to 12 months
Bananas	13-16	80-95	Up to 3 weeks
Berries (incl. Strawberries)	0	90-95	Blackberries/raspberries (3 days), strawberries/cherries (7 days)
Grapes	0	85	Up to 8 weeks
Nectarines, plums, and peaches	0	90-95	Up to 5 weeks
Pears	-1-0	90–95	Up to 7 months
Broccoli and cauliflower	0	95-100	Up to 4 weeks
Carrots, mature and immature	0	98-100	Mature, up to 9 months and immature up to 6 weeks
Onion, white and red	0	65–70	Up to 8 months
Lettuce	0	98–100	Up to 3 weeks

4.2 Improved waste management (EN2)

Formal waste management facilities and novel techniques for waste management help to minimise the impact of waste on the surrounding environment.

4.2.1 Rationale

Provision of formal waste management, combined with use of techniques such as Black Soldier Fly and Biogas digesters, can reduce the amount of harmful waste discharged to the surrounding environment.

Effective waste management is important for both environmental and health reasons, with leachate from improperly managed waste causing contamination of groundwater (Vasanthi et al., 2007). Improperly treated waste can also act as a vector for infectious disease spread (Ziraba et al., 2016). Yet rates of safe waste management remain low, with one estimate setting the rate of solid waste collection in Nairobi at 33% (Njoroge et al., 2013).

4.2.2 Value-added from SFMs

Formal waste facilities, including a dedicated waste track for meat and fish waste, aim to eliminate discarded waste in-market. Organic waste will be used as feedstock for BSF and biogas digestion to reduce harmful effects on local environment and provide income streams.

4.2.3 Evidence and Calculations

In addition to substantially reducing if not eliminating food-borne diseases BSF markets add a new business proposition for remaining food waste. BSF consumes 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 be employed as means of breaking down all organic waste - and produce feedstock for livestock and aquaculture, or potentially for direct human consumption.

Alternatively, or as a complement to BSF solutions, food waste can be used in biogas digesters to generate electricity. Biogas Digestors could be a feature at every fresh food market. They provide both high-quality energy and fertilizer, reducing reliance therein on both fossil fuels and charcoal, and expensive chemical fertilizers respectively. Biogas is a substitute for natural gas to cook, to produce vapor, hot water or to generate electricity. Clearly, solar power is preferable to biogas in electricity generation wherever possible, given its renewable and zero-carbon nature. But biogas can provide an important alternative to natural gas in the other energy uses detailed above. Biogas has a lower global warming potential than natural gas which is 99% methane. In contrast, biogas is generally comprised of 60% methane and 40% carbon dioxide, therefore offering an alternative with lower global warming potential.

4.3 Improved water management (EN3)

Rainwater harvesting and water storage help to reduce and smooth the impacts on surrounding water sources.

4.3.1 Rationale

Rainwater harvesting technologies that do not rely on expensive pumps or filters can offer more reliable water provision. This reduces the impact of markets on local water sources, such as rivers, lakes and aquifers. In turn it can provide needed water for maintaining clean, sanitary conditions, watering produce and providing water for drinking, cooking or washing.

Abstraction of water from Kenyan lakes can cause a decline in ecosystem health and the resultant ecosystem services (Otiang'a-Owiti & Oswe, 2007; Baker & Miller, 2013).

4.3.2 Value-added from SFMs

The improvements to rainwater harvesting and storage are anticipated to result in a reduction in water drawn from ground or mains sources, with which there are both quantity and quality issues, as well as potentially having damaging implications for local ecosystems.

4.3.3 Evidence and Calculations

The primary benefits of rainwater harvesting, and storage solutions are to farmers, whose commodities supply SFMs. On-site SFM water harvesting, and storage provision has added benefits by removing or substantially reducing the need for mains water. This solution is particularly valuable where access to mains water is absent.

4.4 Lower GHG emissions (EN4)

Use of renewable technologies such as solar panels help to reduce GHG emissions from SFMs, compared to diesel generator produced electricity.

4.4.1 Rationale

Use of solar panels to power cold storage, alongside use of biogas for power and cooking reduces GHG emissions compared to current power generation methods. All-in-one units are available and operating in SSA.

4.4.2 Value-added from SFMs

Replacement of diesel generators with renewable energy as part of SFMs will mean lower GHG emissions associated with markets.

4.4.3 Evidence and Calculations

Jakhrani et al (2012), in their report on diesel generator emissions, gave a central estimate of the emissions for a 5kW generator of 12.21kgCO2 per day. It is considered likely that such generators will run most days of the year in market settings. Estimates of the yearly CO2 emissions are highlighted below, for different usage levels.

Table 8 – 5kW Diesel Generator CO2 Emissions per Year

kgCO2 per year			
Days per year	**313 (6 days per week)**	**350 (assuming market open all week, except certain holidays)**	**365 (assuming market open every day of the year)**
Emissions	3821.73	4273.50	4456.65

The above gives indicative emissions for one 5kW diesel generator. We assume that there will be approximately 10 such generators per 100 to 150 stallholders. Given an estimated 112,500 stallholders in Kenyan food markets, this analysis can be extended for all Kenyan food markets, as follows.

Table 9. Total Kenyan SFM Diesel Generator CO2 Emissions per Year

Emissions estimate per 10 generators	38,217.3	42,735.0	44,566.5
Kenya; 10 generators per 100 stallholders	42,994,462.5	48,076,875	50,137,312.5
Kenya emissions; 10 generators per 150 stallholders	28,662,975	32,051,250	33,424,875

Therefore, Kenyan local markets are associated with between 28,662,975 and 50,137,312.5 kgCO2 per year. Alternatively, between 28,663 and 50,137 tCO2 per year.

Kenya's INDC for the 2015 Paris Agreement committed to achieving a 30% reduction on the BAU scenario of 143 MtCO2eq. Entirely abating the CO2 emissions from local market diesel generators would therefore provide approximately 0.04-0.12% of the required 30% reduction to Kenya's GHG emissions under its INDC.

We can estimate the financial cost of the GHG emissions associated with diesel generators by comparison with carbon prices. A range of carbon prices currently exist around the world, ranging from less than \$1/tCO2e, to \$127/tCO2e (World Bank, 2019). The High-Level Commission on Carbon Prices reported that the minimum level required to meet the requirements of the Paris Agreement was \$40-80/tCO2e (HLCCP, 2017). This implies a value of between \$1.15m to \$4.01m associated with GHG emissions from diesel generators in Kenya.

Even if we assume a carbon price of \$10/tCO2e, which may be perceived as more appropriate to the emerging economy context, removing diesel generators from markets would still generate carbon savings equivalent to \$287,000 to \$501,000. As tradable emissions schemes become ubiquitous nationally and internationally under the United Nations Paris Agreement on Climate Change carbon prices standardised at \$50/tCO2e (still below the full social and environmental cost of carbon) represent a five-fold multiplier in relation to these projected savings.

5. Co-benefits with Road Infrastructure Investments

Taking the example (cited in this report at sub-section 2.3.3) where the production cost of maize is \$152/tonne and its retail price is \$372, transport costs represent the highest additional cost as between these two figures. This has much to do with the quality of road infrastructure and the restricted market in transport modes. Noting that traditionally (as also in the 21st Century context) transportation infrastructure has attracted significant foreign public and private investment, it is helpful to illustrate how co-benefits arise between fresh market provision of retail services for food and transport cost reduction in part through wise business practices (as illustrated in sub-section 2.3.3) and modernisation of road infrastructure. The following sources illustrate these interactions understood as co-benefits.

Table 10 - SFM CO-Benefits with Road Infrastructure Investments

Source	Insight
1. Do better roads really improve lives? (worldbank.org) 2. World Bank Document	A World Bank road-building intervention in Brazil caused an increase in girls attending school (potentially leading to increased job opportunities in future); an increase in agricultural jobs, and an increase in household income (by between $40-70 per month in one study area). It also increased bus and car usage. As such food systems, food security and related food-provision was inextricably linked to transport infrastructure.
3. World Bank Document	Review of evidence on transport interventions. 'Big Push' theory claims roadbuilding will reduce costs, leading to a rise in productivity and pushing the economy to a higher growth equilibrium. Empirically, transport investment does cause increase in growth (e.g., Calderon et al, 2015). Improving transport would have large positive effects on trade. Freund and Rocha (2011) find that a one day decrease in overland travel time would lead to a 7% increase in exports in Africa; meanwhile, Buys et al (2010) show that upgrading the primary road network between Sub-Saharan Africa's major cities would lead to an increase in trade of $250bn over 5 years (costs: $20bn initial investment with $1bn annual maintenance). In SSA, reducing travel time to markets causes an increase in agricultural production (Dorosh et al, 2012), and a 1% increase in market access is associated with a 0.03% increase in a country's GDP per capita (Bosker & Garretsen, 2012). Volpe Martincus et al (2014), found that a road improvement program in Peru cause an increase in firms' average annual growth rate of exports by 6.4%, and subsequent employment increases of 5.1%. Ali et al (2015) find that falling transportation costs lead to an increase in the production of high-input crops, highlighting a shift from subsistence to commercial agriculture. Further, Ali et al (2015a) find that falling transport costs in Nigeria were associated with lower probability of employment in agriculture, and higher likelihood of being in full employment – this is indicative of a shift in employment from agriculture to non-agriculture jobs. In Bangladesh, Khandker et al (2009) find that improved rural roads lead to increases in school enrolment. Blimpo et al (2013) find that lower transport access is associated with food security problems.

	In summary, this study points to the relationship between food security, agricultural efficiency, increased revenue and its distribution and export -led growth for valuable foreign exchange income.
4. Assessing the socio-economic impacts of rural road improvements in Ghana: A case study of Transport Sector Program Support (II) - ScienceDirect	A road improvement program in Ghana had strong positive effects on food production and household income. It also saw increases in the amount sold at district or regional markets, as opposed to food sold at home or at village markets; this was also associated with higher prices received for smallholder farmers with knock-on effects for their families and farm workers.
5. The Akatsi-Akanu road project stimulates trade and improves livelihoods in Ghana and Togo - report | African Development Bank - Building today, a better Africa tomorrow (afdb.org)	A road building project in Ghana delivered benefits in the form of increased trade, including cross border trade and reductions to transport costs. It also had ancillary benefits from the creation of food markets along the road – these benefits were felt especially by women, because of the high representation of women in such markets both as sellers and buyers.

6. Conclusion

What this report reveals across three pillars (economic, social, and environmental) and 21 related criteria is the numerous advantages of investing in SFMs and the promise that they hold for advancing healthy communities, local through to national economies and their accompanying climate resilient environments.

As such, investments through loans and grants from national and international private sector financial institutions, national development assistance programmes and philanthropists and charitable foundations make eminently good sense not only in terms of the traditional internal rate of return (IRR) that bankers cherish but with the added co-benefits that attend such investments.

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