Chapter 19

Design of a Food Waste Management Program in Reducing Urban Food Waste

Olubunmi Racheal Ajayi

Griffith University, Australia

Scott R. Baum

<https://orcid.org/0000-0003-1711-2087>

Griffith University, Australia

Cordia Chu

Griffith University, Australia

ABSTRACT

Sustainable food systems can contribute to addressing food security, poverty alleviation, and economic growth. With 870 million people around the world being undernourished, and food shortages exacerbated by climate change, the United Nations, in 2013, made food security a priority. This study aimed to develop a food waste reduction program model to assist with designing and delivering effective responses in relevant institutions. This study conducted desktop review of literature, detailing proven practices in food waste management systems and synthesised key success factors. Three cases, from San Francisco, Taiwan, and South Korea, were chosen for further analysis because they have a proven track record of success. The study also proposes a program for designing, implementing, and evaluating future food waste management programs. The findings have identified significant policy opportunities for food waste management strategies and have provided an opportunity to develop food waste guidelines as many work towards the 2030 Sustainable Development Goal of halving global food waste.

INTRODUCTION

Sustainable development is at the core of our human existence and has evolved as a significant policy concern for governments and business organizations (Mebratu, 1998). The Brundtland report (1987) which brought this concept to the forefront defines sustainable development a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). In 2015, a universal agreement was signed by 193 UN Members States to end poverty. The 17 goals consisting of 169 targets were adopted to address rapidly changing landscapes and developmental initiatives affecting the environment, economies and the social spheres of existence (United Nations, 2015). It is vital to take into cognizance the universal nature of these goals and the freedom embedded in member states to monitor outcomes and progress nationally, using guidelines provided by the United Nations. With projections of global human population increasing to 9.3 billion by 2050 and forty-seven percent of the growth in sub-Saharan Africa (Hanson, 2013), it is pertinent for Africa to combat food insecurity. The Millennium development goals (MDGs) reflect the commitment to sustaining future generations.

Zero waste, one of the most innovative concept of the century (Zaman, 2003 & Zaman, 2004) is a key area for achieving Sustainable development. Several developed countries have implemented zero waste agendas to conserve depleting resources. Many developing economies can benefit from the zero waste concept. This chapter contributes to institutional development in Africa by elaborating on how African countries can use the zero waste concept to their advantage. Overconsumption trends and the materialistic culture of consumers has resulted in unprecedented increases in waste, which cannot be sustained by current purchase, use and dispose of in landfills practice. Zero waste encapsulates holistic (Song et al., 2014) visionary and closed-loop (Park & Lah, 2015) concepts of managing waste as a resource. One of the critical areas where the concept of Zero Waste is crucial is in the area of food waste. Food waste is defined as ‘*food, which was originally produced for human consumption but then was discarded or was not consumed by humans*’ (Thyberg & Tonjes, 2016).

There can be little doubt that food waste continues to be a global problem and one that is increasing over time. Over 2 billion people in the world experience moderate to severe levels of food insecurity. There are increasing levels of hunger in sub regions of Africa (FAO, 2019). As concern grows about the wide-ranging impacts of food waste on human society, the economy and the environment, local, national and international institutions are introducing programs and policies aimed at addressing the problem (Thyberg & Tonjes, 2016). These efforts are laudable and must continue to be implemented in line with the best evidence. Although difficult to measure and quantify, the available empirical evidence suggests that food waste makes up a significant proportion of global food production. It is estimated that globally, food waste accounts for approximately one-third (by weight) of all food produced annually (Hebrok & Boks, 2017; Hamilton et al., 2005). Moreover, it is suggested that while the problem of food waste is more significant in highly developed economies than in less-developed ones, it is becoming an issue across countries as economic development, urbanization and affluence increases (Baig et al, 2018; Koch et al, 2018; Gustavsson et al, 2015).

The impacts of ever-increasing food waste for the planet and society are primarily acknowledged and have been well described in the literature (Park & Lah, 2015; Secondi et al., 2015; Lundqvist, 2008; Asomani-Boateng & Haight, 1999).

Across all levels of analysis from individual consumers to national and international food systems, the impacts of increasing food waste are seen in terms of ever-increasing environmental concerns, fears around the use and sustainability of economic resources and the effects on future food availability and food scarcity (Gustavsson et al, 2011). When food is wasted, so too are all of the resources that went to growing, producing, processing and transporting the food resulting in unnecessary negative environmental and economic impacts. A study estimates that global production of lost and wasted food accounts for 24 per cent of total freshwater resources, 23 per cent of all cropland and 23 per cent of global fertilizer use (Kummu et al, 2012). Other environmental impacts include the release of pollutants into the atmosphere and water bodies through dumping and incineration. In landfills, for example, food waste converts into methane, which has a global warming potential 25 times greater than the equivalent carbon dioxide production (Forster et al, 2007).

Along with environmental impacts, the wasted economic resources associated with the production, distribution and disposal of wasted food is also an area of concern. The FAO reports that food waste has direct economic costs equal to USD1 trillion per year, environmental costs of USD 700 billion and social costs of USD 900 billion. The final impact of food waste and one that has received significant attention is the issue of food security and in particular, the decline in food security across the globe. Access to healthy and nutritious food is vital for human health and development and is also a human right issue (FAO, 2018; FAO, 2013)

The United Nations has identified food security as one of its 17 sustainable development goals, and several authors, including (Reynolds et al, 2014; Lundqvist et al, 2008) have made a vital link between increasing food waste and declining food security. These concerns and the urgent needs for the world to work together to achieve sustainable development goals, including inclusive economic growth, are at the heart of this chapter.

In particular, the chapter will address the issue of food waste by presenting a framework for understanding and building appropriate program responses based on a desktop comparison of three cases drawing from a review of available literature, reports, policy documents and websites. By applying the framework to compare the three cases, we aim to identify the key factors required for food waste reduction programs. The outcomes of this review are then applied to design a step-wise operational model to guide the development and implementation of programs aiming at food waste reduction.

A BRIEF BACKGROUND: DEFINITION, CAUSES AND INTERVENTION

What is Food Waste, and What are its Causes?

Factors characterizing waste vary according to the type of material included, the means of production used and the management approaches adopted (FAO, 2013). Early definitions regarded food waste as the destruction or deterioration of food or the use of crops, livestock and livestock products in ways which return relatively little human food value (Kling, 1943). More contemporary definitions consider food waste as a sub-set of food loss. Food loss is defined as a *'decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption'*. As a subset of this, food waste is defined as *'food, which was originally produced for human consumption but then was discarded or was not consumed by humans'* (Thyberg & Tonjes, 2016).

Causes of Food Waste

The causes of food waste are variable and have been widely discussed in the literature (Neff et al, 2019; Oelofse & Nahman, 2013; Venkat, 2012; Gustavsson et al, 2011; Morisaku, 2000). The upstream processes such as unharvested crops due to disease, pest infestation and weather fluctuations coupled with stringent quality standards of food production accounts for 54% of food loss and waste. In comparison, 46% is a result of processing operations, distribution and consumption patterns (Mebratu, 1998). While there are likely, many sources of food waste, researchers (Buzby et al, 2014) argue that consumers drive a significant proportion of food waste and that understanding the drivers of food waste is an important step in developing and implementing successful institutional programs. In a wide-ranging systematic review argue that ‘food turns to waste within a web of interrelated practices, tools, concerns, skills, knowledge and anxieties’ (Hamilton et al, 2005). Broad macro-level factors can include increasing globalization resulting in more complex food supply chains, packaging, labelling, urbanization meaning change in populations and taste and modernization resulting in changes to values and lifestyles (Gooch et al, 2019; Williams et al, 2012; Gustavsson et al, 2011). Once these are distilled down to the level of individuals and households, factors including consumer values, culture, lifestyle and material and structural aspects all are presented as potentially important drivers. (Mena et al, 2020).

Values and lifestyles influence the way consumers view and use food, and relate to issues around perceived food abundance and cost of food, willingness to use leftovers and meal planning. Modern living is often associated with convenience and the throw-away society, resulting in significant food waste. Cultural aspects such as wanting to be seen as a good provider or a welcoming host to visitors may lead to increased food purchase and preparation and the potential for waste. Moreover, the ability to safely store food, the availability of refrigeration and the type of food packaging used by producers and retailers will also impact on waste (Rockefeller, 2013).

Food Waste Situation in Africa and Around the World

At a more national and country level, the scale of the food waste problem is also significant. In the United States of America, preventable food waste exceeds 55 metric tons annually, representing around 29% of annual food production (Thyberg & Tonjes, 2016). In the United Kingdom, it is estimated that around half (7 million metric tons) of all food fit for human consumption is wasted. In Australia, households discard AUD \$5.2 billion worth of food, which can be broken down to (AUD \$616 per household) annually (Reynolds et al., 2014). The story is not different in developing economies because North Africa, Kenya, South Africa and South-East Asia waste 35-40%. China, Beijing (66.19%), Shanghai (71.44); India (35-40%) (Mebratu, 1998). In some African countries such as Nigeria, many households are food insecure (Osabohien et al, 2020) and some cities such as Lagos waste (68.1%), Accra (85.1%), and Kampala (75%) (Asomani-Boateng & Haight, 1999).

Even though there is an ongoing coordinated strategy to manage food waste in developed economies, it is more challenging to implement an effective waste management strategy in developing countries (Rockefeller, 2013). According to the World Bank, developing countries spend 80% of the Municipal Solid Waste Management budget on collection and landfill management. In comparison, developed countries spend less than 10% on collections and allow more funds for creating awareness, treatment facilities and waste segregation (Prasad et al., 2011). Some other challenges in developing countries are low funding for segregation and recycling activities, insufficient and ineffective administrative processes

and most importantly, lack of policies and regulations (Rockefeller, 2013). These are all institutional inefficiencies slowing down economic growth especially in Africa. It is pertinent for policymakers to initiate actions acknowledging the positive link between strong institutions and economic progress (Vianna & Mollick, 2018).

Intervening in Food Waste

The inter-related web of drivers associated with food waste means that like other complex ‘wicked-problems’ food waste requires coordinated action across various sectors, institutions and groups while utilizing combinations of technology-based solutions, public intervention and incentives. While higher-level national or state governmental practices have a role to play, investment in large-scale technology and broad overarching policy (such as the United States Department of Agriculture’s food waste reduction goal of 50%) (USDA, 2015) programs and national level goals, attention at more local levels is also beneficial. Local municipalities sit in-between individual consumers and national and or state-level governments. Programs used to intervene in reducing food waste, need to influence the behaviour of individual consumers and suppliers, and as a consequence, local municipalities are often best placed to act (Heller, 2019; Peter et al., 2010). The goals of existing food waste programs are diversion of food waste from landfill, strengthening institutions through infrastructural development and capacity building, and behavioural change of consumers and producers to reduce waste production. The following sections will describe the method and highlight salient points from cases of food waste management in other developed countries that could be suited to the institutional context in developing economies in Africa.

Method

The goal of this paper is to present a food waste reduction model that is informed both by the existing literature and three selected cases. The development of this model will enable policymakers and program designers to consider aspects of food waste mitigation and prevention more systematically and is deemed to be a constructed ideal used to approximate reality by selecting and accentuating certain elements. The approach used to develop the model is outlined in figure 1 and detailed further below.

Figure 1. Methodology

Identifying key Success Factors

A search of appropriate literature was undertaken to identify several key factors which may be important in the development of successful food waste programs. We identified relevant peer-reviewed journals articles and grey literature appearing in Science Direct, Scopus and Google Scholar plus manual reference searches, limiting our search to material published in English between the years 1977 to 2019.

The keyword search strings included ‘food waste’, ‘food waste strategies’, ‘food waste systems’ ‘food waste policies’, ‘cases on food wastes’ and ‘best practice and food waste’. Articles were then screened by title and then abstract, and then full papers were reviewed. Information extracted to help develop a summary of key factors that were consistently identified across successful and effective food waste prevention/mitigation programs.

Selected Cases and Their Features

The cases were selected based on the period of operation, replicability of program features, the validity of data and widely known as best practice. The cases were evaluated using a comparative analysis. Some key success factors were identified as critical for their operation. These key success factors were used to help identify and critically assess cases that were selected (or chosen) as exemplary programs based on the review. One program, San Francisco, is based at the municipal level and is guided by national and state-level goals and objectives. At the same time, the remaining two, Taiwan and Korea, are illustrations of national-level programs which are physically enacted at local municipal levels.

Assessment

Supplementary information, where necessary, was gathered on each case, which included grey literature from government sources and additional scientific manuscripts where possible. The use of such literature helped to establish a rich understanding of the cases, and then these cases were assessed concerning the key success factors identified in stage one.

Food Waste Reduction Model

The results of the assessment of the cases against the key success factors then became the background material feeding into the development of the food waste reduction model (stage four). The model was developed concerning the process of Intervention Mapping (IM). Intervention Mapping is a protocol for planning theory-based and evidence-based behaviour change programs, and while it is most often used in health promotion, the potential for its use in other fields has begun to be recognized.³ As a planning and intervention development tool, it recognizes that behaviors are the function of individuals and the physical, social and organizational environments in which individuals operate in, and that intervention content needs to be developed with these multi-faceted spheres in mind. It also recognizes that interventions at one level may have consequences (intended or unintended) at other levels. Intervention Mapping also acknowledges the requirement to involve stakeholders at all stages of development, rollout and evaluation of a program (Kok et al, 2011). Finally, Intervention Mapping demands programs to be built around relevant theories and evidence (Kok et al, 2017).

RESULTS

Review

The outcome of the systematic search was that a range of key success factors was synthesized from the evidence (see Figure 2). Generally, factors accounting for successful programs are divided into **content factors** and **process factors**. Content factors include the resources adopted to influence or change behaviour or to improve skills or knowledge and the infrastructure required to conduct the program successfully. Process factors relate to the logistics of developing a program and focus on issues including planning, engagement and evaluation. Planning process factors include problem identification, program timing, program goals, including the establishment of baselines, and program integration. Engagement process consists of the engagement of stakeholders and the collaboration across sectors or groups. The evaluation process includes processes around piloting programs and testing programs against goals and baselines.

Figure 2. Key factors in successful food waste management programs

SELECTED CASES AND THEIR PROGRAMS

San Francisco

The San Francisco case represents an example of a food waste reduction and diversion program based at the municipal level. Driven in part by higher-level state and national policies, including California's Integrated Waste Management Act, the food waste program is embedded in the city's broader zero-waste policy. The program is holistic by design and is backed by carefully developed processes, and program content has been subject to extensive stakeholder engagement during development and subsequent evaluation.

The success of San Francisco's food waste recovery program is attributed to strong institutions and exemplary policy leadership. During the development of the program, innovative policy initiatives such

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as mandatory recycling, composting and modern outreach programs covering residences, commercial, schools and events have all changed in the way food waste has been produced and handled (EPA, 2016; Cote, 2009). After achieving the state-mandated level of 50 per cent waste diversion in 2000 the city's broader zero-waste policy aimed at diverting 75 per cent of municipal waste from landfill by 2010 (higher than the required legislated state level) and moving to zero-waste by 2020 (Cote, 2009). Legislatively, the diversion goal was supported by mandatory municipal ordinance which was launched 2009 and requires all residents in San Francisco separate recyclable, compostable and landfill materials and participate in recycling and composting programs, with enforcement mechanisms and penalties set out for violations of the code (Cote, 2009).

Residents are encouraged to meet the legislative requirements through the provision of appropriate infrastructure and extensive education and outreach campaigns. The city implemented an innovative "Fantastic Three" residential curbside collection program that includes colour-coded rubbish bins for the collection of commingled recyclables; compostable materials, including all food scraps and any remaining trash. The use of the correct bin is achieved via an online 'customizable sign' portal that allows users to develop appropriate recycling signage to meet their specific needs. These signs allow for visual cues regarding the appropriate content to be placed in each bin and are provided in a multi-lingual format. Also, there is composting and organic transfer infrastructure provided for both households and the commercial sector, allowing the sorting and transfer of organic waste material (Dmitriew, 2018). Education is provided through mechanisms including a face-to-face outreach program run by the Department of Environment and an online recycling database. The outreach program involves Department of Environment officers visiting neighbourhoods and identifying households and businesses requiring information regarding the appropriate waste disposal actions. The online database 'recycle where' provides information to residents about the recycling and waste disposal options, while other online resources offer information regarding composting.

Enforcement of the program is carried out through the Department of Environment. Monitoring is undertaken to start during waste collection, with truck driver tagging contaminated bins. Affected customers are consulted and followed up with a 30-day warning letter and another enforcement letter for non-compliance until the customer is reaudited and regains their status.¹⁰ Enforcement via a fine is considered to be the last resort with education and face-to-face outreach being the preferred management options. Incentives and subsidies were also introduced for both businesses and households as an inducement to change waste management behaviour. Business organizations are eligible to receive a rate discount based on the amount of waste diversion, providing strong financial incentives to reduce waste, recycle and compost (Dmitriew, 2018).

The compostable material collected includes all food scraps pre and post-consumer with meat, together with food-soiled paper, animal bedding, waxed cardboard and wood crates. The organics are transported to a municipal composting facility where they are mixed, ground and composted using state of the art facilities. The final composted material is sold to agriculture and landscaping users, including organic farmers in the San Francisco Bay area, highway erosion control projects and retail outlets for sale to consumers.

South Korea

The South Korean case is an example of a national food waste strategy set within a broader national level framework and implemented at local municipal levels. The impetus for the development and rollout of

the South Korean program was environmental concerns regarding increasing levels of waste products associated with the country's rapid urbanization and the shortage of suitable landfill sites. Developed over several years, the program today focuses on waste reduction, reuse and recycling utilizing incentives, penalties, education campaigns and infrastructural approaches.

Beginning in 1995 with the release of the Food Waste Reduction Masterplan and subsequent plans in 1998 and 2004, South Korea's food waste program has evolved into a highly integrated program. The evolution of the program has included a landfill ban on food waste in 2005, encouragement of composting and recycling as a landfill diversion strategy and the introduction of a cross-sector voluntary food waste reduction program in 2010. The sectors included restaurants, hotels and education institutions. Restaurants were encouraged to use fewer small side-dish plates and adopt eco-friendly menus. At the same time, cafeterias in public institutions such as schools promoted the "no-leftover day" program once a week. One of the most significant advances within the program has been the introduction of Volume-Based Waste Fees (VBWF) as a means of encouraging households to change food waste behavior (EPA, 2019). Up till 1994, the South Korean government had utilized a fixed waste tariff as a means of reducing all types of waste, including food waste. Evaluation of this program identified that rather than reducing waste, it contributed to a gradual increase in the amount of waste produced. This evaluation resulted in the implementation of the current VBWF system in its early form during 1995 by the Korean Ministry of Environment (Park & Lah, 2015; Seo et al., 2004). The South Korean government banned landfilling of food without pre-treatment requiring residents to cautiously separate food scraps collected in the VBWF bags (Park & Lah, 2015).

The main goal of the VBWF system is to pass-on waste treatment costs to each polluter according to the amount of waste produce (Bourtsalas et al., 2019). Local municipalities implement three "pay-as-you-throw" solutions namely paid bio-degradable plastic bags, attached paid sticker or coupons to food - waste bins and technological-based system that weighs individual household waste and record monthly waste totals using Radio Frequency Identification (RFID) Cards. These solutions allow monthly waste disposal charges to be sent to households.

The introduction of the Volume Based Waste Fee system has been supported by a range of ancillary programs and policies. Illegal food waste disposal is discouraged by imposing fine of KRW 1 million (around USD900) levied at individuals caught disposing of waste without the appropriate VBWF bags or unlawfully incinerating waste. Other enforcement tools include mandatory education on appropriate disposal practices and vetoes on waste collection for households found to violate the program practices. Civil servants monitor unlawful activities, and CCTV cameras are installed at problem locations, while local municipalities also operate special reporting centers.

The success and acceptance of the VBWF system have, in large part, been due to the implementation of education programs and continuous evaluation. While the initial rollout resulted in public complaints, the Korean Ministry of Environment developed public promotion campaigns across electronic and print media, including the distribution of promotional materials containing important educational messages. Moreover, workshops, seminars, and symposiums are organized continuously allowing the national ministry and municipal level agencies to evaluate and modify the program where needed.

While installing infrastructural facilities for collection, the government also made provision for the use of the collected food waste in the form of animal feed and fertilizer, which is supporting the growing urban farm movement. Feed safety is guided by several control measures, including certification, registration, strict feed standards coupled with treatment technologies. This introduction and implementation of

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regulations and laws have not experienced disease outbreaks associated with food waste-derived feeds (Vianna & Mollick, 2018).

Taiwan

The Taiwan case represents an example of a nationally coordinated system aimed at landfill diversion through recycling and reuse. The development of the contemporary program, which includes a range of education, incentives and enforcement tools has been developed through several iterations. In 2001, the Taiwanese Environmental Protection Administration (EPA) set up kitchen waste collection programs throughout the nation. The policy encouraged waste recycling and reuse by providing subsidies to counties and townships to develop food waste recycling systems throughout the country. The subsidy system was provided in a staged rollout, and by 2006, all municipalities had established recycling systems (Chen, 2016). This initiative expanded in 2002 to include separation and collection of food waste from hotels, restaurants and residential areas. Furthermore, in 2003, food waste recycling became part of the official function of the EPA with allotted budgets resulting in incentives being offered for the private establishment of food waste reuse and recycling programs.

Under the current program, households and other food waste producers are required to separate food waste before collection by municipal waste collectors. Failure to comply attracts a fine, in addition to waste collectors refusing to collect the offending items. Of all municipal solid waste collected, food waste accounts for approximately one-tenth with the bulk being used to produce pig feed (71 per cent) and the remainder to compost. In total tonnage, food waste for pig feed has increased from 140,090 tonnes in 2003 (Buzby et al, 2014) to 695,000 tonnes in 2018. Food waste for composting has increased from 23,092 tonnes in 2003 (Chen, 2016) to 231,676 tonnes in 2018 (EPA, 2008). In economic terms (Thi et al, 2015) annual benefit of 2.7 billion NT dollars was recorded from the reduced incineration fee and sales revenue of pig food scraps. The power generation potential for the food waste recovered was 68.0 GWh y⁻¹, and the potential excluding composting and swine feeding were 14.0 and 54.5 GWh y⁻¹ in 2006, respectively.

Furthermore, the potential for compost production was 122 MWh y⁻¹ when compared with the energy consumption of chemical fertilizer (ammonium sulfate and calcium superphosphate) production in Taiwan in 2006. These results suggested that recycled food wastes not only reduces the amount of garbage but has immense potentials for power generation and energy conservation (Lai, 2009). Other benefits of Taiwan's food waste recycling program include nationwide awareness of the food waste problem and a National Sustainable Development Award for its contribution towards making Taiwan a Zero waste society (Thi et al, 2015).

Assessment of the Cases Against Key Success Factors

The key success factors presented in figure two were used to assess the three individual case studies as a precursor to the development of a model to assist food waste reduction interventions. The key success factors of food waste reduction listed below are broadly categorized into two main categories; content and process. Content includes key components such as education and awareness, incentives and subsidies and the provision of infrastructure. The method comprises aspects of planning, engagement and evaluation.

All three case studies included the development and implementation of appropriate content focused on changing values, skills and behavior. Although implemented at different times in the planning and

implementation stages, each case successfully used educational campaigns or face-to-face outreach to influence the adoption of the new programs and to initiate appropriate change. The San Francisco program emphasizes continuous education through different platforms, including the monthly waste bills of customers and social media (Cote, 2009). While the Taiwanese program also utilized different signages to target the different sectors. Education must be strategic and targeted to different audiences to allow wide-ranging take-up of key messages across different societal groups and communities. Communities with multi-lingual populations must endeavour to translate the education materials and create an awareness strategy that would resonate with the target audience, as demonstrated in the San Francisco Case. Practical demonstrations of how to store the food waste to be collected and compost them where these facilities are available are also helpful and prevent contamination right from the source of production. Targeted and strategic education and continuous awareness are suggested pathways for implementing successful food waste reduction programs.

Content aimed at behaviour change is also introduced in the form of positive and negative incentives or subsidies. Subsidies and incentives can be in terms of inducements to encourage recycling of food waste for individuals and households, up to incentives for industry to invest in large scale food recycling plant (i.e. commercial level composting). An illustration of incentives is the free collection service offered by the South Korean government in 2006, which facilitated the use of food wastes as soil conditioners and animal feed (Seo et al, 2004). In Taiwan, the policy provided subsidies to townships and counties for the development of food waste recycling systems throughout the country.

Associated with the use of incentives and subsidies is the use of legal frameworks to enforce the required outcomes. All of the case studies had well established legal frameworks setting out the boundaries of their programs, including legislation around penalties, responsibilities and scope of programs. San Francisco passed a Mandatory Municipal Recycling and Composting Ordinance in 2009. This local municipal ordinance requires all residents to separate their compostable, recyclables and landfill trash. The strategy kicked off with a clearly defined diversion goal of 75% diversion by 2010 and zero waste by 2020 (Dmitriew, 2018) Monitoring and enforcement are followed through starting with the truck driver who tags every contaminated bin. On enforcing compliance, the non-complying customer is consulted and followed up with a 30-day warning letter and another enforcement letter for non-compliance until the customer is reaudited and regains their status (Cote, 2009).

On the other hand, the South Korean government initiated a phased solution for food waste management by launching a Food waste reduction masterplan in 1995 followed by a recycling programme established in 1998 and revamped in 2004 to include the collection of food waste in residential areas and restaurants. The program evolved into a landfill ban on food waste in 2005 by the South Korean government. In 2010, the Ministry of Environment, in **collaboration** with other ministries, carried out a food **waste reduction** project by signing agreements with different sectors for voluntary cooperation. The sectors included restaurants, hotels, schools etc. Restaurants were encouraged to use fewer small side-dish plates and adopt eco-friendly menus. Cafeterias in public institutions promoted the “no-leftover day” program once a week. In Taiwan’s case, the government encouraged the policy of mandatory waste sorting in stages according to Article 12 of the Waste Disposal Act since 2005. It regulates that the discharge of waste from households should be sorted into three categories: “Resources”, “Kitchen waste” and “Trash”, which shall be respectively sent to resource recycling vehicles, refuse trucks and recycling bins for the kitchen waste (EPA, 2019).

A common theme through the case studies was the provision of necessary infrastructure to enable the successful rollout of programs. The infrastructure can be hard-infrastructure such as massive food

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waste composting, or treatment facilities, waste collection infrastructure down to the provision of suitable waste containers at the household level, or it can be a term of the provision of soft-infrastructure such as the provision of bureaucratic systems to manage education and enforcement. This is a missing factor in most of Africa's waste disposal systems.

In San Francisco, compostable food materials are collected using semi-automatic side loading, single compartment compactor loadings. In contrast, the recyclables are collected using semi-automatic vertically split dual compartment side-loading compactor vehicles. Collected organics are delivered to the city's transfer station where the material is top-loaded from the refuse pit too large possum belly trailers (Biocycle, 2002). In South Korea, the food waste program operated a Volume-based food waste fee system in 2010, where households pay based on the amount of food waste they generate. Municipalities have three *"pay-as-you-throw" solutions (paid standard plastic bags, attaching paid stickers to food-waste bins- not emptied without labels and a high-tech solution, operating food-waste bins with magnetic card-readers that households must use when disposing of their waste.* Technology has played a significant role in the success of the program. The country's capital Seoul installed 6,000 automated bins fixed with Radio Frequency Identification (RFID) and scales to weigh and charge residents as they deposit the food waste using an I.D.card. City officials claim the recycling machines have led to a reduction of 47,000 tonnes in six years. Residents are encouraged to minimize the weight of their food waste by removing moisture, and this reduces their charges because Food waste contains about 80% moisture and also saved the city \$8.4 million in collection charges during the period. While installing infrastructural facilities for collection, the government also made provision for the use of the collected food waste in the form of animal feed and fertilizer, which is supporting the growing urban farm movement. Feed safety is guided by diverse control measures, including certification, registration, strict feed standards coupled with treatment technologies. This introduction and implementation of regulations and laws have not experienced disease outbreaks associated with food waste-derived feeds (Vianna & Mollick, 2018).

While the content of food waste programs is important, several process factors are also required. All of the case studies were developed following extensive planning and after identifying a problem in terms of food waste reduction or waste diversion. In all three cases, clear goals in term of food waste reduction were identified and were used to evaluate and provide ongoing reporting. In the case of San Francisco for example, the city was driven to meet state-mandated targets in terms of waste reduction and these goals became the impetus for developing and managing the food waste problem as part of the overall waste strategy. The success of the case studies was driven by the inclusion of stakeholders during the development and implementation of the programs and through collaboration between different sectors and levels of government. This was especially the case in the South Korean and Taiwanese examples where the national level waste reduction policies and programs had to be filtered down to and instigated at the local level. Finally, all of the case studies included some form of pilot work or staged rollout, and all have completed evaluation periods. South Korea, for example, developed the food waste program over several iterations of policy and program design and have undertaken constant evaluation involving input from stakeholders at various levels.

Intervention Mapping in the Context of Food Waste Program Success Factors

Developing appropriate food waste reduction programs has become increasingly important in developing counties, such as Africa and the success of such programs has the ability to significantly impact on the path of inclusive and sustainable growth (Hanson, 2013). Despite the fact that there are many examples

in the literature dealing with issues of food waste and the best approaches to achieve reductions in food waste, it is often the case that approaches are ad-hoc in design. One way to overcome these short-comings is through the adoption of systematic processes of program design. One such approach, which was developed in the field of public health (Bartholomew et al., 1998), but has been expanded to other fields (Kok et al, 2015) is Intervention mapping. Intervention mapping has defined as a planning framework for the development of theory and evidence-based behaviour change programs. It is ‘a framework for effective decision making at each step in the intervention development process (Bartholomew et al., 1998). When combined with the key content and process-oriented success factors identified from the three case studies, the intervention mapping protocol can be modified to provide a useful matrix outlining key opportunities, issues and structures (Figure 3).

The benefit of utilising an intervention mapping approach is that it describes an iterative path involving six steps (figure 3) running from problem identification to problem solving to evaluation and provides opportunities for feedback loops to be integrated into the program development process. The completion of various tasks at each step creates a product that feeds-in to subsequent steps. The completion of all of the steps provides a useful blueprint for designing, implementing and evaluating an intervention based on a foundation of theoretical, empirical and practical information.

Step 1: Logic of Model

Developing the logic of the model involves conducting a needs assessment or an analysis of the problem and includes the identification of the extent of the problem and the issues that need to be addressed or changed (Bartholomew et al., 1998). In the context of the success factors identified, this necessarily involves engagement with stakeholders who can help identify suitable data sources dealing with food waste in the local context, identifying potential key informants and understanding food waste in the broader social and economic context. Here program developers and planners would establish the extent of food waste at different organisational and institutional context (farmers, distributors, retails, households) as well as geographic levels (country, regional, municipal, local community/ neighbourhood). They would ask what behaviours need to be targeted and what the target populations are. On completion of step one, program designers and planners, in conjunction with stakeholders, would have developed a list of food waste behaviours and the context in which these behaviours occur.

Step 2: Program Outcomes

The second step in intervention mapping involves identifying the goals for a given food waste reduction program and understanding the who, what and why of program outcomes. Here again stakeholder engagement is important in identifying agreed goals. Developing agreed goals that are built around the broader context of step 1 allows for ownership of programs to be cemented. Depending on context, goals may include farmers reducing waste by a certain number of tonnes or changing to more sustainable crops. At the household level, goals may include reducing the amount of food purchased that is subsequently wasted or changes to other buying habits. In step two the outcome should be a matrix of goals associated with particular contexts that allow for specific targeted program design to be initiated.

Step 3: Program Design

Program design is a crucial stage of intervention mapping and involves understanding the values, skills and behaviours of target groups and brings into play important aspects of planning. It involves linking the matrix of goals developed in step 2 and considering theoretical methods that will result in meeting these goals. Here designers and planners begin to think about links between values, skills and behaviours and particular objectives. As an example, practitioners may consider theories of planned behaviour and consider how they help understand behaviour that will move towards desired goals. The main aim will be to populate the goal matrix from step 2 with broad conceptual ideas that can feed into practical applications.

Step 4: Program Production

Step 4 is closely aligned with program design and involves taking output from the previous step and integrating methods and practical applications into an organized program. Practitioners will now begin to engage with a broad range of context success factors across values, skills and behaviours and logistics. Here, successful case studies can be engaged and modified where necessary to meet particular contexts. Understanding the broader contexts from earlier steps allows practitioners to better grasp the potential for success of any one intervention and undertake pilot programs to test potential interventions. Program production may involve the development of context specific educational packages and approaches, approaches that reward or punish particular behaviour or the development of logistical requirements. The end of the program production stage provides a package of approaches tailored to specific contexts and aimed at reaching specific agreed goals (Kok et al, 2011).

Step 5: Program Implementation

The penultimate step in program design is program implementation and draws on an understanding of context success factors (values, skills and behaviour, logistics) and the associated program design and process success factors (planning). A key in implementation will be to plan for the adoption, implementation and sustainability of the program designed in stage 4. Successful design at this step is important as programs often fail to meet goals and objectives due to poor implementation planning. As with previous steps, step five draws heavily on previous intervention mapping outputs. Practitioners will need to understand linkages between programs and goals and need to consider a number of context specific issues. Will implementation occur all at once or will a staged approach be undertaken? How will different programs be interlinked and how will this impact of the timing and process of implementation. Who will be implementing the programs and in what context? At the implementation stage previous steps may need to be revisited for fine tuning to allow the alignment of goals, programs and implementation.

Step 6: Program Evaluation

The final step of program design in the intervention mapping protocol focuses on evaluation and allows for feedback loops to be considered as a way of improvement of program design. The goal here is for practitioners to generate appropriate evaluation plans drawing on stakeholder input and considering best practice evaluation approaches. In many senses, the evaluation of the programs will be ongoing

with practitioners considering outputs from program design onwards and considering how the design and implementation of program will help meet specified goals and targets. Appropriate evaluation will provide information on successes as well as failures and allow these to be understood in the appropriate contexts. For successful outcomes, evaluation will be fed back to stakeholders for use in redesign and future planning.

Figure 3. Intervention Mapping Protocol Matrix

	Case study success criteria				
	Content		Process		
	Values, skills and behaviour	Logistics	Planning	Engagement	Evaluation
<i>Intervention Mapping protocol</i>					
Step 1: Logic of model				X	
Step 2: Program outcomes				X	
Step 3: Program design	X		X		
Step 4: Program production	X	X			
Step 5: Program implementation	X	X	X		
Step 6: Evaluation plan				X	X

CONCLUDING REMARKS

Food waste is a significant and growing concern across the globe with significant implications for sustainable development. Proponents of food waste reduction programs point to the significant benefits that can flow from investing in the development of a sound evidence-based waste reduction program. This paper is developed within the growing concern around food waste and presents an analysis of the key success factors required for the implementation of a successful food waste reduction program and provides an ideal type model for program development.

The review of the example cases suggests that there are several key factors required for a successful food waste programs and that these can be divided into factors related to the content of the program and factors associated with the process surrounding the development of the program. Our findings suggest that pathways for a good food waste program should include: pilots, phased rollouts, education and continuous awareness, convenience, consistency, monitoring and enforcement, measurement of waste collection, key success indicators, integration with existing stakeholders, logical plans and demand for collected food waste. Combining the case study evidence and an intervention mapping protocol the paper outlines an approach to program development that allows for the successful development and monitoring of food waste programs in Africa that are context specific and flexible to need.

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