

19

Business Models for Urban Food Waste Prevention, Redistribution, Recovery and Recycling

Dehaja Senanayake, Maren Reitemeier, Felix Thiel and Pay Drechsel



About the Resource Recovery & Reuse Series

Resource Recovery and Reuse (RRR) is a subprogram of the **CGIAR Research Program on Water, Land and Ecosystems (WLE)** dedicated to applied research on the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams. This subprogram aims to create impact through different lines of action research, including (i) developing and testing scalable RRR business models, (ii) assessing and mitigating risks from RRR for public health and the environment, (iii) supporting public and private entities with innovative approaches for the safe reuse of wastewater and organic waste and (iv) improving rural-urban linkages and resource allocations while minimizing the negative urban footprint on the peri-urban environment. This subprogram works closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU) and many national and international partners across the globe. The RRR series of documents presents summaries and reviews of the subprogram's research and resulting application guidelines, targeting development experts and others in the research for development continuum.



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RESOURCE RECOVERY & REUSE SERIES 19

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Dehaja Senanayake, Maren Reitemeier, Felix Thiel and Pay Drechsel

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Acknowledgements



This research was carried out as part of the CGIAR Research Program on Water, Land and Ecosystems (WLE) and supported by contributors to the CGIAR Trust Fund (<https://www.cgiar.org/funders/>).

Senanayake, D.; Reitemeier, M.; Thiel, F.; Drechsel, P. 2021. *Business models for urban food waste prevention, redistribution, recovery and recycling*. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 85p. (Resource Recovery and Reuse Series 19). doi: <https://doi.org/10.5337/2021.208>

/ resource recovery / resource management / reuse / food wastes / business models / waste management / urban wastes / waste reduction / redistribution / recycling / food consumption / food losses / waste collection / food supply chains / stakeholders / entrepreneurs / public-private partnerships / markets / incentives / energy recovery / nutrients / Sustainable Development Goals / Goal 12 Responsible production and consumption / environmental impact / food preservation / composting / feeds / regulations / policies / awareness raising / consumer participation / costs /

ISSN 2478-0510 (Print)
ISSN 2478-0529 (Online)
ISBN 978-92-9090-915-6

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	DEFINITION
AD	Anaerobic Digestion
B2C	Business-to-Consumer
CSR	Corporate Social Responsibility
FAO	Food and Agriculture Organization of the United Nations
FLW	Food Loss and Waste
HDI	Hasiru Dala Innovations
ICT	Information and communications technology
MaGIC	Malaysian Global Innovation & Creativity Centre
MSW	Municipal Solid Waste
MT	Metric Tons
n.d.	No date
NPO	Nonprofit organization
PPP	Public-Private Partnership
R&D	Research and Development
SDG	Sustainable Development Goal
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UK	United Kingdom
UN	United Nations
US	United States of America
WRAP	Waste & Resources Action Programme

SUMMARY

The number of people living in cities is expected to reach 68% of the global population by 2050. Food security for growing populations is an increasing concern. Currently one-third, or 1.3 billion metric tons of food is lost or wasted along the food value chain, which results in not only loss of calories and nutrition available for human consumption, but also valuable inputs required for its production and distribution.

Target 12.3 of the United Nations Sustainable Development Goals (SDGs) is to 'halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, by 2030'. This is relevant for both low-middle and high-income countries, where food loss and waste occurs at all points along the supply chain, from postharvest production to consumption. The effects of reductions in food loss and waste can be seen socially, environmentally and financially.

Over 400 businesses were analyzed for this study to understand the types of entities working to reduce food waste. Subsequently, 18 business models were developed to provide greater insight into proven models utilizing excess food or waste as part of their operations, and where this occurs along the supply chain. The categorization followed the Food Waste Recovery (and Mitigation) Hierarchy and is presented using business model canvas flows.

Systems for monitoring and management of excess food and food waste were most prevalent in prevention organizations. For redistribution, creating connections among stakeholders through platforms to form a secondary market and providing logistical services to move excess food to charities were the most prominent. Common recovery methods include transforming excess food and food waste into both food and non-food products. For example, utilizing food suitable for human consumption in cafés, soup kitchens or preserved products, and waste converted into non-food products such as bio-plastics. If none of these options is available, recycling pathways such as processing for animal feed, compost or energy recovery are available.

These models could be supported by policies and regulations which are often missing at the national and local levels. There has been some success by governments in creating supportive enabling environments for the activities of businesses to grow and succeed, such as standardizing the production of animal feed in Japan and tax deductions for donations, enabling redistribution efforts in the United States.

Ultimately, the success of these initiatives requires education and training for staff as well as consumers, and raising awareness among policy-makers of the need to include the reduction of food loss and waste on the national agenda. An enabling environment can increase the possibilities for the prevention, redistribution, recovery and recycling of excess food and food waste.

1. OBJECTIVE AND SCOPE OF THE STUDY

This report aims to capture existing and emerging food waste reduction strategies and initiatives with a focus on identifying innovative business models as references for good practice to inspire entrepreneurs to reduce food loss and waste in their current operations.

Eighteen different business models were identified, analyzed from over 400 businesses that are working with the overall aim of reducing food waste. The business models focus on urban food waste reduction, from processing to consumption. The businesses were identified through an Internet-based search using keywords such as ‘food waste reduction business’, ‘food upcycling’ and ‘food recycling’. A database was created using journal articles, reports, newspaper

articles and previous lists compiled by organizations such as Food Tank (<https://foodtank.com>) and ReFED (<https://refed.com>). The businesses were then categorized based on their objectives and the strategies they used to achieve them. The approach was limited to those businesses with websites in English so the database is not comprehensive, but rather an indicative snapshot of the business models found globally at the time.

Figure 1 shows the breakdown of food businesses by the categories developed for this report. The overlapping activities of many businesses made a clear categorization difficult in some cases. Therefore, the selected approach presents one option where others are possible.

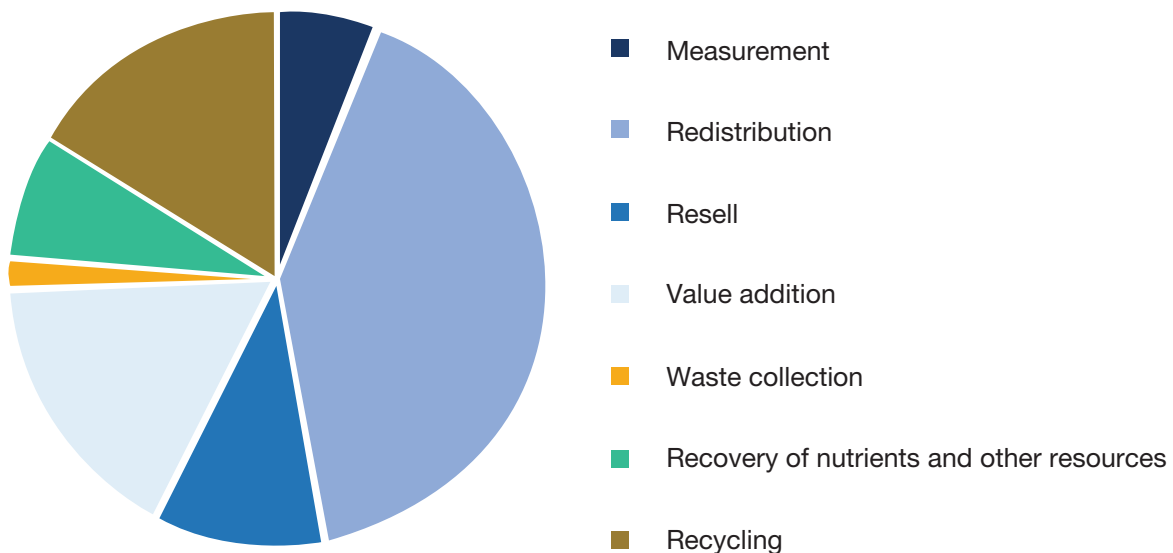


FIGURE 1. FOOD WASTE BUSINESSES PER DEFINED CATEGORY OF INTERVENTION AREA.

The maps in this report show the locations where these business cases were found. As the food waste sector is very dynamic, there will be many more cases which our search did not capture, in particular cases with limited

web presence. In this sense, the maps should only be seen as an indication if, for example, particular models are also common in the Global South or predominantly in the Global North.

2. FOOD WASTE AND ITS GLOBAL IMPLICATIONS

Currently, 55% of the world’s population lives in urban areas. By 2050, the number of people living in cities is projected to grow by 2.5 billion, reaching 68% of the global population (United Nations 2019). Ensuring food security for growing populations is already a concern. The current food production system has been identified as a major contributor to global challenges in this context. Multiple inputs, such as land, water, fossil fuels and human labor, are required for the production, transportation and processing of food before consumption. Along the value chain, approximately 1.3 billion metric tons (MT) of food remain unconsumed annually (FAO 2011) worth USD 1 trillion (FAO 2015). This implies the loss of not only valuable and necessary calories and nutrients, which if properly utilized could feed the estimated 1 billion malnourished people living today (Naylor 2011), but concomitantly the waste of resources used in global food cultivation, i.e. freshwater (24%), cropland (23%) and fertilizer (23%) (Kummu et al. 2012).

Target 12.3 of the United Nations Sustainable Development Goals (SDGs) is to ‘halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, by 2030’. As food loss and waste reduction is described as a ‘triple win’ situation (Flanagan et al. 2019), this target is extremely relevant for both low-middle and high-income countries, where reducing food loss and waste along the supply chain can have immediate and significant impacts environmentally, socially and financially

for their populations. Furthermore, for low-middle income countries there are public health and safety issues stemming from inadequate waste management. Landfill slides have killed over 30 people in Colombo, Sri Lanka, and 100 in Addis Ababa, Ethiopia; these are reminders that the current linear system of resource use is not only unsustainable and damaging for ecosystems, but a public health hazard and danger to the public. Organic waste constitutes a significant portion of any municipal solid waste (MSW) stream and can reach over 50% in low-middle income countries (Hoorweg and Bhada-Tata 2012). Currently, less than 2% of available nutrients is recovered from cities (Ellen MacArthur Foundation 2019). Thus, the availability of large amounts of unused resources demonstrates a huge potential for waste recovery and recycling.

The abundance of food waste, not only at the end, but along all points in the current supply chain provides opportunities for resource recovery and reuse. In high-income countries, advanced levels of loss occur during consumption, whereas in low-middle income countries, the levels of waste are higher in postharvest activities and distribution (Rezaei and Lui 2017). By identifying the reasons for waste at each stage of the supply chain, targeted solutions can be identified to address the particular cause of waste. This report focuses on food waste, defined as food wastage that occurs at the levels of distribution and retail, restaurants and catering, and domestic consumption. Figure 2 displays selected challenges resulting in food waste.



FIGURE 2. CLASSIFICATION OF FOOD WASTAGE INTO FOOD LOSS AND FOOD WASTE.

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3. BUSINESS MODELS FOR FOOD WASTE MANAGEMENT

In this report, the term ‘business’ does not limit the scope of models to profit-maximizing companies; rather, it also encompasses not-for-profit organizations and social businesses. The latter are particularly relevant in the field of food waste reduction. These businesses are directed by socially orientated goals which they achieve

by generating revenue. Dedicated to solving human problems, they reinvest generated revenue in their own operational affairs to sustain themselves and donate additional profit to other good causes (Yunus 2010). This reduces or removes the need for fundraising compared to traditional charitable organizations.

For-profit organization

Business: Aims to maximize profit for growth and distribute income among shareholders, leaders or members.

Nonprofit organization (NPO)

Nongovernmental organization, charity: Aims to solve social problems with the support of funds and tax exemption benefits.

Social business

Aims to solve social problems, while generating profit to be financially self-sustaining and reinvesting profits back into the mission.

The business models are presented using the framework of the business model canvas, which enables analysis of the requirements of an entrepreneur or business to achieve its value proposition. While used for specific business organizations, it has been used here as a framework for the general requirements for businesses and possible revenues and costs. Therefore, the business models generated from an analysis of global models currently in operation, provide basic guidelines and inspiration for interested stakeholders.

The business canvas and rankings are guided by the work of Osterwalder and Pigneur (2010). Also included are social and environmental costs and benefits to evaluate any resulting externalities (see Table 1) as presented, for example, by Otoo and Drechsel (2018). The basic structure of the canvas has been altered to display a flow to assist the reader in illustrating the connections between each section. A brief Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis (Figure 3) has been added to each model.

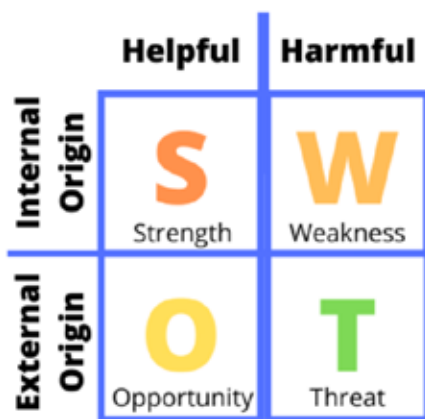


FIGURE 3. SWOT ANALYSIS FRAMEWORK.

The business models in this report will be categorized following the Food Recovery Hierarchy (Figure 4). This hierarchy ranks possible uses for food waste by their benefits for the environment, society and the economy. The primary goal of these efforts should be to reduce the generation of excess food and food waste in all operations of the value chain. The most preferable approach is the redistribution of edible excess food for human consumption and thereafter recovering excess food and waste as value-added.

The organization type of business models could also encompass the public sector, either in partnerships with the private sector (public-private partnership [PPP]) or as public sector companies themselves. While this report does not cover in detail the business models as part of these organization types, Table 2 illustrates which models are most common in which type(s).

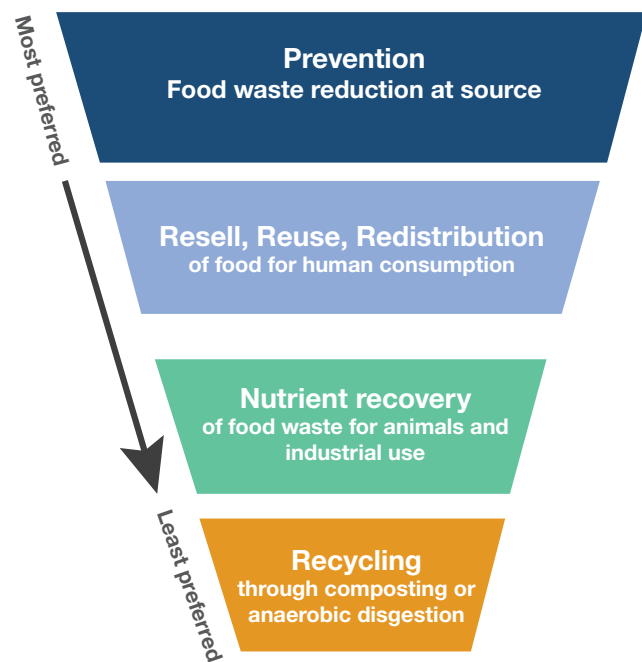


FIGURE 4. FOOD RECOVERY HIERARCHY. SOURCE: MODIFIED FROM USEPA 2020.

TABLE 1. BUSINESS MODEL CANVAS.

<p>Key partners</p> <p>Who are the key partners?</p> <p>Which key resources are acquired from which partners?</p> <p>Which key activities do partners perform?</p>	<p>Key activities</p> <p>Which key activities are required for:</p> <ul style="list-style-type: none"> - value propositions? - channels? - customer relationships? - revenue streams? 	<p>Value propositions</p> <p>What bundle of products and services is offered to each customer segment?</p> <p>What added value is being delivered to the customer?</p> <p>Which one of the customers' problems is solved?</p> <p>Which customer need is satisfied?</p> <p>What is unique about the offer (compared to the competition)?</p>	<p>Customer relationships</p> <p>What type of relationships have to be established and maintained?</p> <p>How are they integrated with the rest of the business model?</p>	<p>Customer segments</p> <p>For whom is the business creating value?</p> <p>Which jobs do they really want to get done?</p> <p>Who are the most important customers?</p>
<p>Key resources</p> <p>Which key resources are required for:</p> <ul style="list-style-type: none"> - value propositions? - channels? - customer relationships? - revenue streams? 			<p>Channels</p> <p>Through which channels do your customer segments want to be reached?</p> <p>How are you integrating them with customer routines?</p>	
<p>Cost structure</p> <p>What are the most important costs inherent in the business model?</p> <p>Which key elements drive the costs?</p> <p>How much does each cost item contribute to overall costs?</p>		<p>Revenue streams</p> <p>For what value are the customers willing to pay?</p> <p>For what do they currently pay?</p> <p>How are they currently paying?</p> <p>How much does each revenue stream contribute to overall revenues?</p>		
<p>Social and environmental costs</p> <p>What are the potential environmental risks of the business?</p> <p>What are the potential health risks for workers and the wider society?</p>		<p>Social and environmental benefits</p> <p>What potential benefits could the business model bring to the environment?</p> <p>Can the business model improve/reduce health hazards?</p> <p>Does it provide jobs?</p>		

TABLE 2. SUITABLE ORGANIZATION TYPES FOR THE BUSINESS MODELS PRESENTED.

Public	Private	PPP	NPO	Models
3, 5, 11, 18	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18	5, 11, 13, 14, 16, 18	3, 4, 5, 17	I. Tracking and analytical software for managing food II. Measuring and analyzing food waste III. Community fridge IV. Connection platform V. Logistics services VI. Box subscriptions VII. Online secondary market VIII. Store secondary market IX. Restaurants serving rescued food X. Food upcycling and preservation XI. Responsible waste collection XII. Mushroom cultivation XIII. Rearing insects XIV. Swine feed XV. Nonfood products XVI. On-site compost or energy recovery XVII. Social community composting XVIII. Off-site compost and energy recovery



Businesses can only flourish with an enabling regulatory and financial environment, supported by awareness creation on the challenge they address.

The most common methods to create awareness are campaigns and voluntary agreements. For example, the campaign “Love Food, Hate Waste” run by the charity Waste and Resources Action Programme (WRAP), in the United Kingdom (UK), encouraged lower waste levels by offering solutions for leftovers and increasing the shelf-life of produce. The Intermarché supermarket campaign in France used posters of ugly fruits and vegetables to promote the sales of unattractive produce. Both were successful in reducing levels of waste at the household and retail levels. Such campaigns not only increase consumer understanding and change behavior, but also enable dialogue and the greater acceptance of products and services created from food waste. Voluntary agreements are directed at businesses that sign up to nonbinding, voluntary commitments to reduce their current levels of food waste. When legislation is not feasible or employed, both campaigns and voluntary agreements can create change by engaging stakeholders via these frameworks.

Where possible, policies at local and national levels can create an environment that supports efforts to reduce food wastage levels. For entrepreneurs or businesses investing in equipment, infrastructure or research, these policies are a commitment from governments which can give greater confidence in undertaking the investments necessary. In making these commitments, it is possible for a dedicated state or national government to achieve targets by improving or enabling more desirable behavior. Table 3 gives an overview of legal instruments that have been enacted globally to reduce food waste. The incentives range between creating possibilities for encouraging waste reduction through tax deductions and subsidies or fines and bans to discourage waste completely. In the US, tax deductions for donations encourage businesses to donate waste whereas in France supermarkets are banned from disposing of waste in landfills. These approaches target different stakeholders and sources of waste in the supply chain.

Business models across the supply chain utilize a plethora of financing mechanisms to achieve their goals. The wide scope of the food waste issue requires a combination of private, public and philanthropic funding to achieve scaled solutions. Private financing

FAO: DO GOOD SAVE FOOD!

The Food and Agriculture Organization of the United Nations (FAO) and the International Food Waste Coalition joined forces in developing the ‘Do Good Save Food’ series of teaching guides targeted at children of four different age groups.

These guides seek to promote awareness of the economic, social and environmental consequences of wasting food, advantages of preventing food waste, actions that children can take to reduce food waste, and good habits that they can develop and introduce to their friends, families and communities to reduce food waste.

Source: <https://internationalfoodwastecoalition.org/do-good-save-food/>

includes loans, green low-interest loans, crowdfunding and venture capital. In 2018, in the US, start-ups reducing food waste raised over USD 125 million (ReFED 2018) from venture capital, where initiatives focused on recycling or prevention technologies such as connection platforms. Public capital encompasses grants or subsidies from governments and local authorities. These funds are most often available in countries with targets for reducing food loss and waste. This financing tends to be for recycling solutions to meet targets for waste management or landfill reduction, to subsidize the cost of biogas or compost plants, and increasingly, for redistribution purposes. Philanthropic funding largely supports redistribution programs to transport food to charities or foodbanks; however, there are growing levels of funding directed at preventative measures such as the Bill & Melinda Gates Foundation providing a grant of USD 100,000 to Apeel Sciences Inc. for their development of an edible peel to increase the shelf-life of fruits and vegetables (www.apeel.com/science).

Other support for food waste reduction start-ups comes from accelerator programs, designed to support start-ups by refining their business plans, networking, scaling, and in some cases, providing access to low-interest loans or equity investments. Numerous accelerators accept food waste reduction start-ups and some, such as Maersk and ReFED, have a specific program for food waste reduction businesses (Gunders 2018; ReFED 2018).

TABLE 3. LEGAL INSTRUMENTS AND INCENTIVES TO REDUCE, REUSE OR RECYCLE FOOD WASTE.

Policy	Explanation
Tax incentives	Businesses can access tax deductions or tax credits for food donated to charities or food banks. These are financial incentives for businesses to divert excess food for human consumption.
Subsidies or grants for research and infrastructure	Subsidies for research and development (R&D) and large infrastructure projects by local authorities to support initiatives.
Landfill taxes	Taxes on landfills for organic waste raise the price of landfill disposal, making it a less attractive disposal option.
Landfill bans	Banning organic waste from disposal in landfills. Alternative methods of disposal are required for all food waste such as edible surplus to redistribution to charities and inedible waste to compost or anaerobic digestion. Fines for noncompliance.
Liability protection	Protecting donors in the donation of excess edible food from the risk of legal and criminal liability if measures are taken to ensure the safe transfer of the donation. Fear of liability issues is a commonly cited reason for not donating food.
Targets and measuring	Measuring waste levels and setting targets for reduction allow for more accurate management and aim for initiative implementation. Data for waste levels enable better modelling to facilitate optimal strategy decisions (Pearce and Berkenkamp 2017).
Food waste as swine feed	Enabling the safe use of food waste as animal feed reduces reliance on alternative feeds such as soybean. This can reduce costs for farmers and the environmental impact of feed.
Simplified redistribution framework	Recommendations and clear guidelines that describe how to donate excess food to donors and recipients. Advice on how to safely transport the food and organize logistics.
Pay-as-you-throw pricing for waste	Waste is priced per unit such as volume or weight. The more waste produced, the higher the cost of disposal.

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4. MODELS FOR FOOD WASTE REDUCTION

4.1 Measurement

The most preferred method for reducing excess food and waste is prevention. Successfully addressing the issue involves the prioritization of mitigation measures. One of these is to measure the levels of loss and waste, recalling ‘what gets measured, gets managed’; implementing steps to measure waste levels reveals the nature of the type and amount of waste for informing more accurate decision-making. “Data provides insight into: why losses occur in operations; which areas provide the biggest opportunity for improvement; and how to continuously make progress towards goals” (Spoiler Alert 2017). Food businesses can develop inventories and waste-tracking systems specifically to meet these needs.

This section describes one business model, ‘Surplus and Waste Tracking and Analytical Software’, which is applied to multiple stakeholders. For wholesalers and retailers, better tracking of stocks and products nearing expiry allows more accurate forecasting from analyzing trends and applying discounts on excess food to reduce losses.

This model can be utilized in the hospitality sector for both inventories as well as wasted food. Systems track the type of food wasted and reasons for the waste. This information provides insights on a microscale to adjust current practices on a dish-by-dish basis if desired. For households, applications (apps) track grocery purchases, provide nudges for products nearing expiry and recipe ideas for using these products. Additional practices that consumers can include to prevent food waste are planning shopping in advance and becoming more familiar with the difference between ‘use by’ and ‘best-before’ on labels (Abeliotis et al. 2014; ICF 2018).

As the first step to reducing food loss and waste, understanding where waste occurs in the business is necessary to incorporate new strategies into workflows, forecast sales and ultimately offer discounts to sell more of the goods. In particular, there is a short time limit for the shelf-life of perishable products and this model offers cost savings to stakeholders through the reduction of waste.

4.1.1 Model I: Tracking and Analytical Software for Managing Food

Brief	Software that records inventory to ensure efficiency in ordering and reductions in wasted produce (Business Model Canvas 1)
Waste stream	Expired food products
Value-added product	Automated date and location tracking to optimize discounting and product movement
Key stakeholders	Processors, retailers, consumers
Geography	Urban, peri-urban (see also Figure 5)
Profit objective	For-profit
Organization type	Private

The Business Model

Expiry date checking and product rotating are time-consuming activities for employees of large-scale retail entities and therefore cost-intensive. The expiry of processed food items while on shelf display has negative impacts on the food business owing to customer complaints and lost revenue from unsold stock, plus eventual costs from the disposal of such items.

The primary goal of this model is to provide support for businesses in reducing their levels of food waste by providing smart solutions. By facilitating easy tracking of inventory and waste, the software enables the effective use of data for discounts or offers to prevent products becoming waste. This software is used by both for-profit and nonprofit businesses, whereas the creators of the software tend to be private, for-profit businesses. The businesses creating the software

require many inputs including skilled labor such as software engineering, finance and marketing expertise. A high level of research and development is also required to launch such a system, where various entities have partnered with existing businesses such as supermarkets to test and redevelop the program so that it satisfies the needs of the partner (Table 4).

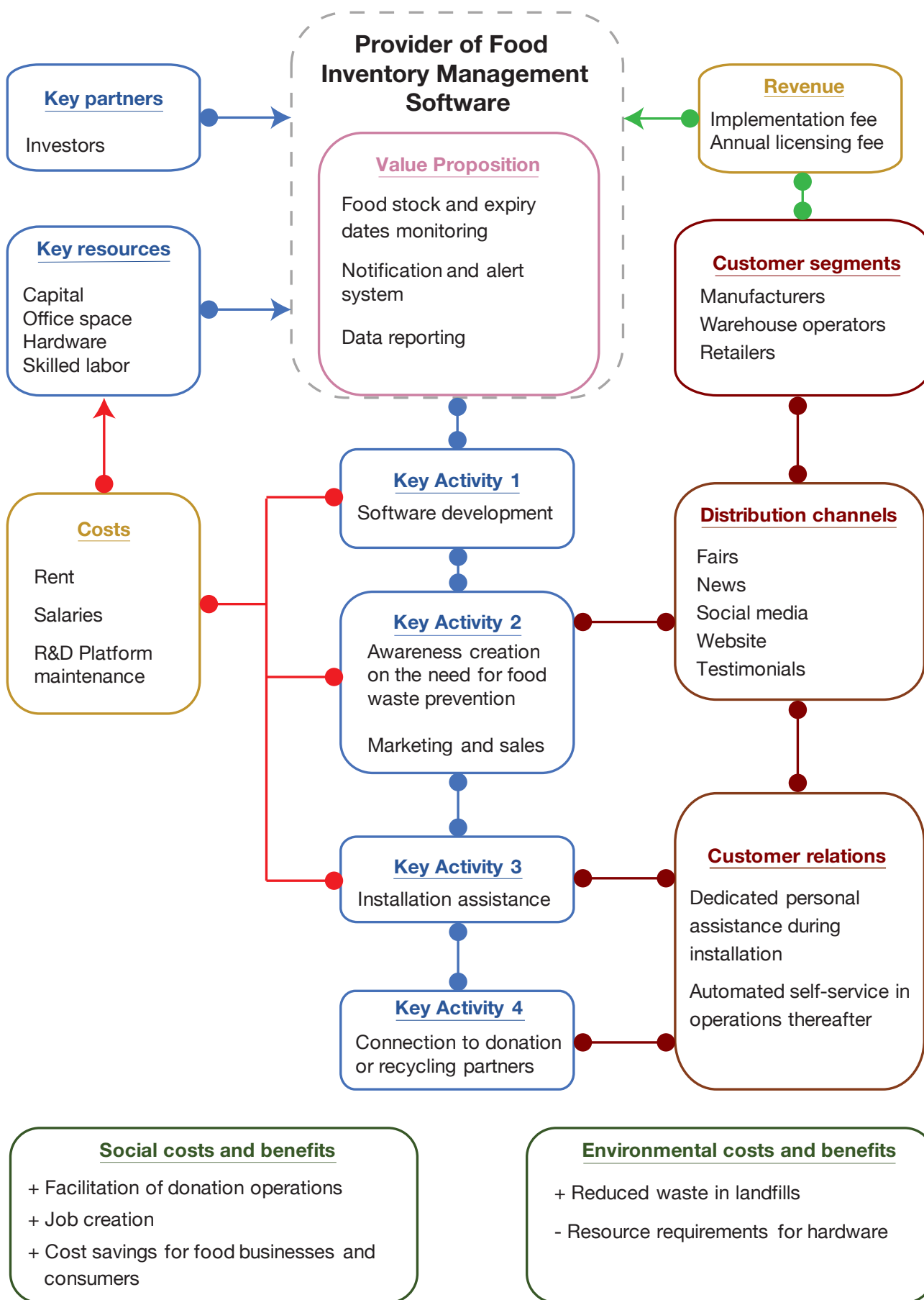
The inventory and tracking system is most often utilized by large retailers and food distributors. After the installation process, all products can be scanned

as they enter the facility and where they are placed in-store to record their expiry date and location in the warehouse or store. The system then sends alerts or notifications to managers about products nearing expiry. The system can estimate discounts, based on previous sales. This can determine which products will actually sell if discounted and how large the discount should be. These early notifications enable preventive procedures. In addition to discounts, the system can determine if the produce should be donated or sold to third parties to ensure the consumption of the product.

TABLE 4. SWOT ANALYSIS OF THE TRACKING AND ANALYTICAL SOFTWARE FOR MANAGING FOOD MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Strong client relationships • Marketing • Employee engagement • Effective training (digital literacy) 	<ul style="list-style-type: none"> • High adaptability required for every client • High cost of product
EXTERNAL	<ul style="list-style-type: none"> • Previous client satisfaction and waste reduction • Greater awareness of the food waste issue • Taxes and subsidies supporting food waste reduction 	<ul style="list-style-type: none"> • Capacity to implement change • Competition • Poor internet connectivity





BUSINESS MODEL CANVAS 1: TRACKING AND ANALYTICAL SOFTWARE FOR MANAGING FOOD.

Case Example

Spoiler Alert, United States

Spoiler Alert is a business focused on data and connectivity. It was founded in 2015 and currently employs thirteen people, seven of them being software engineers who are supported by the nation's leading food, agriculture and supply chain investors.

Spoiler Alert started as an online marketplace and quickly perceived a strong demand for food waste but lack of providers. After recognizing this mismatch in November 2016, Spoiler Alert introduced the enterprise's software model. It is designed to work as a complement to existing inventory management software of food distribution businesses so that they are able to gain a clearer insight through the aggregated data into their food recovery, donation and waste reduction efforts. In addition to the data dashboard, businesses have access to their networks consisting of more than 200 foodbanks and 200 discount retailers and even more organic recycling partners on the platform. Thus, they facilitate the donation process to organizations, discounted sales to other companies or transportation to organic-recycling initiatives. Interested parties can communicate via the Spoiler Alert network in real time. The Spoiler Alert software sends out notifications to promote moving of products close to expiry. The combination of

relationship management and providing software is what makes the impact of Spoiler Alert so effective, and the impact is growing.

Spoiler Alert's vision is to build a company that maximizes profitability, sustainability and efficiency across global supply chains. The company acknowledges that its success with clients has more far-reaching implications than its own financial and operational improvements – “contributing to a more sustainable world by tackling some of the greatest environmental and social challenges of our time”. In achieving this the company builds technology that empowers the world to minimize food waste.

Model Variation: Apps to Manage Groceries for Consumers

These are apps through which consumers record their purchases to keep track of what is in their cupboards at home to prevent purchasing duplicate items and to receive notifications about expiration dates. The apps reduce food waste by allowing users to ‘see’ if they already have a product while at the supermarket. The user updates the app to reflect the addition or consumption of any product. Value-added features include a shopping list within the app and multi-user capabilities or recipes to use items that are nearing their expiry date. App examples are 222 Million Tonnes, Eatby, and Prep & Pantry.

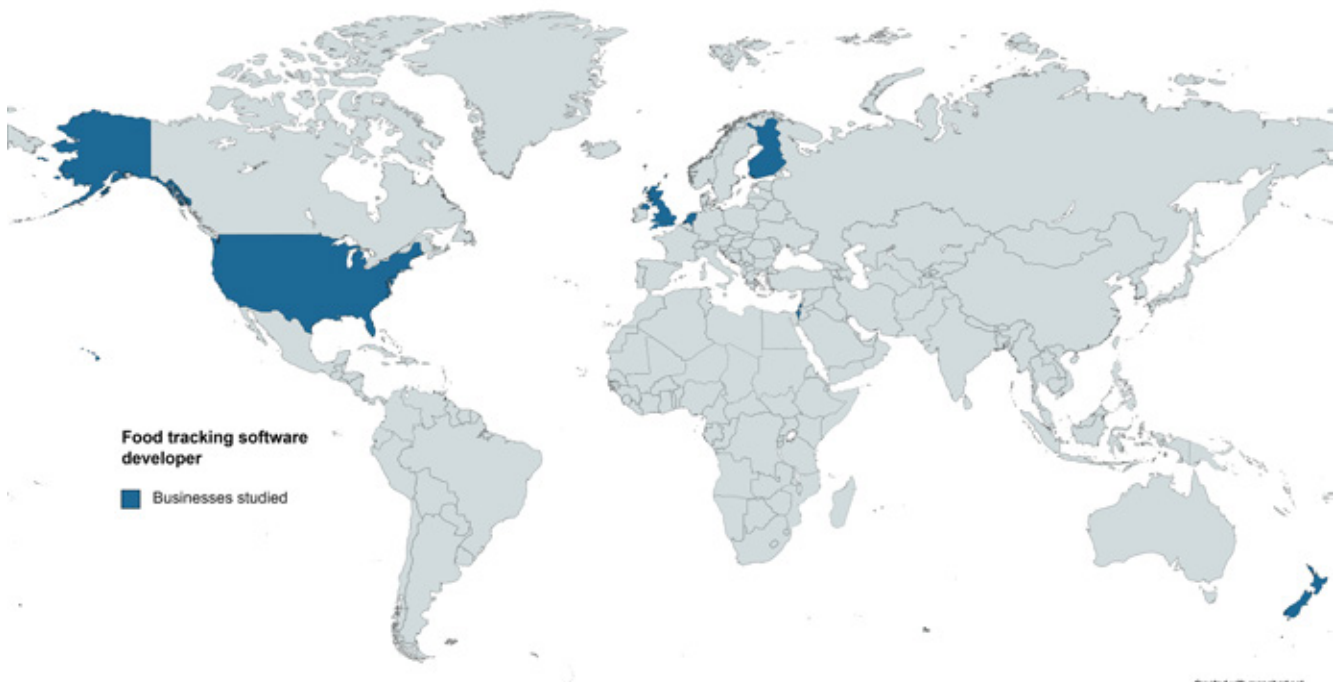


FIGURE 5. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL I.

4.1.2 Model II: Measuring and Analyzing Food Waste

Brief	Software that tracks the quantity and reason for wasted produce, providing insights and reports for better decision-making (Business Model Canvas 2)
Waste stream	Prepared meals
Value-added product	Smart scale connected to a software system to analyze waste
Key stakeholders	Restaurants, hotels, canteens
Geography	Urban, peri-urban (see also Figure 6)
Profit objective	For-profit
Organization type	Private

The Business Model

Excess food in the hospitality sector is generated from either buffets or events where less meals are consumed as forecasted. Often this food is discarded as it takes a significant amount of time and resources to find alternative ways of handling it. This is a source of monetary loss to the food business.

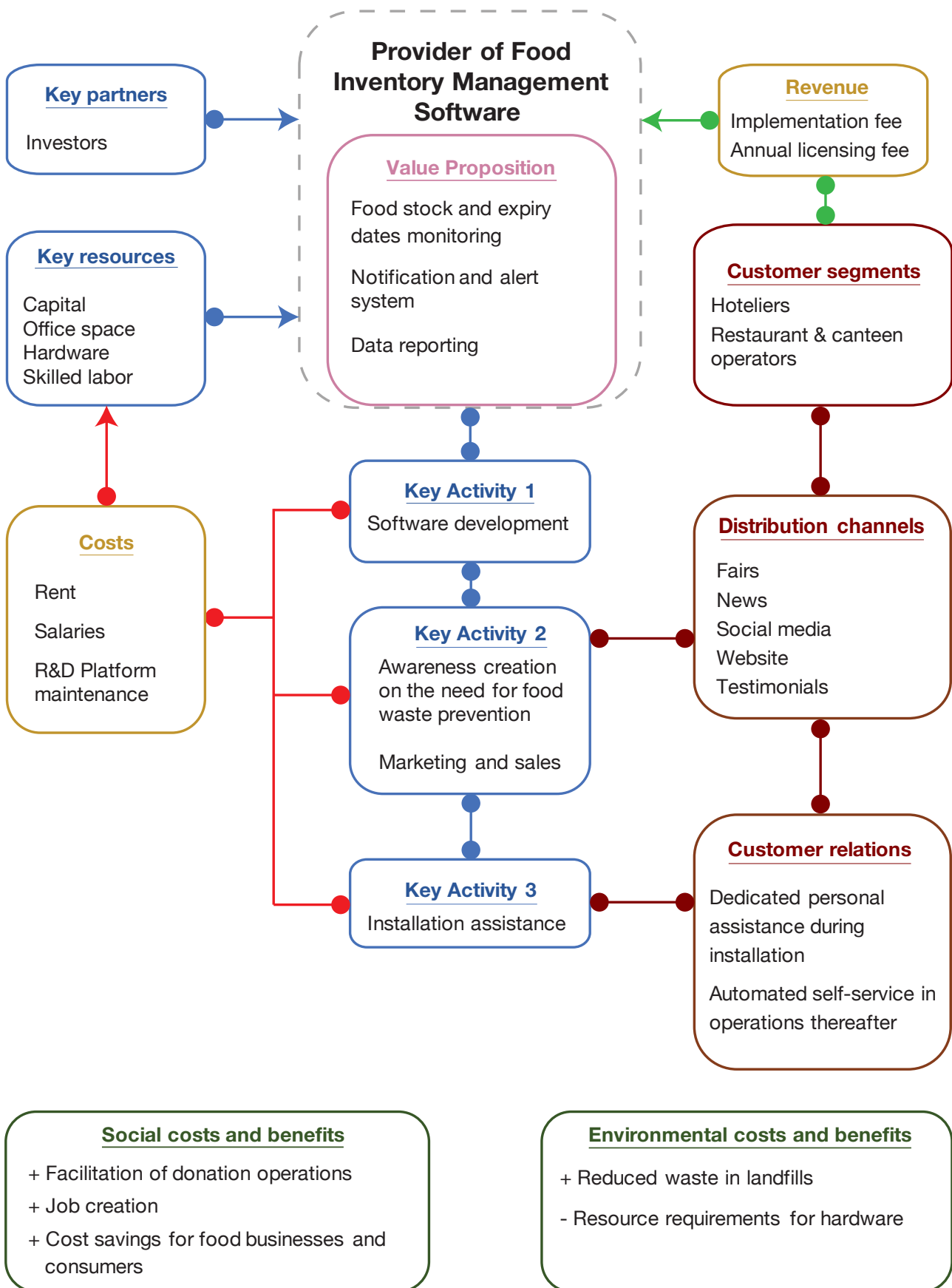
The software system consists of a digital scale, connected to a touchscreen monitor to record not only the weight but also the reason for the wastage. In addition, an 'intelligent camera' is installed above the bin, where the discarded food is captured. This not only enables accurate impact calculations such as calories, cost and resources wasted by the technology, but also provides recommendations

from the bin and software providers as to whether this food could have been recovered for an alternative use, such as transformation into another meal, donation or receiving benefit from value-added processing.

From the collected data, trends and reports are generated to inform chefs and decision-makers how to adjust their own operations based on where the highest levels of waste occur. For example, a particular dish that is consistently overproduced or under consumed in order to more accurately forecast demand and prepare food accordingly. Identified cases have confirmed that awareness of discarded quantities has led to a reduction of waste already. Table 5 shows a SWOT analysis of the model.

TABLE 5. SWOT ANALYSIS OF THE MEASURING AND ANALYZING FOOD WASTE MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Strong client relationships • Marketing • Employee engagement • Effective training (software use) 	<ul style="list-style-type: none"> • High adaptability required for every client • High cost of product
EXTERNAL	<ul style="list-style-type: none"> • Previous client satisfaction and waste reduction • Greater awareness of the food waste issue • Taxes and subsidies supporting food waste reduction 	<ul style="list-style-type: none"> • Capacity to implement change • Competition • Different cultural practices of food waste handling



BUSINESS MODEL CANVAS 2. MEASURING AND ANALYZING FOOD WASTE.

Case Examples

Leanpath (United Kingdom, United States, Spain and Australia)

Leanpath was founded in 2004 and has expanded its impact scale since then to more than 20 countries around the world, working with thousands of commercial kitchens. Leanpath invented a food waste tracking technology with a 'complete food waste prevention platform'. Using a large database of food waste images and artificial intelligence, the waste classification is fast and accurate.

The Leanpath website offers free resources and webinars as well as several case studies from large multinational clients such as Google and IKEA. Leanpath brings together hardware (scales, cameras, tablets and displays) with its software that enables managers to track all food waste events in their kitchens. The analytical program allows clients to analyze the drivers of their food waste with a high degree of granularity. An integrated dashboard provides summaries, participation and trend reports and

talking points for weekly meetings with the kitchen staff (www.leanpath.com). In the case of the University of Illinois, 63% of its food waste was reduced after working with Leanpath.

Winnow (United Kingdom)

Founded in 2013, Winnow is currently operating from five global offices and is installed or contracted in more than 1,000 institutions in about 40 countries (Figure 5). It is a leading food management solution for contract catering, hotels and casinos, quick service restaurants, supermarkets and cruise ships. It connects commercial kitchens all over the world to the cloud, allowing them to record and analyze exactly what food items are discarded. Its technology helps to identify and prevent avoidable waste, where most food thrown away has value and could be reused to make something else. The system takes photos of wasted food as it is thrown away and, using the images, the machine learns over time the type of food in the bin for automatic data collection (www.winnowsolutions.com)

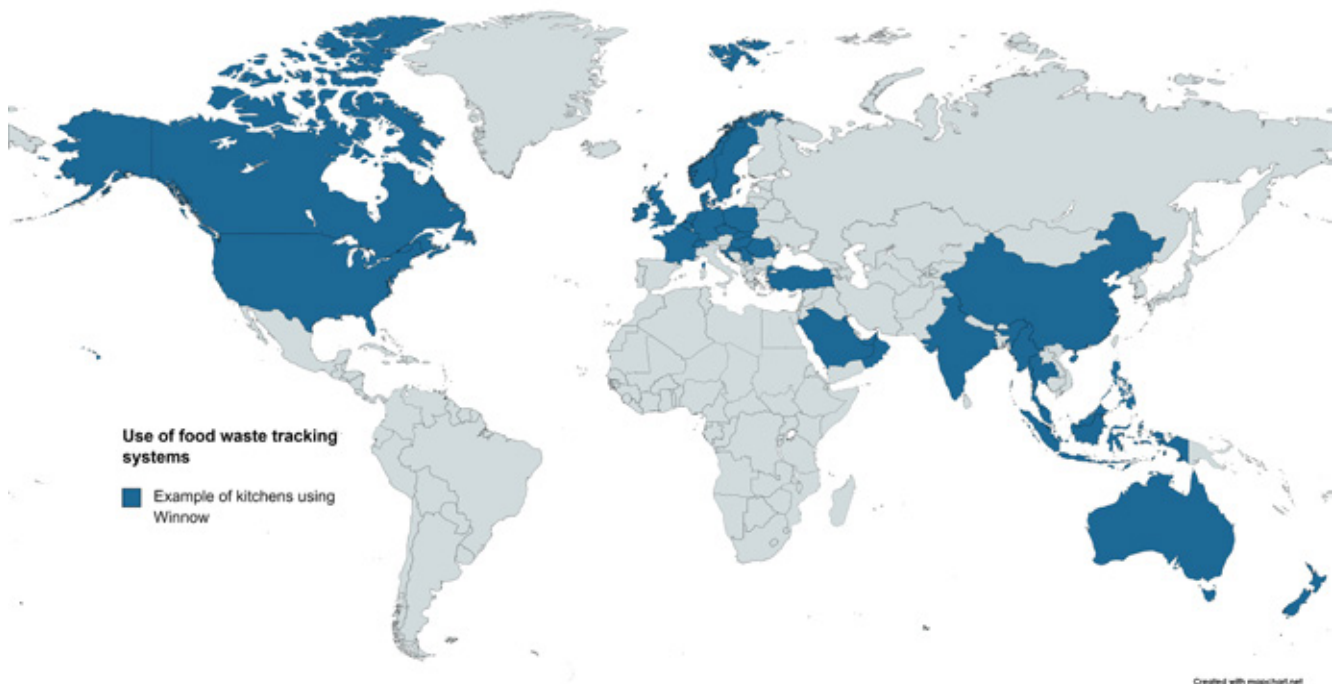


FIGURE 6. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL II.

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4.2 Redistribution

Following the Food Recovery Hierarchy, if food waste cannot be prevented, the subsequent most preferable strategy for food loss and waste reduction is through the redistribution of excess food for human consumption, wherever the infrastructure is available to do so safely. Procedures, guidelines and regulations to do so differ at country levels. The main challenge to overcome is the logistical gap between the food donor and the recipient. Due to the perishability of many foods, methods of redistribution must be innovative to overcome the challenges associated with transporting and storing available surplus to ensure it reaches the intended recipient safely. Engaging people, transport and communications is key for successful redistribution operations.

Around the world, new initiatives are forming, enabled by communities as well as entrepreneurs, to create models which overcome the barriers of redistribution. At the community level, food sharing extracts, street markets and community fridges are common worldwide in both low- and middle-income countries. The increasing trend of community fridges provides access to meals and donated produce for anybody, regardless of status or need. This initiative overcomes logistical gaps in redistribution by managing a central location for the collection and distribution of excess food.

Volunteer organizations are integral to redistribution networks. With minimal inputs, many have achieved huge milestones in delivering millions of meals to their clients. These initiatives operate with little to no funding but achieve their work through partnerships and the hard work of local volunteers. While traditionally, and largely still a nonprofit activity, for-profit models for the redistribution of food are increasingly becoming evident. These are enabled by sound policies such as

Food waste reduction during Ramadan

Every year, during festive seasons such as Ramadan, tonnes of food end up in the dustbin. Based on statistics by the Malaysian Solid Waste and Public Cleansing Management Corporation (SWCorp), about 4,000 MT of edible food are thrown away in landfills every day during Ramadan, and the numbers are increasing every year. This amount of food waste could feed 2.97 million people three times daily. To help combat the issue, SWCorp has initiated a food waste reduction program dubbed 'Love Food Hate Waste' at Ramadan bazaars in every state. The program aims to study the amount of food surplus from Ramadan bazaars and save the excess food in a food bank for channeling to underprivileged students, for example.

tax deductions for donations in the US and France as well as landfill bans or taxes. These provide incentives for alternative uses and potential revenue streams for entrepreneurs.

For-profit models are increasingly common for business-to-business and business-to-consumer platform connection models. On the other hand, business-to-donation platforms are more often nonprofit. Each of these models provides methods of moving excess food between donors and recipients as well as buyers and sellers. Each model in this section provides a solution that can be suited to the needs and resources available in a particular community. Creating solutions to overcome logistical gaps enables access to food waste and therefore provides meals to various stakeholders in the local community.

4.2.1 Model III: Community Fridge

Brief	A fridge where excess food is placed by donors for recipients (Business Model Canvas 3)
Waste stream	Donated food from retailers, restaurants, consumers
Value-added product	Provides access to food for the community
Key stakeholders	Retailers, restaurants, consumers
Geography	Urban areas
Profit objective	Nonprofit
Organization type	NPO, public

The Business Model

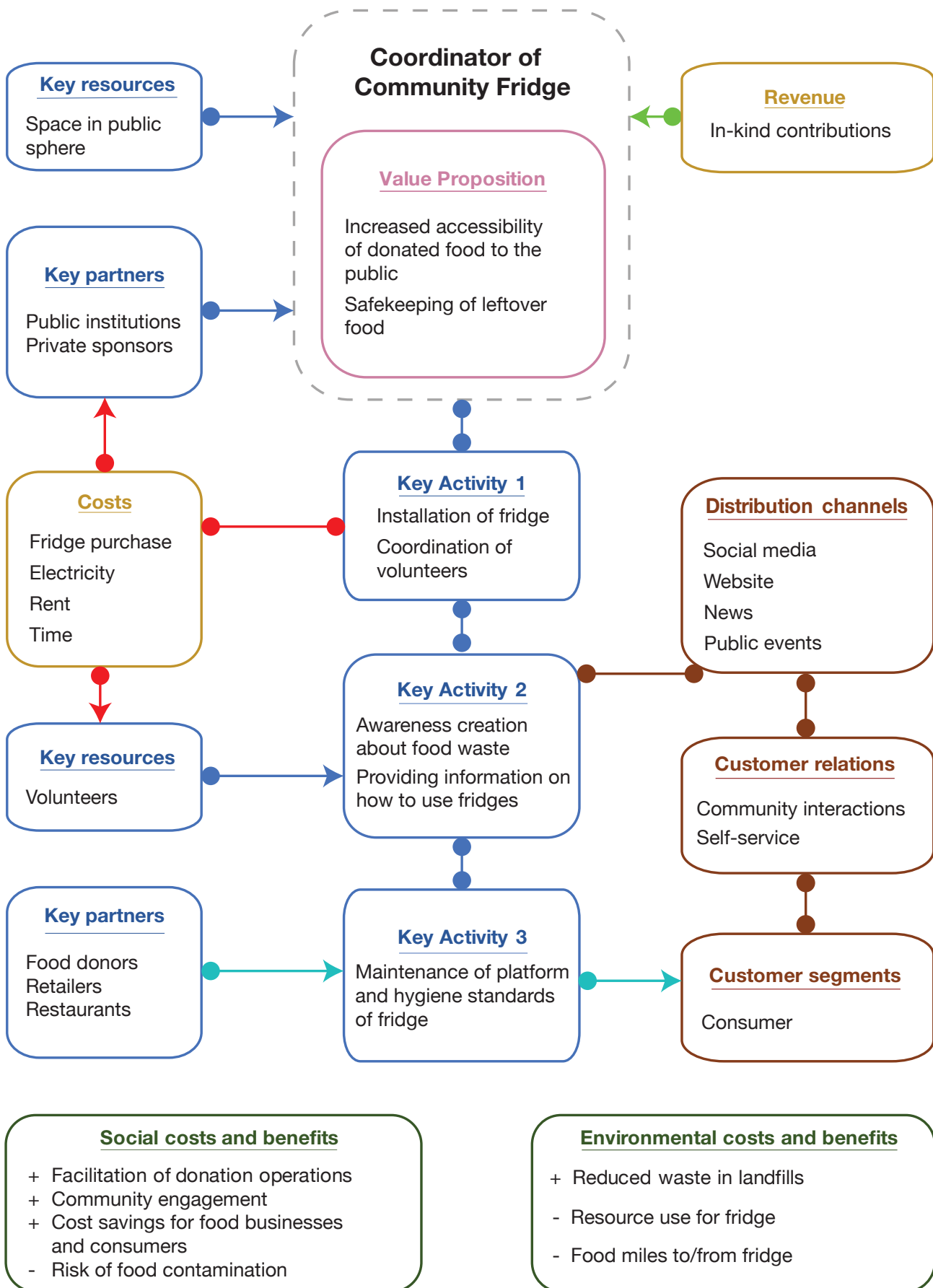
The model for community fridges is nonprofit and socially driven to solve the issue of local hunger as well as to reduce food waste. Closing the logistical gap for redistribution between food donors and recipients is achieved by installing a community fridge. Placed in an easily accessible location, the fridge acts as a central point, for which the placing and taking of donations do not have requirements based on time or distance between individual stakeholders; rather they are able to donate and access the food at a time convenient to them (Figure 7). The only requirements for the location of the fridge are accessibility and constant electricity supply (Table 6). Common locations are in community centers, religious buildings, universities, outside restaurants or other community-managed spaces. As the model is nonprofit, a team of volunteers manages the operation to keep it running. For the sustainability of the model, a team of dedicated volunteers

is vital. Their roles will vary but should address cleaning and sorting, placing produce into the fridge, measuring donation types and amounts, establishing funding sources, engaging with suppliers and consumers, and informing and coordinating with stakeholders. Additional responsibilities include any legal or safety requirements such as creating guidelines for donations, managing liability insurance or registering as a food business. These will depend on the country in which the fridge is located (Figure 8).

Donors are typically food businesses (supermarkets, restaurants, market vendors, bakeries, etc.). The acceptance of certain food types depends on the safety regulations for the fridge; in some cases, the fridge only accepts cooked food from registered businesses or requires home-cooked food to be labelled. In others, all food is accepted. However, common products not accepted are raw meat, fish, eggs or products past their 'sell-by' date.

TABLE 6. SWOT ANALYSIS OF THE COMMUNITY FRIDGE MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Strong relationships with partner organizations • Low investment costs • Marketing or awareness-raising strategy • Centrally located and easily accessible • Clear guidelines for donations • Volunteer training 	<ul style="list-style-type: none"> • Reliance on donations • Mainly volunteer run • Unreliable electricity supply
EXTERNAL	<ul style="list-style-type: none"> • Previous client satisfaction and waste reduction • Strong community base • Various food businesses located close to the fridge • Awareness of the food waste issue 	<ul style="list-style-type: none"> • Liability for donated food • Acceptance by the public to consume food of unknown origin • Too high demand resulting in tensions and conflicts



BUSINESS MODEL CANVAS 3. COMMUNITY FRIDGE.

Case Examples

Foodsharing (Germany)

The trend of community fridges was created by the nonprofit association Foodsharing in Germany. It has established a network in many European cities with fridges in public spaces like universities with open access to society. The locations can be found on a digital map on its platform (<https://foodsharing.de>).

The People's Fridge (United Kingdom)

The People's Fridge in Brixton was started in 2016 through a crowdfunding campaign which raised over GBP 2,200 (approximately USD 2,950). A group of food traders and local activists brought the concept to London after hearing about similar initiatives in Germany, Spain, India and elsewhere in the UK. The local council, chefs, restaurants and other local businesses and organizations support it. The fridge is located in Pop Brixton, an area for independent start-ups working in food, retail, design and social enterprise. Since starting, the fridge has helped to redistribute hundreds of kilograms of excess food.

Sharing Shelves, Feeding India (India)

Sharing Shelves is the community fridge arm of the charity 'Feeding India' (2020). It has pledged to donate over 500 fridges across 100 cities in India. By collaborating with the organization, interested parties request a fridge for a particular location that is set up with the help of volunteers from Feeding India. In these community refrigerators, people can store surplus food or can donate food to the needy. They estimate one



FIGURE 7. COMMUNITY FRIDGE IN A GERMAN UNIVERSITY.

fridge will help to serve between 1,500 and 2,000 meals per month. Partner organizations include radio stations, private businesses and individuals around the country. The food is mainly cooked food which, when donated, is apportioned individually.

Model Variations

- To establish a reliable funding stream, volunteers offer a collection service of food from retailers for a fee, which could contribute to covering the costs associated with running the fridge.
- A membership model, where local businesses or households pay for access to the fridge and its contents to cover operational costs.

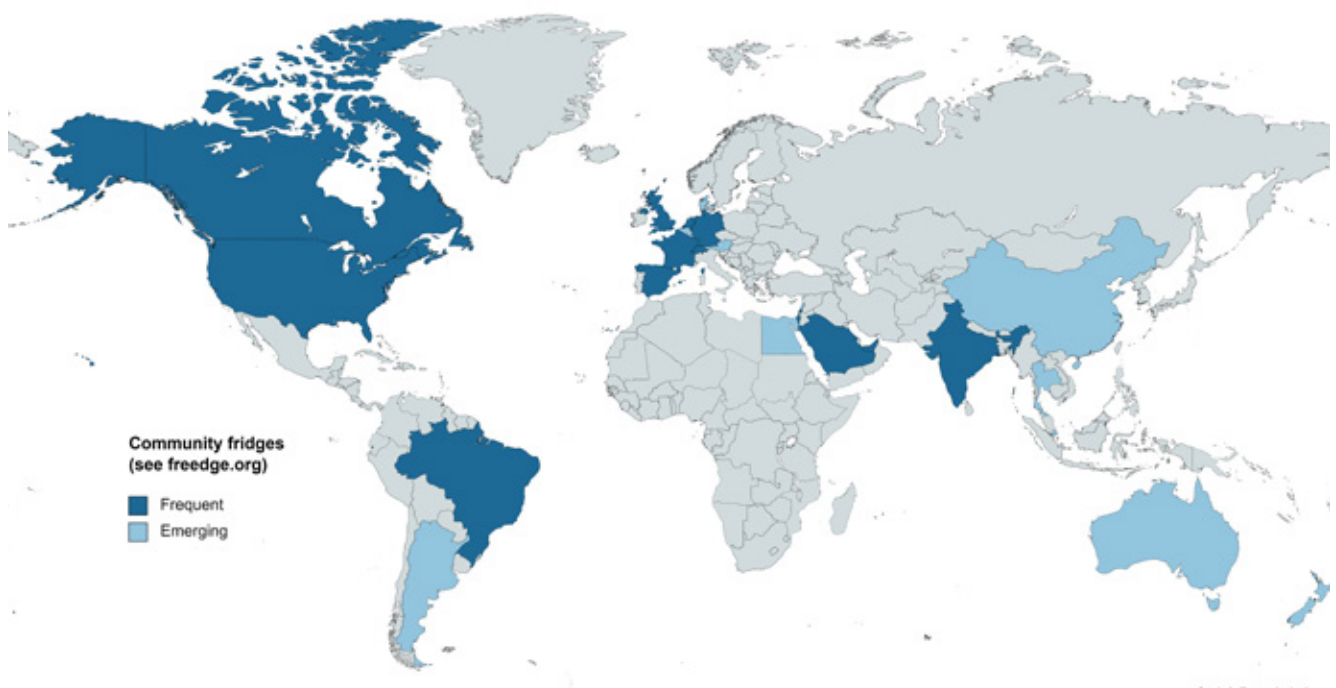


FIGURE 8. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL III.

4.2.2 Model IV: Connection Platform

Brief	Information and communication technology (ICT)-mediated excess food sharing from food businesses to potential customers (Business Model Canvas 4)
Waste stream	Excess food, close to expiry products, prepared meals
Value-added product	Enhanced visibility of discounted produce
Key stakeholders	Retailers, restaurants, consumers
Geography	Urban, peri-urban (see also Figure 9)
Profit objective	For-profit, nonprofit
Organization type	Private, NPO

The Business Model

For-profit

In this model an app or website connects buyers and sellers of excess food. The platform enables sellers to post their available produce, and buyers to make purchases, providing a payment system of which a percentage of sales is taken as commission. The platform connects various combinations of stakeholders, e.g., farmers to restaurants, retailers to consumers and suppliers to other suppliers; however, it generally focuses on two stakeholder groups – sellers and buyers. The entrepreneur maintains the platform to facilitate the connections. The business model creates value by offering a means for suppliers to offload extra produce and recover some of the associated costs and provides discounted produce for buyers. Additional

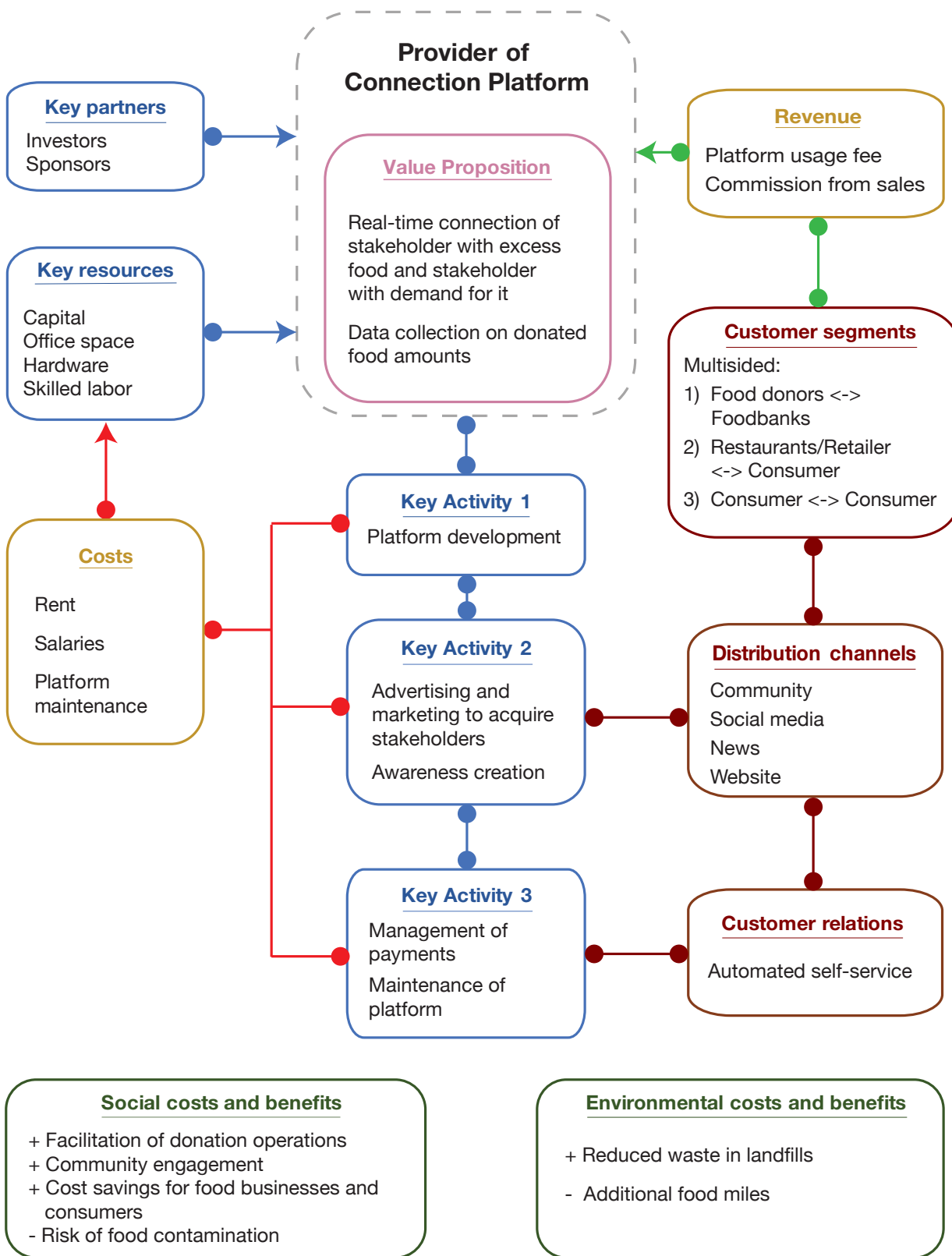
incentives for using the platform for sellers are low-cost advertising and marketing, driving foot-traffic to the store and promoting a green brand for customer engagement (Table 7). The platform is an intermediary, where an entrepreneur acquires buyers and sellers, creating value with an increasing number of both; it also processes and manages payments between the two. The method of transporting goods is agreed on between the two stakeholders.

Nonprofit

The nonprofit platform connects food donors to foodbanks or other charitable organizations. The use of the platform is free for both stakeholders and solely provides a space for each to upload and view the available excess food. Once an agreement is reached, the transportation of produce between the donor and recipient is arranged mutually.

TABLE 7. SWOT ANALYSIS OF THE CONNECTION PLATFORM MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Strong client relationships • Marketing • Easy to use platform • Low operational and maintenance costs 	<ul style="list-style-type: none"> • Initial start-up costs • Skilled labor shortage, e.g. software engineers
EXTERNAL	<ul style="list-style-type: none"> • Greater awareness of the food waste issue • Taxes and subsidies supporting food waste reduction • High potential to scale up 	<ul style="list-style-type: none"> • Competition from other platforms • Lack of finance



BUSINESS MODEL CANVAS 4. CONNECTION PLATFORM.

Case Examples

Grub Cycle (Malaysia)

Grub Cycle is a social enterprise founded in 2016. As a start-up, it raised USD 250,000 from impact investors and graduated from the MaGIC accelerator program. Its key activities include (i) an app to connect restaurants and other retailers to customers for discounted excess meals, (ii) an online discounted grocery service, (iii) redistribution of overproduced vegetables to low-income households, and (iv) preserving fresh produce so that it has a longer shelf-life. Grub Cycle has partnered with local restaurants and cafés, enabling waste reduction and reaching new customers. Customers can view nearby deals, subscribe to particular retailers and purchase the meal through the app. The amount of money and kilograms of food saved are recorded in the app. The biggest challenge for Grub Cycle was changing the mindset of suppliers. Overcoming this required consistent communication with the suppliers, i.e. disseminating what Grub Cycle was doing and how it was growing. The process of reselling surplus produce may be new to many partners and so they need to be convinced of how it can work and informed of the benefits; currently in Malaysia there are few or no practices for supermarkets to reduce waste levels (<https://grubcycle.my>).

Model Variations

- The B2C model: This is a platform, such as a mobile app, for connecting food retailers, particularly restaurants or supermarkets to consumers to offer discounted excess food. If retailers overproduce a certain dish, or sell less than expected, they upload the type and quantity of the excess meal onto the app. Consumers can view the available deals near them or are notified if a restaurant they have subscribed to uploads a deal. Either the consumer pays through the platform for the food and collects it at a certain time or pays and collects it directly from the store. Consumers benefit through access to discounted food and retailers benefit through both reduced disposal costs and income for otherwise wasted food.
- Once two stakeholders have made a connection, the business provides the logistical service necessary to collect and deliver the produce between the seller and buyer. Fees for this service are a percentage of sales made using the platform. This model requires a greater investment in physical capital such as trucks, as well as hiring drivers and coordinators to manage deliveries. The transportation of produce can be a challenge for small businesses; therefore, providing the option of this service can add greater value to the model.

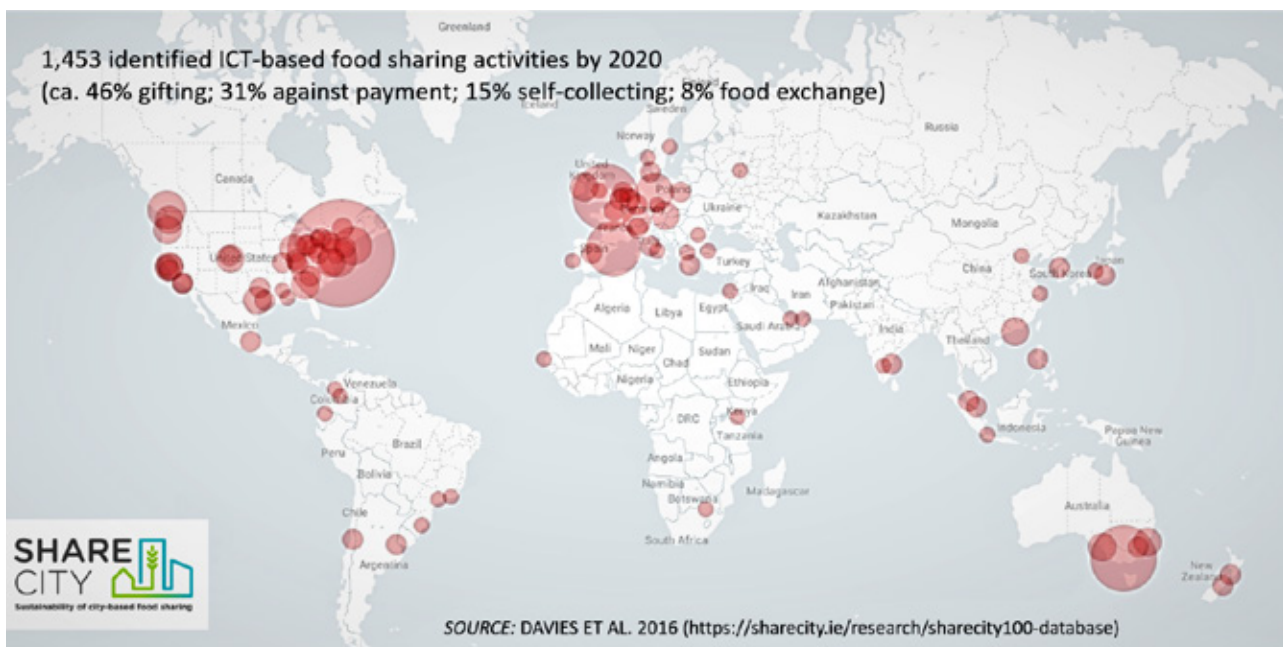


FIGURE 9. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL IV.

4.2.3 Model V: Logistics Services

Brief	Service to transport and manage food excess (Business Model Canvas 5)
Waste stream	Caterers, restaurants, hotels, canteens
Value-added product	Transporting excess food from food donors to recipients
Key stakeholders	Entrepreneurs, foodbanks, food retailers
Geography	Urban (see also Figure 10)
Profit objective	For-profit, nonprofit, social enterprises
Organization type	Private, NPO, public, PPP

The Business Model

For-profit:

The primary service provided by this model is the administration and transportation of food between the donor organizations and recipient foodbanks. The business primarily serves large offices, caterers, restaurants or hotels as they are likely to have regular excess food to donate. Primarily the food is prepared, cooked food, however, this model can equally meet the needs of supermarkets in delivering uncooked food. The business is the intermediary between the two stakeholders, providing a solution for logistics and on-demand matching in real-time. As an additional incentive for businesses to donate, value-added services are included in the fees charged which may include tracking excess food types and amounts, analysis, reporting, sessions with staff to raise awareness, marketing materials and, where applicable, accounting for tax deductions. Services can be priced per pick up, via a monthly subscription fee or by the percentage of

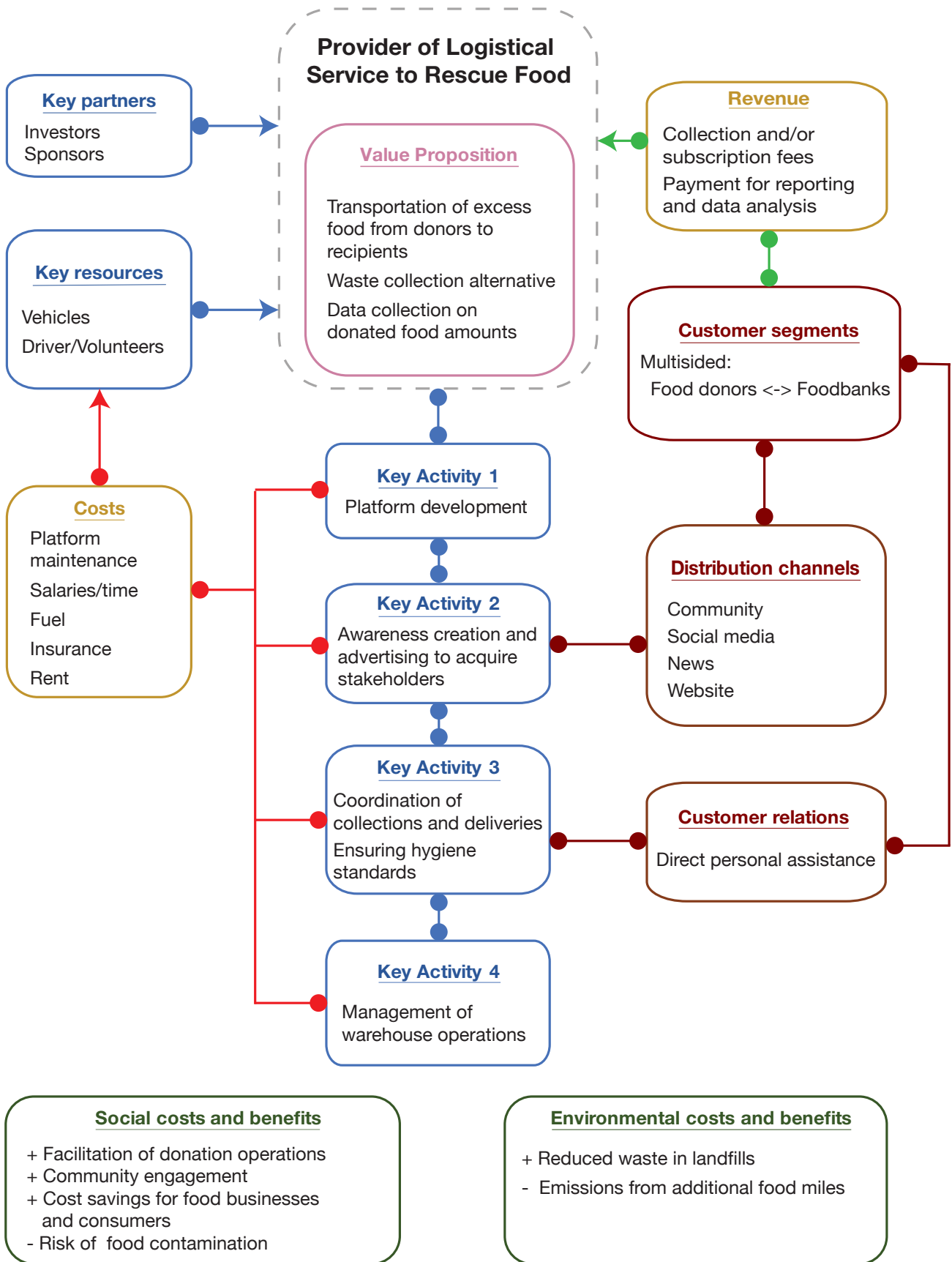
tax deductions, depending on the policy environment and needs of local businesses. Both businesses and recipient foodbanks sign up for services through a website where their requirements are matched for optimal redistribution.

Nonprofit:

The model provides the logistics to transport excess food between donors and foodbanks, charities, communities or a central space where people come to receive the food. The key difference of the nonprofit model is its reliance on volunteers who manage the operations of the business in coordinating collection times, collections and deliveries, which can entail risks (Table 8). The donors served by the nonprofit model are likely to be smaller and require more irregular collections compared to those who use for-profit services. A central platform coordinates both donors, recipient organizations and volunteers. These models tend to be hyper-local with donors and recipients within the same neighborhood. The flexibility of this model means services can be tailored to meet the needs of the community.

TABLE 8. SWOT ANALYSIS OF THE LOGISTICS SERVICES MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Good relations with donors • Training for drivers and volunteers to ensure food safety guidelines are adhered to • Guidelines for all stakeholders to follow 	<ul style="list-style-type: none"> • Unreliable drivers (if volunteers) • High investment • Skilled labor shortage, e.g. software engineers
EXTERNAL	<ul style="list-style-type: none"> • Tax deduction policy for donations • Awareness of the food loss and waste issue 	<ul style="list-style-type: none"> • Cheap or no fees for waste collection



BUSINESS MODEL CANVAS 5. LOGISTICS SERVICES.

Case Examples

Copia and Replate (United States)

Both Copia and Replate based in San Francisco offer logistical services for the transportation of excess food between donor organizations and recipient foodbanks. Both cases offer various subscription packages as well as value-added services such as reporting, analytics and tax deduction accounting. Copia, however, is for-profit and Replate is nonprofit.

The main difference between the two cases is their financing structure. Copia is financed by venture capital investors such as Structure Capital, Emerson Collective and 8VC among others (Crunchbase) and also taps into tax deductions food donors receive. Whereas, as a social enterprise nonprofit organization, Replate relies on government and philanthropic funding sources as well as collection fees which cover the operational costs of the business. The benefit of incorporating as a nonprofit organization for Replate is the ability to focus on the needs of the end-users to ensure the highest quality of food for them. Difficulties can be acquiring talent and funding as it takes time and resources to apply for funding and grants for capital. Copia, on the other hand can raise capital more quickly if necessary, however it may not retain complete autonomy over operational decisions (Weymes and Davies 2019).

Model Variations

For-profit:

Instead of hiring drivers, the model utilizes gig-economy delivery drivers who are working for companies such as Uber, Lyft or Deliveroo as part-time contractors to transport the food between donors and recipient organizations. The drivers are paid a set amount per delivery that is funded by fees charged to donors. This model requires a high density of gig-economy drivers to be effective, although volunteers can be used to supplement required services. Using a variety of transport options can be effective in cities; for example in areas with significant traffic, bicycles can deliver food more quickly. The urban environment will determine the most suitable transportation option.

Nonprofit – Gleaning:

Gleaning is a food rescue action, focused on the food production sector, i.e. through collecting leftover crops from fields after the commercial harvest. This approach requires an additional workforce which is handled by volunteers. All eight cases found under this variation are based in the US with a nonprofit objective. The fresh vegetables and fruits are either transported to partnering foodbanks or soup kitchens or distributed within the community.

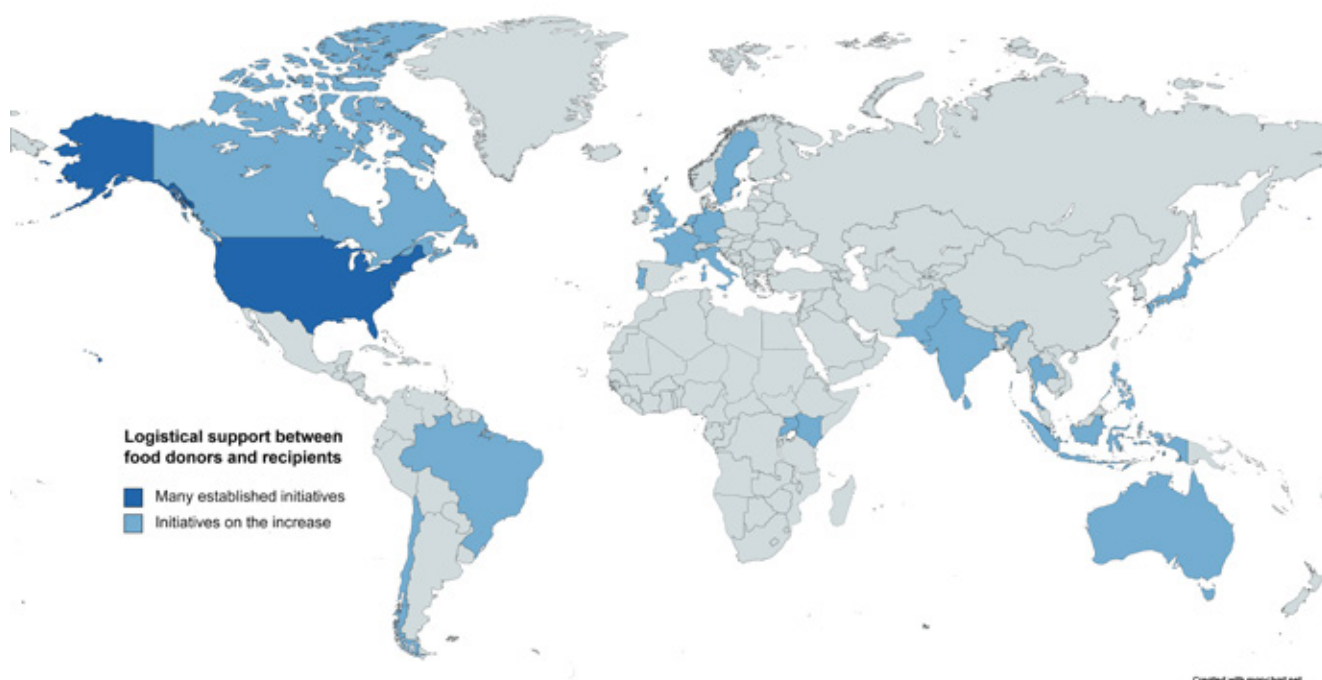


FIGURE 10. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL V.

4.2.4 Food Redistribution during the Covid-19 Pandemic

In 2020, the amount of generated food waste was probably larger compared to previous years (Mok 2020). Due to the closing of restaurants, hotels, schools, etc. farmers did not find their normal market and were forced to discard their products. On the other hand, locked-down communities as well as households with Covid-19 related loss of work were increasingly facing food shortages and the share of the food-insecure population started growing (UNICEF 2020). Hence, there is a high demand for food donations and direct distributions to consumers during the Covid-19 crisis.

Initiatives working on food waste reduction and redistribution face additional challenges. The company Imperfect Foods, for example, alerted their customers about delays because of the increase in demand but for safety reasons decrease in staff or even pause of operations (Imperfect Foods 2020). Other food rescue initiatives like Foodsharing (a volunteering organization collecting food waste and redistributing it to others) overcame challenges in physical distancing by formulating new rules of conduct to lower the risks of spreading the coronavirus. For example, the group of volunteers collecting the food has to remain as small as possible with the required physical distance between people, but is also asking on its webpage openly for ideas on how to operate during the Covid-19 pandemic (Foodsharing 2021).

Not only have new rules of conduct been established during this time, but also new business models. For example, Brothers Produce, the largest Texas-based food and beverage distributor operating in the US, was collecting fresh produce from farms and delivering it to retailers, schools and restaurants. With a decrease in demand from these entities during the pandemic,

they have adjusted their business model to start home deliveries of fresh produce. The company now offers boxes of fruits and vegetables for direct delivery to homes in Houston and Austin, Texas (Mok 2020; Brothers Produce 2020).

The crisis can offer opportunities to expand existing nonprofit food redistribution operations as shown in the cases of Replate (US), Rock and Wrap it Up (US), The Felix Project (UK) or Mesa Brasil SESC (Brazil). Besides their expansion in scale, some initiatives have shifted their field of operation due to Covid-19. The nonprofit organization Food Recovery Network is operated by students on 230 college campuses across the US, which are currently closed. Yet, with donations of several companies, the students can continue the redistribution of excess food. The Refettorios and Social Tables of the initiative Food for Soul continue to serve the community during the crisis and the founder offers cooking demonstrations on how to repurpose household food waste into meals (Mok 2020).

Other organizations have provided support as well as research to further enable redistribution operations. The Harvard Law School Food Law and Policy Clinic analyzes options for low-cost home food delivery and the support of emergency food systems (Mok 2020). While ReFED, an organization which analyzes solutions to reduce food waste, has created a USD 10 million fund which it hopes to distribute to organizations for preventing or redistributing food waste (Kaufman 2020).

Questions arise about the long-term effect of the pandemic crisis on our food system. For example, will it result in increased awareness and habitual changes? Can this situation open long-lasting solutions for the future? (Kaufman 2020).

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4.3 Resell

Primarily, these models address large quantities of uncooked food from manufacturers, wholesalers and retailers. The food may be perishable, such as fruits and vegetables rejected by buyers for aesthetic reasons in the supply chain or nonperishable products with long shelf-lives such as cereal bars and jams or chutneys. All food is safe for human consumption. However, it is rejected for sale through primary retail routes. Additional reasons for rejection may be damaged packaging, discontinued lines, overordering or labelling. By following labels, retailers, as well as consumers, tend to dispose of products past their best-before date which is an indicator of product quality, whereas use-by dates address product safety.

Reselling products in secondary markets is not a new business model. However, applying this to

food can be innovative. The resale of produce offers benefits for both buyers and sellers. For sellers, this means cost recovery from an additional income on potentially wasted produce. For buyers, the produce is available at discounted rates, offering savings on purchases. In addition to financial benefits, discounted food offers social benefits in accessing cheaper food and environmental benefits through the reduction of discarded edible food.

The three models in this section offer solutions for producers, processors, wholesalers and retailers as alternatives to disposal of the excess food in landfills. Following the Food Recovery Hierarchy, redistribution for human consumption is the most preferred method of reutilizing the nutrients of edible excess food. These secondary marketplaces offer a new possibility for stakeholders to engage in mutually beneficial transactions.



4.3.1 Model VI: Box Subscriptions

Brief	Unsold fruits and vegetables are repackaged and delivered to households or offices based on a subscription (Business Model Canvas 6)
Waste stream	Produce rejected for aesthetic reasons (farms, wholesale)
Value-added product	Delivery of discounted produce
Key stakeholders	Farmers, processors, wholesalers, consumers
Geography	Urban, peri-urban (see also Figure 11)
Profit objective	For-profit, social enterprises
Organization type	Private

The Business Model

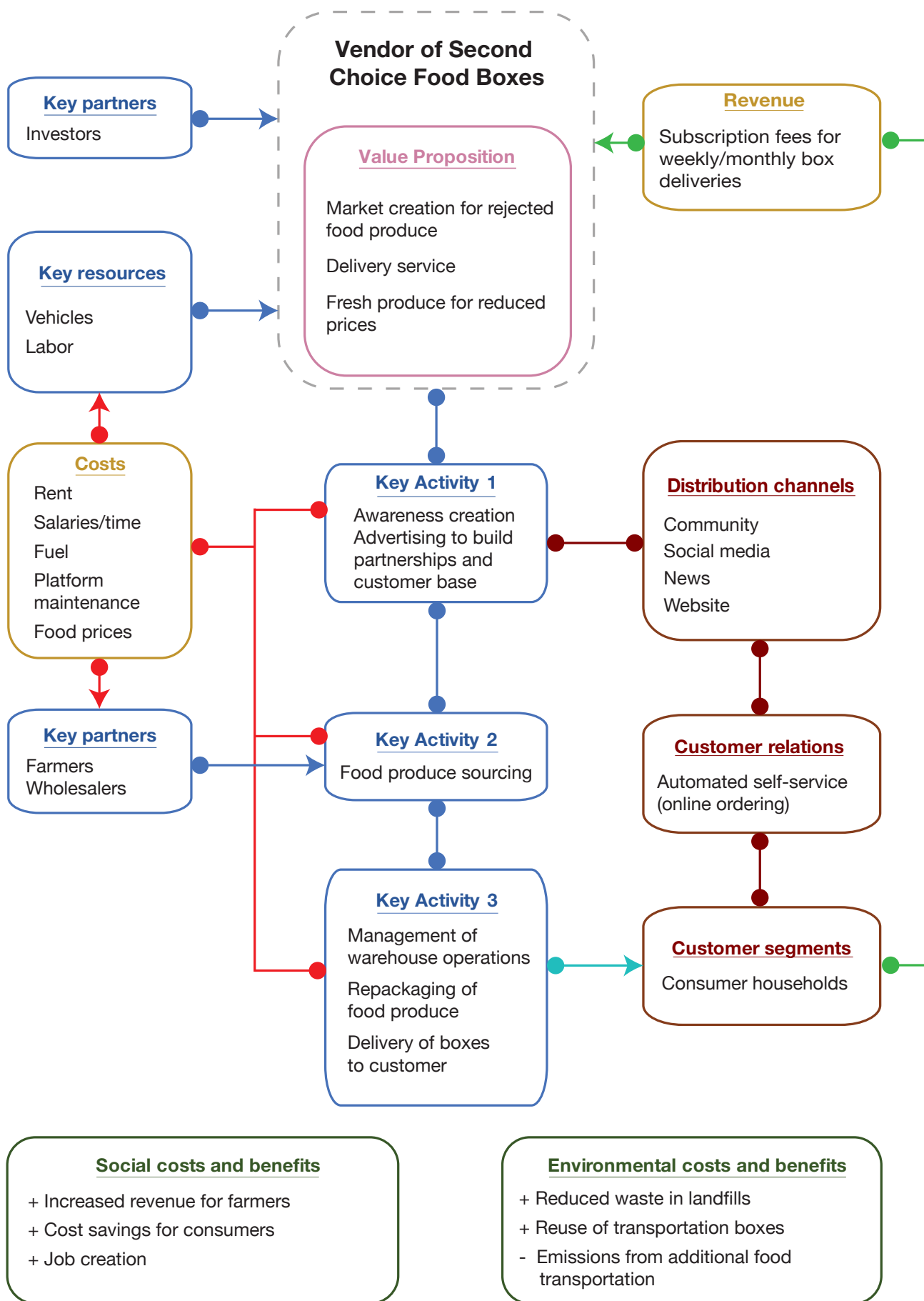
The produce box subscription model delivers fruits and vegetables to consumers sourced from farms, processors or supermarkets that are rejected for aesthetic reasons (for example, too small, too large or too misshapen). In addition to reducing food waste, value in the model comes from discounted produce, as it is priced lower than that available in supermarkets, as well as reliable delivery. The model is based on a subscription pricing system where customers pay a monthly subscription fee for the delivery of a box of ‘unattractive’ produce. The model requires an entrepreneur to create a logistical system capable of sourcing and transporting

rejected fruits and vegetables from the point of surplus to a central warehouse where the produce is packed into boxes and delivered to customers, which include households as well as offices.

Another key requirement of the model is the website where customers can place their orders; through the website, the entrepreneur can communicate with customers and address their needs. Often the bundle of how many different types of fruits and vegetables are available in each box is displayed as opposed to the exact produce to be delivered. Suppliers are also able to contact the business to indicate their excess food availability through the website (Table 9).

TABLE 9. SWOT ANALYSIS OF THE BOX SUBSCRIPTIONS MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Strong client relationships • Marketing • Creation of new market • Strong logistics framework 	<ul style="list-style-type: none"> • Limited access to finance
EXTERNAL	<ul style="list-style-type: none"> • Awareness of the food waste issue • Greater-than-expected harvest • Good internet connectivity • Greater awareness of subscription box models 	<ul style="list-style-type: none"> • Competition for input can raise the prices of the produce • Competition from other box subscription or similar businesses • Prejudices against ‘wasted food’



BUSINESS MODEL CANVAS 6. BOX SUBSCRIPTIONS.

Case Examples

Hungry Harvest (United States)

The Hungry Harvest mission is to reduce food waste and hunger. To date, the organization has rescued over 5,000 MT of food and provided 415 MT to food-insecure people. Hungry Harvest currently operates in nine states in the US. It sources rejected produce from farms, manufacturers and wholesalers. The organization began in 2014 and was started through a market stall on the founder, Evan Lutz's college campus. This inspired the delivery of fresh produce. The founder started by knocking door to door to sign people up for the service. The first delivery was for 30 people, with half on a free trial. Securing USD 100,000 in funding enabled expansion of the organization. Since then, the company has received USD 525,000 in additional funding, including investment from Conscious Venture Lab. Current annual revenue is USD 36.7 million. Hungry Harvest employs 40 people and has plans to expand to new states in the near future.

The business has scaled up rapidly over the five years since it began. The IT infrastructure allows fast scaling

up of new geographical areas. Although awareness is increasing about the issue of food waste, the market generally does not exist and so resources are required to create it. In 2019, the company merged with Ungraded Produce, an American enterprise working with the same business model (<https://hungryharvest.net>).

Model Variations

- Offering other types of produce, such as day-old bread or surplus eggs. Including these additional items depends on the ability to source produce locally and the necessary logistics to transport it to the central warehouse.
- The ability of customers to customize the produce in their boxes for delivery; a fee may be charged, providing an additional revenue stream.
- Offering services for wholesale customers. For larger orders, the produce is sourced directly from a farm, where those with surplus 'harvest-to-order', offering discounted fresh produce for restaurants or other food retailers.

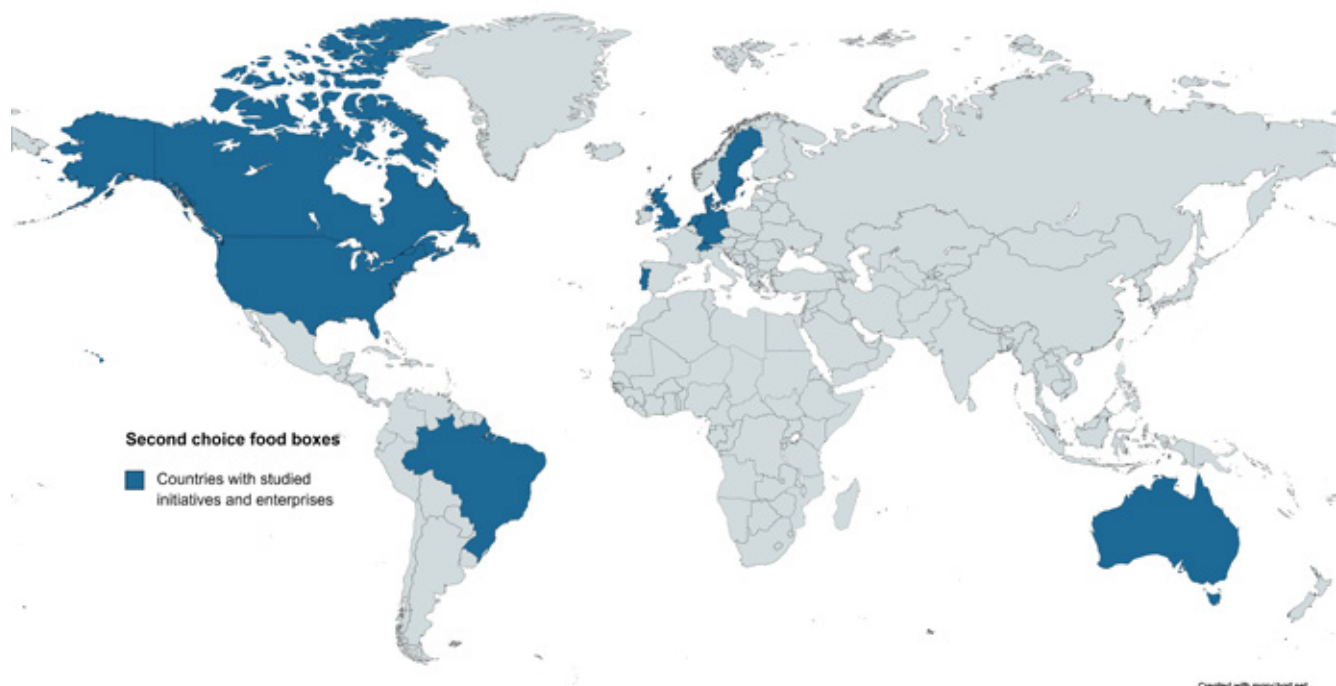


FIGURE 11. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL VI.

4.3.2 Model VII: Online Secondary Market

Brief	A website where the business resells purchased excess food (Business Model Canvas 7)
Waste stream	Produce rejected for aesthetic reasons, produce close to expiry
Value-added product	Discounted produce
Key stakeholders	Manufacturers, wholesalers, supermarkets, consumers
Geography	Urban, peri-urban (see also Figure 12)
Profit objective	For-profit
Organization type	Private

The Business Model

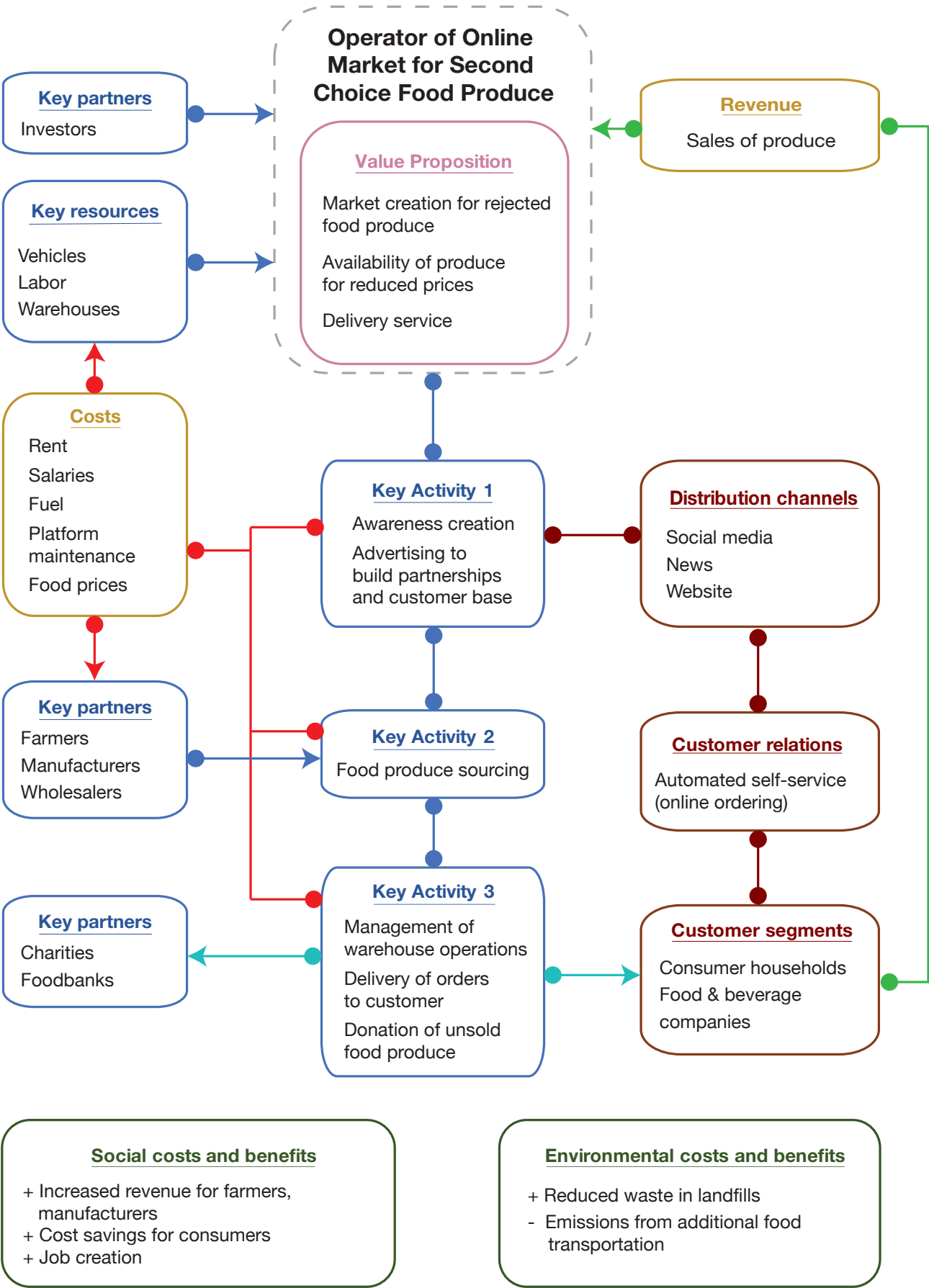
The Online Secondary Market model for reselling excess food requires sourcing nonperishable food items, creating a platform from which customers can place their orders and delivering the orders to each customer. The produce is rejected from its primary route of sale due to incorrect labelling, overordering, discontinued lines or because it has passed its best-before date. The source of produce tends to be supermarkets, wholesalers and processors. The produce is sourced at a discounted rate and part of the discount is passed on to customers offering, in addition to reduced food waste, cheaper produce that is delivered to their homes.

Like other online supermarkets, the website is consumer-facing, where customers can view the available items and indicate how much of a certain item they require before paying directly through the online system (Table 10).

While the numerous value propositions are likely to retain customers, repeated customer engagement is necessary to incentivize additional orders. To achieve this, software infrastructure to send new products and discounts available to customers is necessary, such as marketing through e-mail or social media. The software may be able to send new or discounted products to previous customers based on their previous purchases. Social media is important for customer engagement and can be an additional marketing tool to highlight new products available.

TABLE 10. SWOT ANALYSIS OF THE ONLINE SECONDARY MARKET MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Location of the warehouse, close to good transportation links • Various revenue streams • Strong partnerships with suppliers 	<ul style="list-style-type: none"> • Limited access to finance • High costs of operation • Low profit margins • Unreliable drivers
EXTERNAL	<ul style="list-style-type: none"> • Awareness of the food waste issue • Greater-than-expected harvest • Internet access and easy online payment systems 	<ul style="list-style-type: none"> • Suppliers determine the timing and quantity of products available • Consumer prejudice against products past their best-before date



BUSINESS MODEL CANVAS 7. ONLINE SECONDARY MARKET.

Case Examples

Approved Food (United Kingdom)

Approved Food, based in Sheffield in the UK, sources excess food, short back-dated products as well as those past their best-before date for resale through its website, at discounts of up to 70% on retail price. The company was founded in 2009 and currently has an annual revenue of over GBP 4 million, with 20% growth between 2013 and 2014. The current warehouse space is about 5,600 square meters and serves over 100,000 customers annually. The range differs depending on the supply of products available from suppliers. The savings estimated for customers are up to USD 900 per year. As a promotion, the company offers 'lucky boxes', where customers pay a set amount for a surprise box of products. Financing sources for the company include placing second in a pitching competition with Virgin, investments from UK Steel Enterprise and Finance Yorkshire and re-investing profits (www.approvedfood.co.uk).

FoodMaven (United States)

FoodMaven™ is an Internet start-up that provides a digital market for dated and perishable grocery items approaching expiration. These items are bought at steep discounts by food preparation establishments and are

conveniently delivered for a minimal fee. Grocery stores receive pure profits for inventory otherwise lost, and food preparation establishments benefit from dramatically reduced costs for convenient food delivery. FoodMaven coordinates the collection and delivery of the produce, stores it in its own warehouse and markets the products. It does this online and via phone. Any produce which is not sold is donated to foodbanks. The supplier receives the enhanced tax benefits (<https://foodmaven.com>).

Model Variations

- Additional types of products are offered on the website such as household cleaning items and beauty products that cannot be sold via their primary sale route.
- Click-and-collect service, in which customers place their orders online and collect their basket of items directly from a designated location, e.g. a counter in the central warehouse.
- Offering delivery services to customers internationally.
- Offering a 'surprise box' as an extra through the website. The box is priced at a standard amount and the contents are unknown to the customer before delivery. This can help move items for which there are large amounts available.

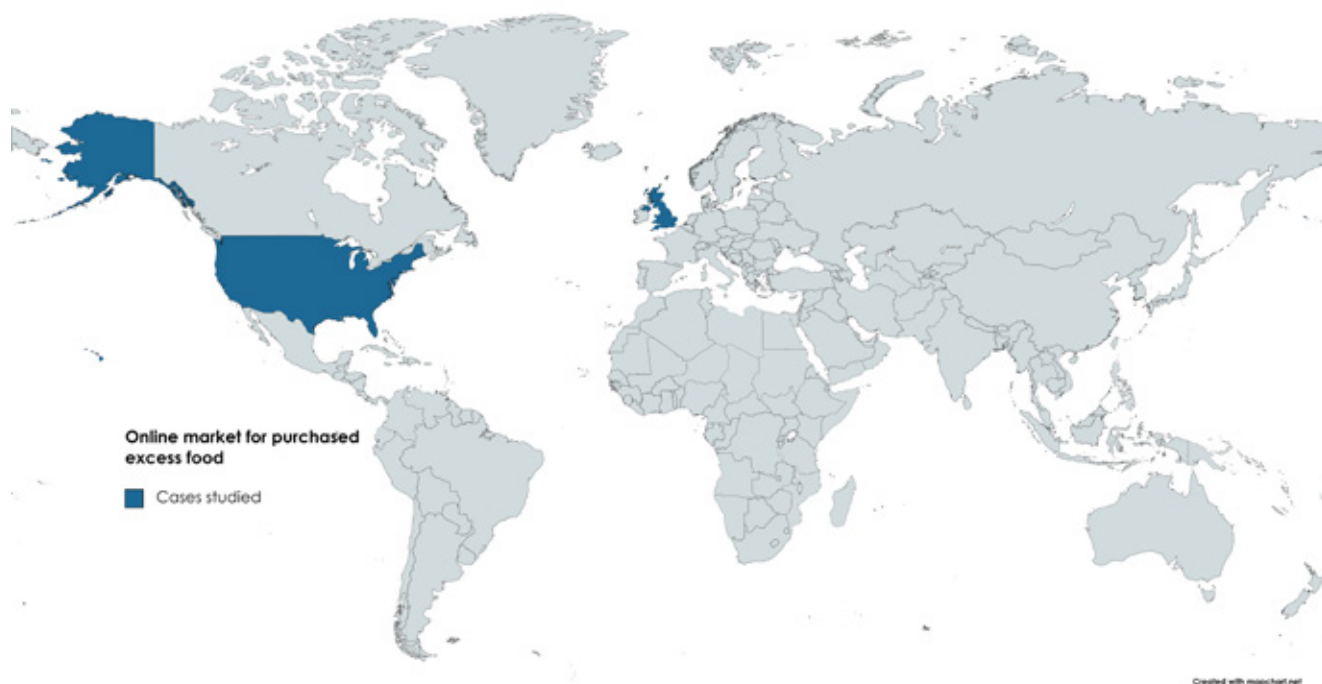


FIGURE 12. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL VII.

4.3.3 Model VIII: Store Secondary Market

Brief	A physical store where the business resells purchased and unconsumed food (Business Model Canvas 8)
Waste stream	Produce rejected for aesthetic reasons, produce close to expiry
Value-added product	Discounted produce
Key stakeholders	Manufacturers, wholesalers, supermarkets, consumers
Geography	Urban, peri-urban (see also Figure 13)
Profit objective	For-profit, social enterprises
Organization type	Private

The Business Model

For-profit:

In this model the excess food is primarily sourced from supermarkets, wholesalers and manufacturers; however, it may also include farmers’ surplus as well as unattractive fruits and vegetables which are not bought by the original buyer for aesthetic reasons. The produce includes meat, fish, fruit, vegetables and processed food. Either, the produce is transported between the seller and a central warehouse before being distributed at each retail outlet, or it can be taken directly to the retail outlet, depending on the case. Once at the retail outlet, the model is similar to a generic supermarket with reduced prices. Revenue streams come from the sale of products. Costs are rent for the space, labor, operational overheads and transportation of produce (Table 11).

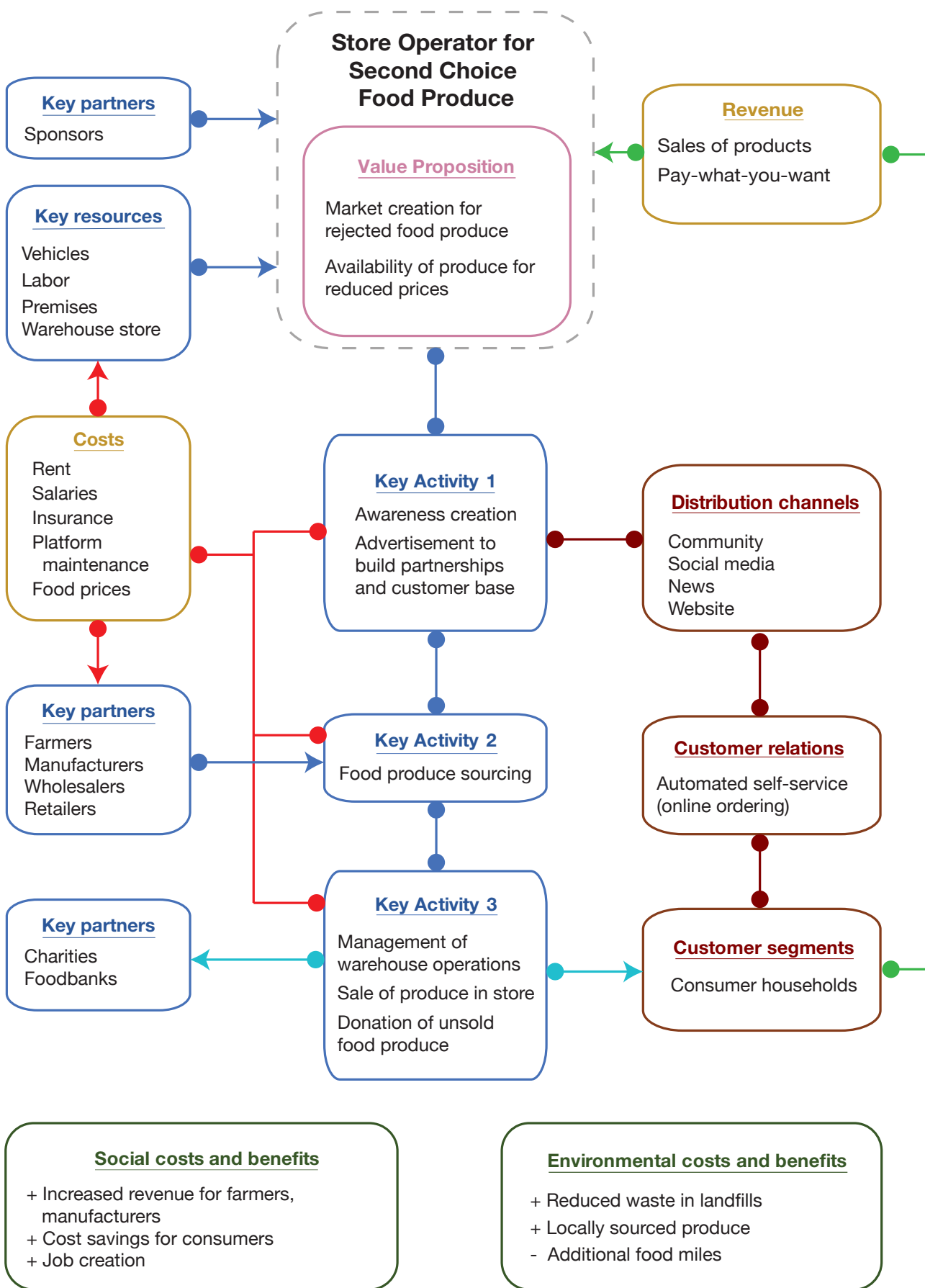
Nonprofit:

Most cases under this variation sell discounted produce to low-income members of a community. The social stores intend not only to reduce food waste, but also to address food poverty. The approach is an alternative to food businesses donating to foodbanks or charities, acting between a foodbank and traditional retailer. The model of a social market is often combined with a social café to encourage interaction between customers and to include support to employment or other needs (EU Fusions 2015).

The main costs in the model are staff and rent. Financing for the model tends to be a combination of support from local authorities such as providing space or reduced rent and grants or funding from charitable organizations. Other support may include in-kind donations, freezer space or use of transportation from private businesses. In certain cases, the prices of goods are flexible and defined by the customers.

TABLE 11. SWOT ANALYSIS OF THE STORE SECONDARY MARKET MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Strong community base • Location of the store, close to source of produce • Various revenue streams • Partnerships with local organizations 	<ul style="list-style-type: none"> • Limited access to finance • High costs of operation • Low profit margins
EXTERNAL	<ul style="list-style-type: none"> • Awareness of the food waste issue and knowledge on date labelling • Abundance of excess food • Policies encouraging alternatives to landfill disposal 	<ul style="list-style-type: none"> • Disruptions in or unreliable supply • Regulations against selling expired food produce • Consumer prejudice against products past their best-before date



BUSINESS MODEL CANVAS 8. STORE SECONDARY MARKET.

Case Examples

Daily Table, Boston (Boston, United States), a nonprofit social supermarket with value-added products

Daily Table not only creates a new market for produce but also adds value to excess food by preparing packaged meals sold in-store. Since 2015, the supermarket has diverted approximately 600 MT of food waste annually. The supermarket is located in a low-income area in Boston to provide access to healthy food for underprivileged populations and to reduce food poverty. While anyone can shop at the supermarket, it focuses on providing cheaper healthy food options for low-income households in the community where it is located. The food is priced to compete with fast-food alternatives in the neighborhood so that price is not a barrier for making healthy choices in food purchase. Food is sourced from processors, wholesalers and retailers, transported to the store and sorted with the assistance of volunteers from the local community. A portion of this is sold directly to customers and the rest is used to prepare ready-made meals. In addition, free cooking classes are offered for any interested participants.

There is strong community involvement in this case. Community members have been chosen as ambassadors and advisors to the project and hiring is mostly local, with 80% of the 30 new full- and part-time employees at the first store living within a two-mile radius. New jobs created include chefs, drivers, dishwashers and retail clerks.

The project funds its services through financial, product and service donations from various charitable foundations as well as revenue from sales of produce. As of 2017, Daily Table had made USD 2.3 million in revenue. However, it was losing approximately USD 50,000 a month. The high fixed costs – rent for kitchen and preparation space, an executive chef, equipment, a truck logistics manager and social media costs all fell on the single store, therefore it did not make profit. A second store opened in 2018 that the kitchen will also serve. Spreading the fixed costs over multiple stores enables a greater chance of making each store profitable. For long-term sustainability in the model, the stores must cover their operational costs. Investments in scale are considerable as high-quality infrastructure such as refrigerated trucks and freezers are required. These are financed through grants, donations and philanthropic funds (<https://dailytable.org>).

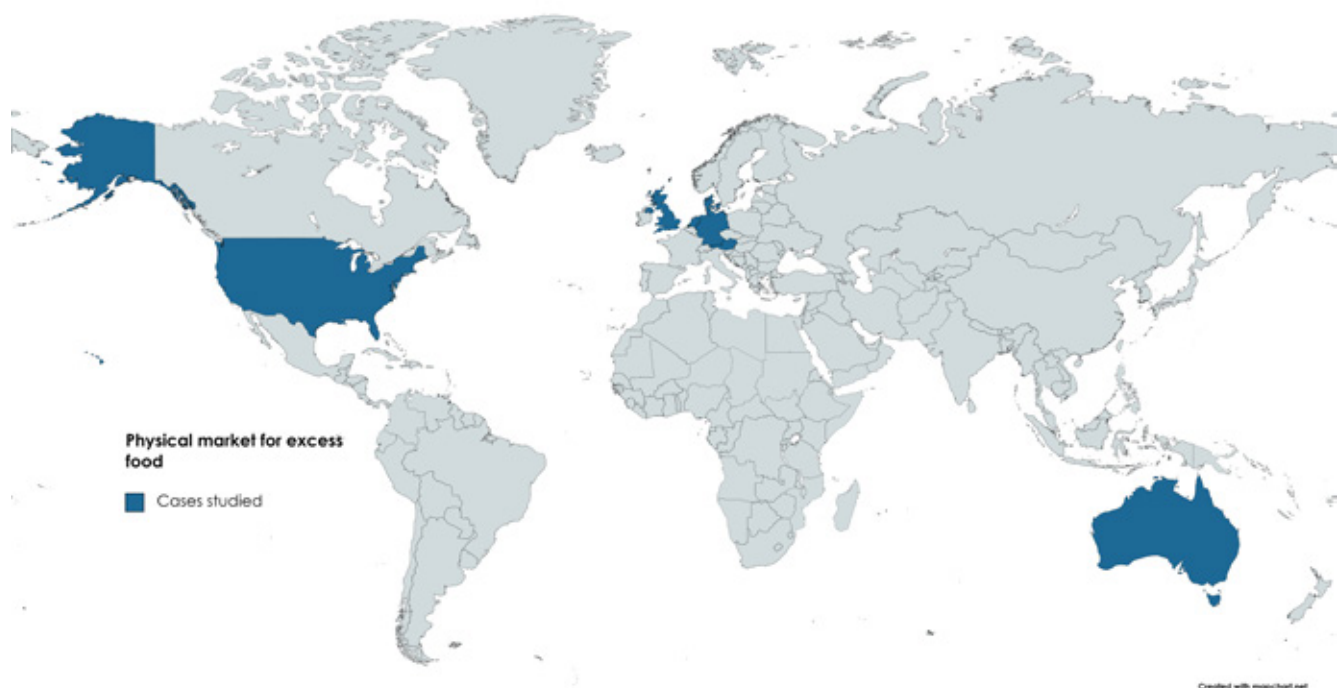


FIGURE 13. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL VIII.

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4.4 Value Addition

Tristram Stuart, the author of 'Waste: Uncovering the global food scandal' emphasized that the problem of edible food turning into waste has a simple solution: "Consuming it" (Stuart 2009). However, certain excess food and by-products that are fit for human consumption require additional processing to be more marketable. The approach of value-added processing to surplus food has been divided into two basic categories for this report:

1. Preparing meals from surplus food.
2. Transforming excess food into longer shelf-life products.

Even though fruits and vegetables may not meet regular retail standards, they are edible and appropriate for processing purposes. Therefore, many business models in this section source their supply of food from farms or distribution centers for the large quantities discarded. Other cases prove that excess food derived from latter supply stages also holds potential for food recovery. For example,

one waste stream of interest is that of the bakery industry as further elaborated in the presented case studies.

The opportunities of value-added food processing are various, reflected by the total number of identified cases. There is an obvious distinction between the fields of excess food cooking and excess food for preservation in terms of revenue generation. The prepared meals are more often charged on a pay-as-you-feel basis, while preserved food with a longer shelf-life is sold to customers for a given price. The point of commonality between these initiatives is that they are social businesses, working towards achieving a reduction in excess food and food waste, among other goals. Innovative partnerships have also been identified in this section, such as charities partnering with private businesses to produce new food products.

What the cases clustered under this section have in common is that they add another value to their meals or products: they serve as a channel to raise awareness about the food waste issue. Many cases place emphasis on consumer education regarding healthy nutrition, tackling poverty and enhancing community relations.

4.4.1 Model IX: Restaurants Serving Rescued Food

Brief	Sourcing unsold food to operate a rescued food restaurant (Business Model Canvas 9)
Waste stream	Produce rejected for aesthetic reasons, produce close to expiry
Value-added product	Discounted produce
Key stakeholders	Manufacturers, wholesalers, supermarkets, consumers
Geography	Urban, peri-urban (see also Figure 14)
Profit objective	For-profit, social enterprises
Organization type	Private

The Business Model

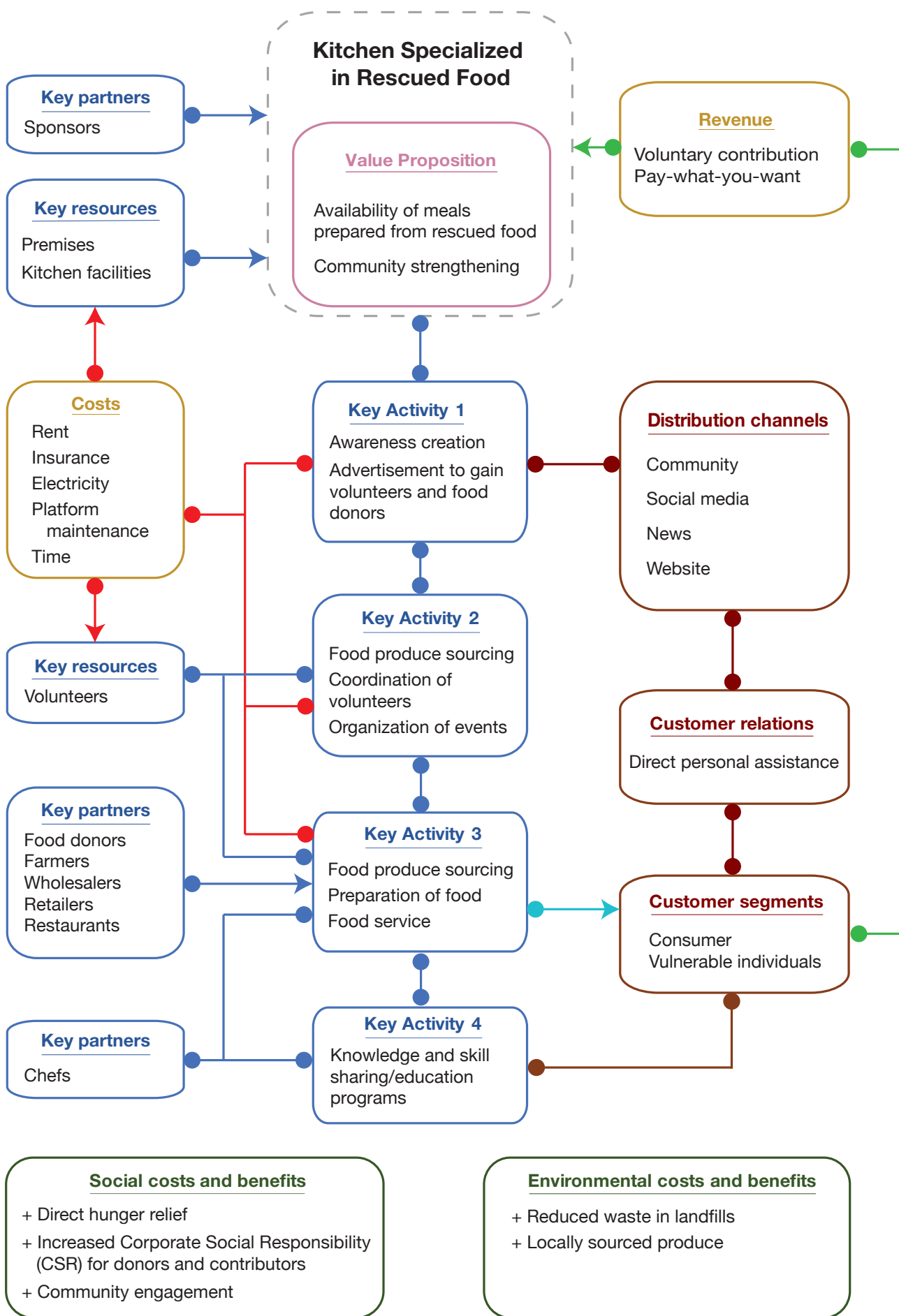
A key goal of this model is to provide rescued food for everyone, without restrictions in terms of social and financial status, ethnic background or gender and to share values and increase the well-being and knowledge within the community. With this philosophy, several entrepreneurs and charities around the world have created a space, not only to offer meals from unsold food but also for creativity and sharing. Education in the form of skill and knowledge exchange, participation, equality and inclusion as well as awareness-raising on food waste and sustainability are often core values of these institutions. Management is mostly executed by a group of dedicated individuals, in the form of a social business.

The pricing concept ‘Pay What You Want’ is not an innovation made by these cases but is a common strategy for businesses under this model. These restaurants or cafés have no set prices, but guests are invited to pay an amount available to them. Other than monetary payment, in certain cases contributions of working hours in the kitchen or by cleaning are also accepted or even desired. The reasoning is that young people gain experience or receive training and learn about nutrition. Certain cases have partnerships with local restaurants or globally popular chefs, who provide support through cooking sessions (Table 12). Volunteers play an essential role in this concept. They are engaged in collecting and preparing the excess food. The social business and nonprofit operating model of these businesses encourages food donors to hand out their unsold or unsellable produce free of charge or at a bargain price.

TABLE 12. SWOT ANALYSIS OF THE RESTAURANTS SERVING RESCUED FOOD MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Partnerships with local organizations • Strong community base • Dedicated commitment by founders and operators • Efficient coordination of volunteers • Operational transparency • Creating a trend 	<ul style="list-style-type: none"> • Reliance on food donations • Limited access to finance • Dependency on volunteers
EXTERNAL	<ul style="list-style-type: none"> • Awareness of the food waste issue • Abundance of excess food • Policies encouraging alternatives to landfill disposal 	<ul style="list-style-type: none"> • Liability on food safety • Disruptions in or unreliable supply • Consumer prejudice





BUSINESS MODEL CANVAS 9. RESTAURANTS SERVING RESCUED FOOD.

Case Examples

Lentil as Anything (Australia)

Driven by his passion for social justice, the founder of this initiative aimed to challenge convention by not pricing his meals but by giving the guests the freedom of donating on the basis of trust. As guests responded very positively to his concept of generosity, providing food to everyone with the same attention and care, and not making any monetary profit in the first year, he was able to sustain the restaurant and his way of living. Over a decade, the initiative grew into a bigger nonprofit organization, creating a trend. Today the 'lentil family' not only offers nutritious meals from excess food at their four restaurants, but also education for volunteers, employment for staff and support to the wider community through services and assistance such as legal advice, training, counselling, housing as well as fundraising for other charities. Additionally, it operates a vegan catering service and a convenience store. One of the main challenges faced was handing over 10% from the donations for the 'goods and services' tax. However, after five years they won the legal battle against the tax office and achieved a change in legislation to make allowances for the 'Pay-as-you-Feel' philosophy, which was a significant victory (<https://www.lentilasanything.com>).

Model Variations

- Food used in charity soup kitchens where guests dine free of charge. The targeted 'customer group' is narrowed down to vulnerable society members who face difficulties in affording food. This concept works on a triple-donation model: food businesses donate food, volunteers donate time, local partners donate kitchen space and equipment. This reduces the initial investment costs for individuals or organizations but increases the dependency on corporations. In the concept of this variation, volunteers play not only an essential role in the collection and preparation of excess food, but also in the interaction with the guests.
- Selling meals: The possibility of charging customers normal prices for meals from rescued food is evident in other cases, for example, Rude Food (Sweden), Instock (Netherlands), Rethink Food NYC, Kitchens for Good or the Ugly Apple Cafe (US). Despite creating revenue, these cases do not aim to maximize profit, but rather to reinvest in operational affairs or support other organizations with additional revenue. The 'normal' prices are justified by the argument that rent and other costs still need to be covered.

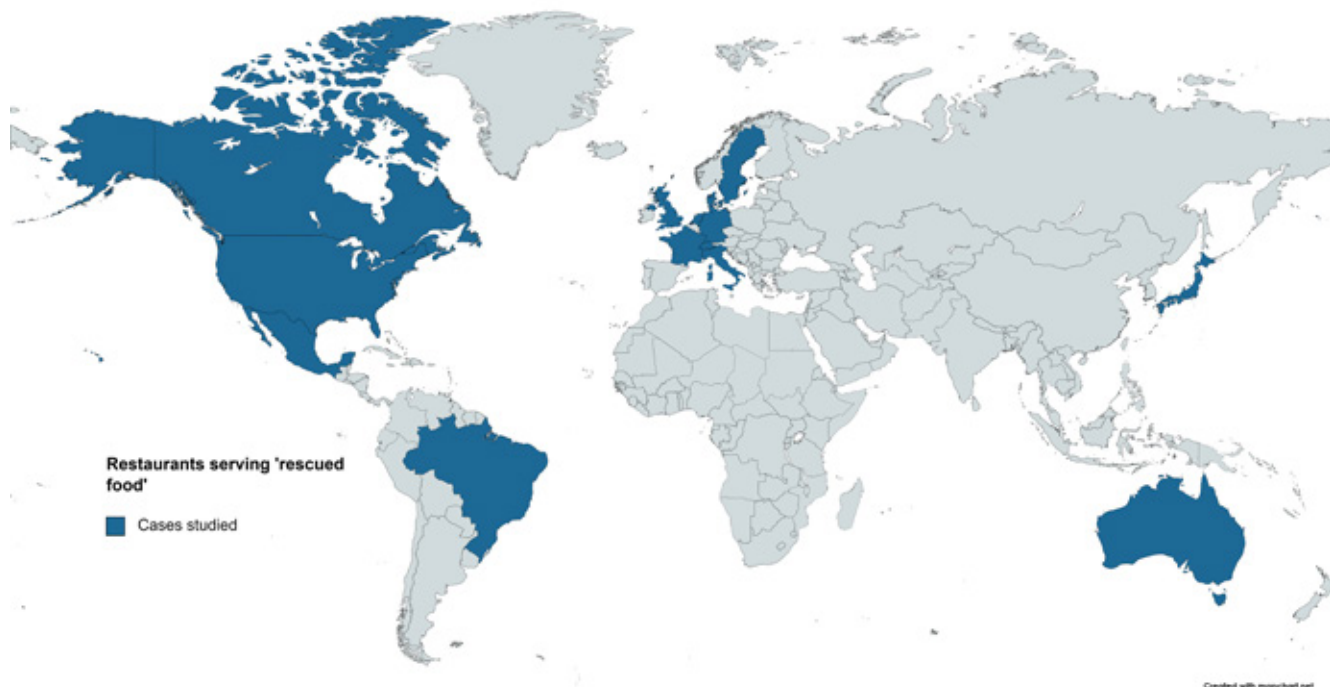


FIGURE 14. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL IX.

4.4.2 Model X: Food Upcycling and Preservation

Brief	Add value by converting donated perishable food into food with a longer shelf-life (Business Model Canvas 10)
Waste stream	Produce rejected for aesthetic reasons, food by-products
Value-added product	Increased shelf-life through innovative product design
Key stakeholders	Manufacturers, wholesalers, supermarkets, consumers, farmers
Geography	Urban, peri-urban (see also Figure 15)
Profit objective	For-profit, social enterprises
Organization type	Private

The Business Model

Preserving food has a very long tradition in human food production dating back to 8,000 BCE when food was dried in the sun (Belessiotis and Delyannis 2011); and a wide variety of methods exist. Start-up companies revive and improve old preservation methods, for example, developing modern solar drying systems. Making jam, chutney or pickles are also favored by the businesses found under this section.

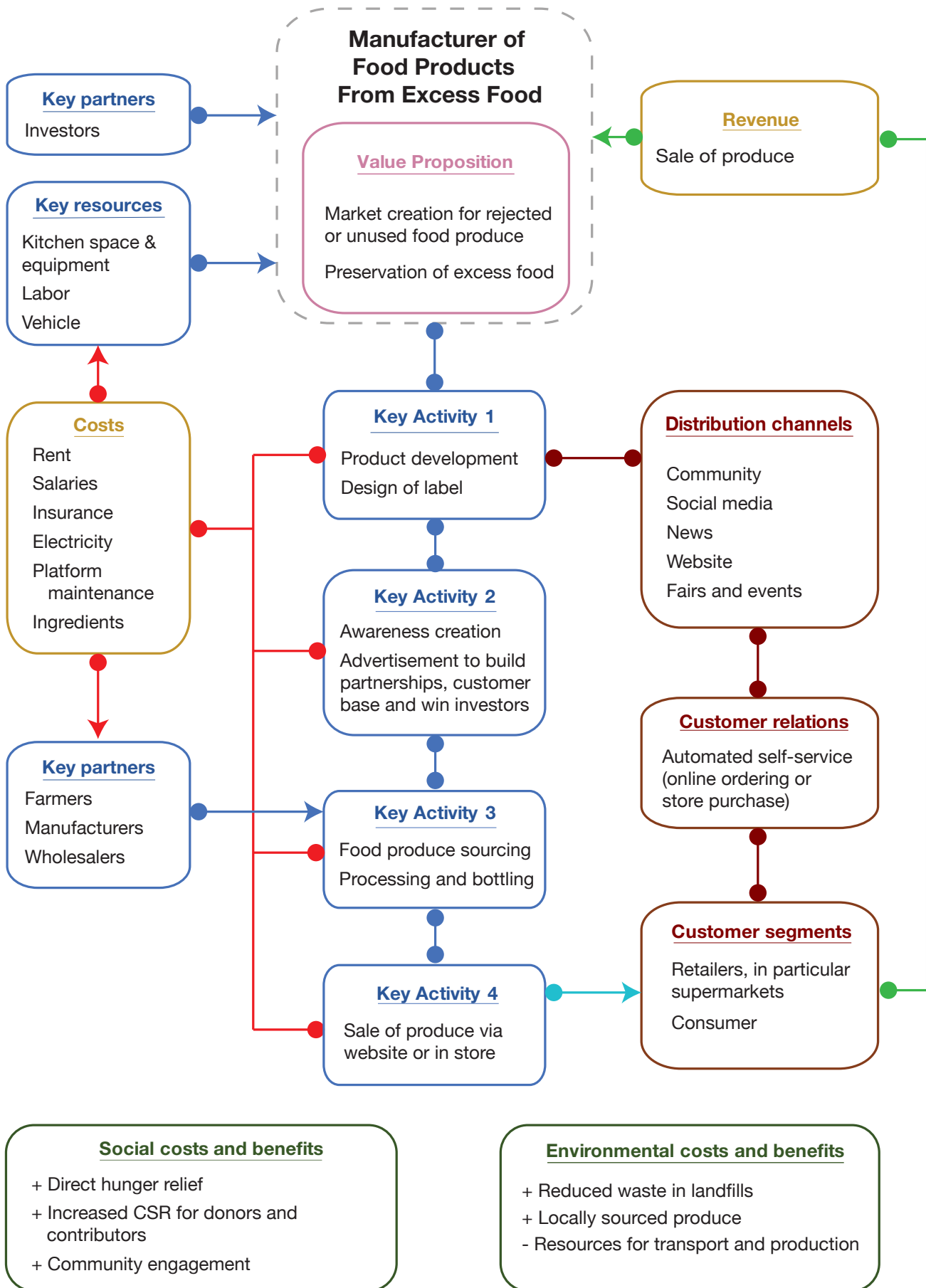
Entrepreneurs identify the potential use of a food stream, create a product and develop a marketable brand to reduce the level of waste. The founder often has previous experience working within the food industry; however, this is not imperative to the success of a business. More crucial seems to be strong partnerships with suppliers of the unsold excess produce (Table 13). The sourcing might be directly from one large entity, or various smaller ones, to meet requirements. Local farmers or retailers may be

approached where a private or customer relationship already exists. The waste often poses a burden on the producer and recovering it may offer a useful service for the supplier. Therefore, the possibility of reaching agreements to receive the produce free of charge is created. On the other hand, purchasing the produce from the supplier, even at a discounted rate, offers income for produce previously unexploited. Each preservation method requires diverse equipment, so the investment capital varies. Marketing and sales are a major part of the model. The target audiences tend to be younger generations as well as environmentally conscious consumers.

A common form of partnership to reduce waste is between two manufacturers, where one is sourcing another's by-products to utilize those for the creation of a new product. As the business grows (like export of dried fruits), it needs a reliable supply at scale, which works best with contract farmers, targetting first choice produce and no longer possible food waste.

TABLE 13. SWOT ANALYSIS OF THE FOOD UPCYCLING AND PRESERVATION MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> Partnerships with local organizations Strong community base Operational transparency Marketing 	<ul style="list-style-type: none"> Reliance on consistent supply of excess food Operational costs Scale-up costs
EXTERNAL	<ul style="list-style-type: none"> Creation of trend/market Awareness of the food waste issue Abundance of excess food Rewards from governments or other organizations 	<ul style="list-style-type: none"> Liability on food safety Disruptions in or unreliable supply Consumer prejudice



BUSINESS MODEL CANVAS 10. FOOD UPCYCLING AND PRESERVATION.

Case Examples

Rubies in the Rubble (United Kingdom)

Rubies in the Rubble is an award-winning brand which has seen its output grow significantly over the past few years. Their goal is: “At *Rubies in the Rubble* we make condiments with a conscience. We make our delicious range of award-winning relishes, ketchups and mayo sustainably, from ingredients that would otherwise go to waste, often for simply being the wrong shape, size or color. Some say it’s a load of rubbish... we take that as a condiment.”

After realizing the scope of food waste in London, founder Jenny Costa started the company in 2011, based on first experiments in her kitchen with her family’s traditional recipes. The growth of her company was possible because of funding from Mustard Seed in 2015 and 2019. Since then the company has grown to have an annual turnover of USD 5.2 million and has multiple partnerships with businesses in the local region. To scale, much of the excess food now comes directly from farms, where the products are manufactured and then transported to and stocked in supermarkets (<https://rubiesintherubble.com>).

Mustard Seed (<https://mustardseed.vc>) is a venture firm that invests in fast-growing European ventures and also invests in other food waste reduction businesses such as Winnow (<https://www.winnowsolutions.com>), a commercial kitchen waste tracking and analytics software, and Olio (<https://olioex.com>), a food sharing app. This is some evidence that investors see food waste management as a viable market.

Product Line ‘Just Peachy Salsa’ by the Food Bank of South Jersey and Campbell’s (United States)

A partnership between Food Bank of South Jersey, local farmers and Campbell’s (manufacturer) has generated a profitable business from food loss. New Jersey has large areas of peach production. Aesthetic standards have resulted in annual waste of almost 363 tons of fruits. The Food Bank buys the peaches for pennies on the dollar. The farmers, instead of paying to haul the peaches away to landfills, earn some extra cash. Campbell’s (<https://www.campbells.com>) donate the manufacturing and packaging costs. The profits from the sales of the sauce provide a sustainable source of funding for the Food Bank’s hunger relief programs (<https://foodbanksj.org/justpeachysalsa>).

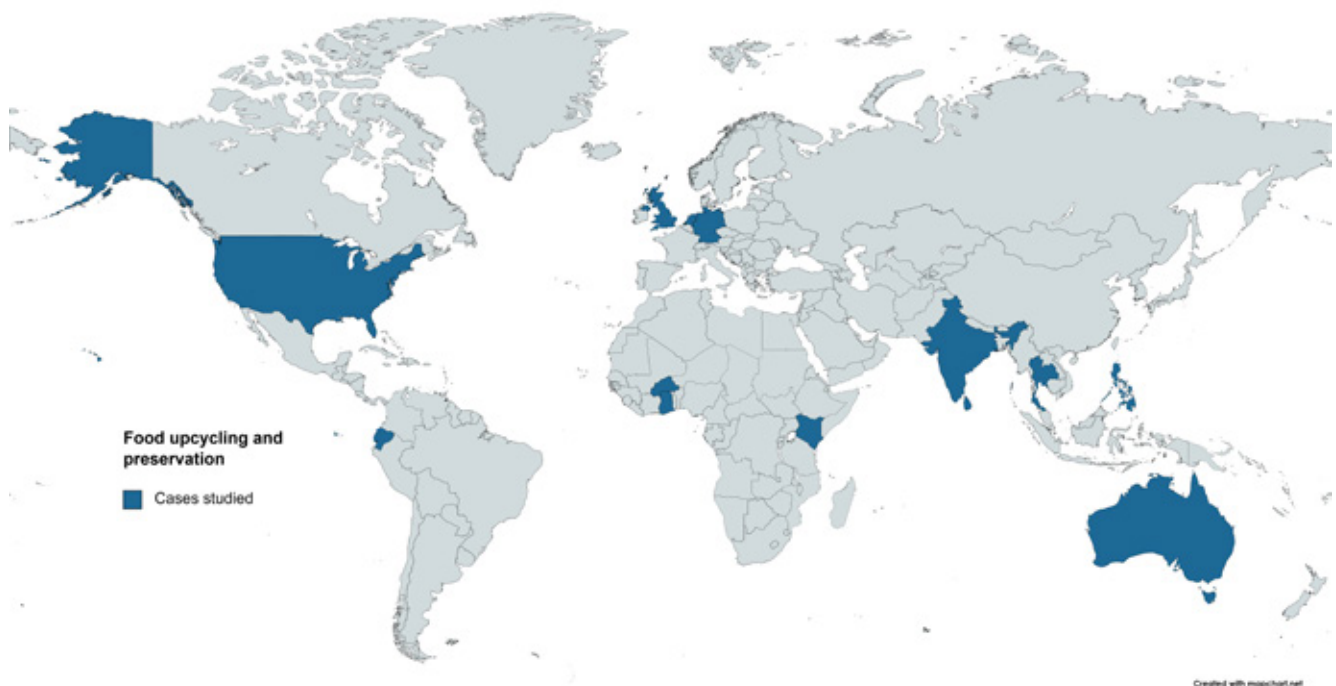


FIGURE 15. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL X.

References

- Belessiotis, V.; Delyannis, E. 2011. Solar drying. *Solar Energy* 85(8): 1665-1691. <https://doi.org/10.1016/j.solener.2009.10.001>
- Stuart, T. 2009. *Waste: uncovering the global food scandal*. London: Penguin Books.

4.5 Waste Collection

A problem afflicting many low-middle income countries is the open dumping of garbage. This can be due to insufficient budgets, lack of labor or limited management for the collection of waste. In addition to bad odors and degradation of natural environments caused by the dumping areas, the garbage can cause more unseen degradation such as the pollution of groundwater, soils and vegetation. Education campaigns to inform the public on how to correctly manage and separate their own waste can be effective at the household level; however, if there are insufficient collection or waste management services to propagate this, the efforts will have limited results as with limited waste collection the likelihood of open dumping is greater. Therefore, private collection services may have a role to play in bridging the gap between the collection service provided by local authorities and demand for collection, to provide a reliable service for the collection and responsible treatment or disposal of waste.

There are innovative business models in this area operating in both high- and low-income countries. The business

models are profitable and growing while addressing an environmental issue. Customers served, either households or businesses in these cases, are willing to pay a fee for the responsible collection and management of their waste. While in the UK and the US legislation such as landfill taxes and support for anaerobic digestion plants affects the potential of these models, in India without such legislation, the models are evident, indicating the willingness of customers to participate.

The business models presented in this section bridge the gap between where waste is generated and where it can be treated, recycled or discarded. The food waste is that which is spoiled, has expired, is unsellable or unusable for human consumption. Nearing the end of the value chain, the food waste is still valuable and can be used for composting, anaerobic digestion and may be suitable for insect rearing or animal feed. The difficulty with many of these initiatives is maintaining a consistent uncontaminated waste stream. The models for the logistics and transportation of the waste solve this problem through segregating and delivering the feedstock for their operations.

4.5.1 Model XI: Responsible Waste Collection

Brief	The waste collector provides assurances that wastes are disposed of correctly through partners (Business Model Canvas 11)
Waste stream	Unavoidable food waste
Value-added product	Assurance of responsible disposal of waste
Key stakeholders	All involved stakeholders
Geography	Urban, peri-urban (see also Figure 16)
Profit objective	For-profit, nonprofit
Organization type	Private, public, PPP

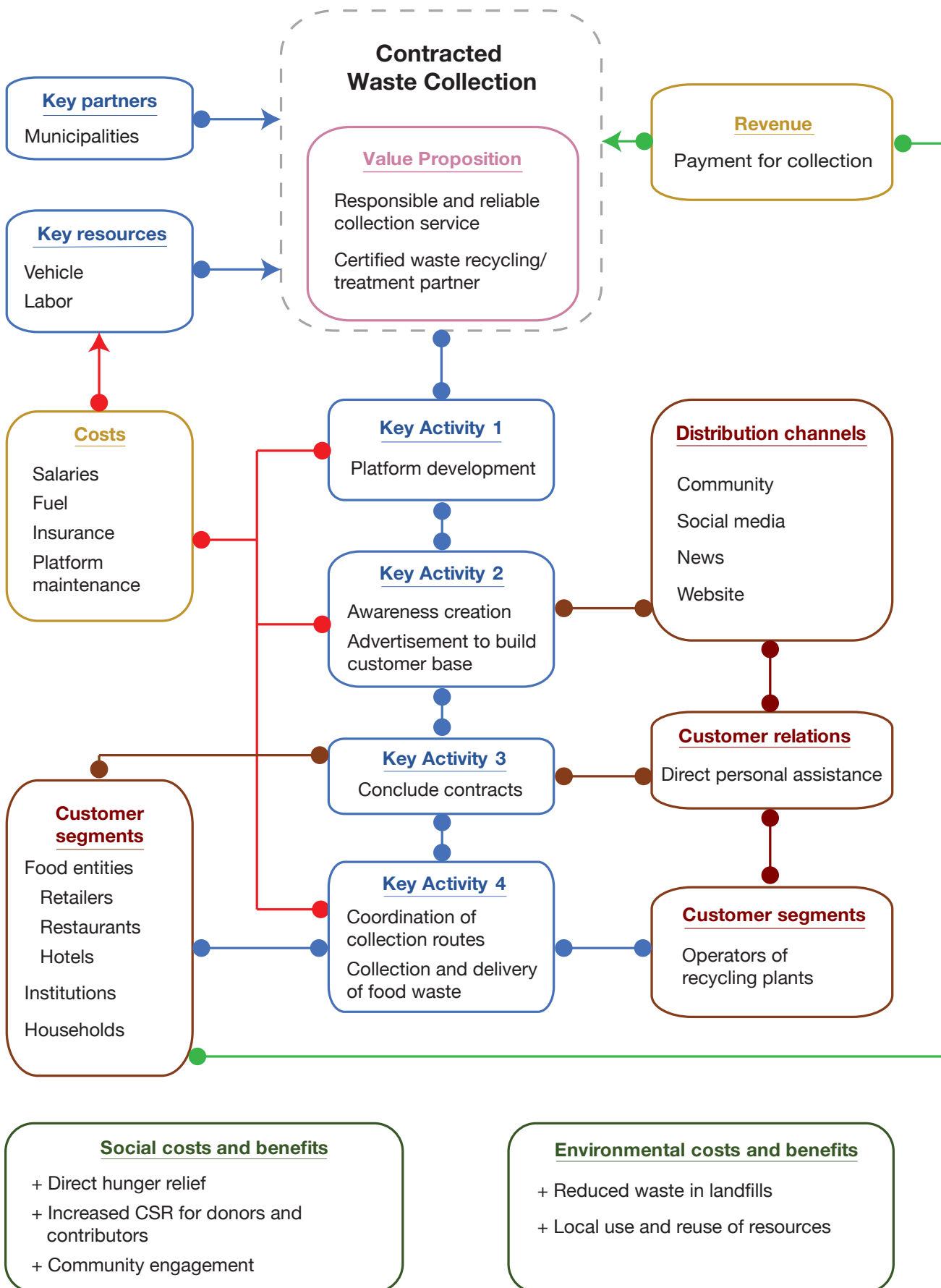
The Business Model

The business model bridges the logistical gap between the generation of waste by businesses or households and demand for the waste from recycling centers or correct disposal in landfills. To achieve a sustainable business model for responsible waste collection, it is necessary to create strong partnerships with waste recycling centers which can process the waste or transport it to landfill sites. Anaerobic digestion plants, animal feed processors, insect-rearing businesses, composting plants and fertilizer manufacturers are all examples of potential partners. It requires at-source segregation of waste for more efficient transportation to respective recycling centers (Table 14). As the business serves both customer segments, the waste generators and recycling entities, it must ensure that practices are appropriate for the needs of both segments.

Value in the business is created by solving unreliable collection services by local authorities; therefore, even if customers are less concerned about where their waste is taken, they may still be willing to pay for a reliable collection service. Value may be added to the model by on-demand collection for waste, or the ability to choose a convenient time from the specified times given. Apps or websites for this service create a platform accessible by all stakeholders for effective customer management. Differentiation of price options, such as a subscription fee model with variable pricing for waste amounts, incentivizes the reduction of waste on site. Value-added services such as waste reporting and analysis of waste amounts collected can attract more customers, as they can use this information to change their practices and advertise their achievements.

TABLE 14. SWOT ANALYSIS OF THE RESPONSIBLE WASTE COLLECTION MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Good coordinator or platform to organize collection times • Multiple revenue streams • Strong partnerships with treatment or disposal centers 	<ul style="list-style-type: none"> • High investment requirements in transport
EXTERNAL	<ul style="list-style-type: none"> • Availability of external recycling centers • Recycling awareness and engagement in the community 	<ul style="list-style-type: none"> • Competition for waste streams from other collectors • Recycling partner sales are low, less demand for feedstock • Missing monitoring options • No waste disposal fees for households or businesses • Local rules and regulations surrounding collection and management of waste



BUSINESS MODEL CANVAS 11. RESPONSIBLE WASTE COLLECTION.

Case Examples

Hasiru Dala Innovations (India)

Using an innovative model in India, Hasiru Dala Innovations (HDI) has created a system of waste collection for event caterers, offices, apartment blocks and restaurants to reduce levels of waste sent to landfills. By providing training and on-site assistance for segregating waste, the company transports each waste stream to a recycling partner, providing assurance for the waste generator of where the waste will be deposited. HDI provides entire waste management services in addition to specific waste streams; it also works with retailers to reduce their waste amounts. The pricing structure of HDI incentivizes retailers to reduce their waste and segregate streams well. It has a fixed component and variable which is higher for larger amounts and unsegregated waste (<https://hasirudalainnovations.com>).

Eco Friends (Sri Lanka)

An app acts as a platform where consumers can indicate their waste amounts and types ready for collection from Eco Friends. Waste is collected in separate categories and so is segregated by consumers prior to collection. Fees are paid on a monthly subscription service through the app as well and are currently LKR 200 per month (approximately USD 1.20 in 2020). For waste generated in

each category, the user gains points which are redeemable twice a year against the subscription fee. This waste management solution seeks to service the on-demand service model for waste collection and provide a solution to the mismanagement of garbage currently affecting Sri Lanka (<http://www.ecofriends.lk>).

Organic Waste Logistics (OWL United Kingdom)

This case provides storage and subsequent transportation and logistics for large food waste generators. The company installs storage tanks on site for businesses. The levels of waste are monitored remotely; once full, a truck is dispatched to collect the waste and transport it to a partnering anaerobic digestion plant. In addition to providing logistical services, waste tracking and analytics are part of the offer. It operates on a subscription basis, which can make it more attractive to potential business customers. It is most suitable in an environment with waste disposal fees, where the cost of subscription is close to these fees, although businesses may also be willing to pay for the assurance of responsible disposal of their waste. However, the initial investments require high levels of capital to purchase the units as well as trucks for collection. In addition, regarding demand for food waste, if anaerobic digestion plants have enough feedstock, an alternative disposal partner is required (<http://www.organicwastelogistics.com>).

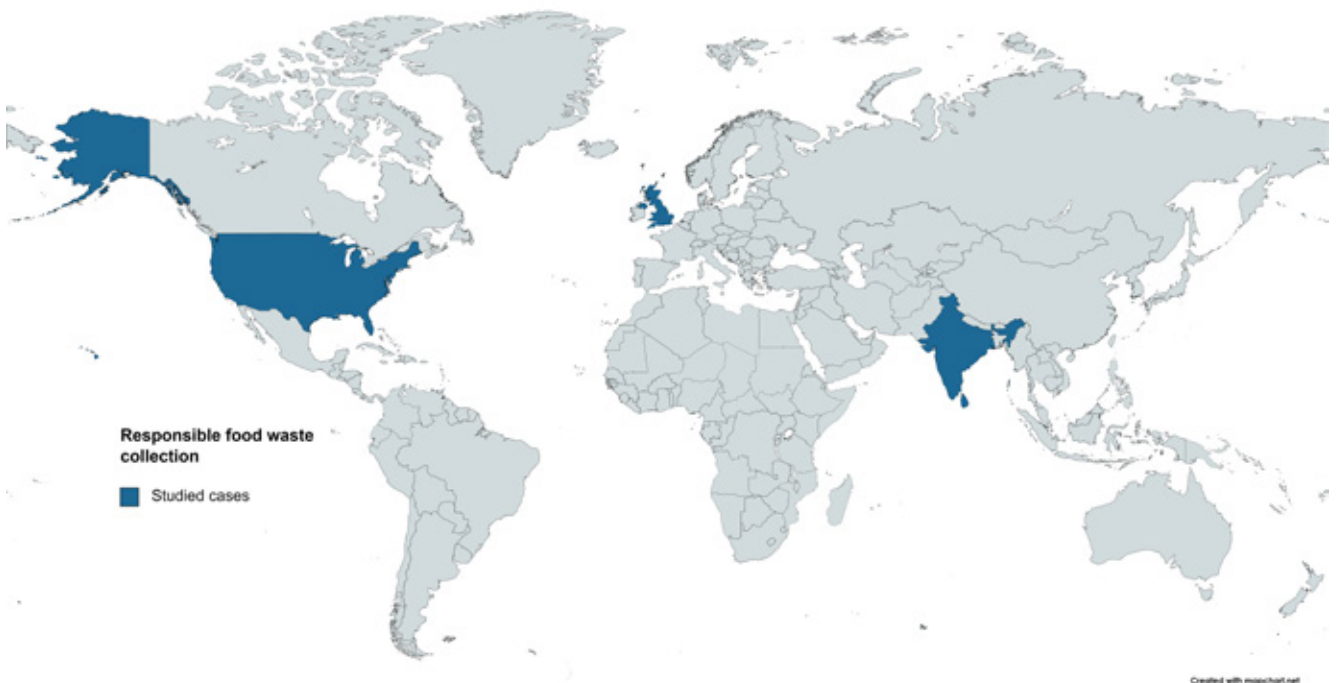


FIGURE 16. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XI.

4.6 Recovery of Nutrients and Other Resources

Adding value to food unfit for human consumption removes it from the traditional waste stream. Related initiatives can contribute to the waste objectives of cities and reduce the burden of waste management on local authorities.

Recovering food, for example, as feedstock for mushrooms, insects or livestock, or the production of organic packaging reduces the use of alternative resources. Global crop production for livestock is very resource-intensive, where 33% of cropland is used for livestock production (FAO 2012). The safe use of food waste as an alternative has

the potential to ease this (growing) burden on the planet. Using waste streams for nonfood purposes creates new markets, reducing the need for fossil fuel-derived products and contributing to a circular and bio-based economy.

The source of food waste utilized for these models is primarily consumer plate waste and uneaten food which is unsafe for human consumption. In each local environment, the ability to prevent, redistribute or recover excess food can be limited or constrained by lack of financing, space, infrastructure or the availability of partner organizations. However, in general, these can all be profitable business models that recover waste to transform it into valuable new products, building on their value addition, strength, opportunities, weaknesses and threats (Tables 15-18).

4.6.1 Model XII: Mushroom Cultivation

Brief	Using food waste to cultivate mushrooms for human consumption (Business Model Canvas 12)
Waste stream	Unavoidable food waste, inedible food parts
Value-added product	Gourmet mushrooms grown on a waste product
Key stakeholders	Restaurants, hotels, canteens
Geography	Urban areas
Profit objective	For-profit, social enterprises
Organization type	Private

The Business Model

In the coffee brewing process, only 0.2% of the nutrients are transmitted into the drink, while 99.8% remains in the grounds. The use of nutrient-rich coffee grounds to grow mushrooms has been practiced for many years in different parts of the world, yet only a few businesses in Europe are advertising themselves as waste recovery initiatives in this context. They use oyster and shiitake mushrooms which seem to grow best on coffee ground residue.

Coffee grounds are a common waste stream of the hospitality sector. This makes cafés, restaurants or hotels valuable partners for this model. A strong partnership with good communication is beneficial for

this model because the general waste stream must be further separated before coffee grounds are collected (sometimes by bicycle if the mushroom cultivation site is nearby). Treatment usually occurs within 24 hours to exploit the unchanged properties of the grounds. At the mushroom farm, the grounds are mixed with sterilized straw and the mushroom spores, before being placed in a growing container. The container has good airflow and is kept in a cool, dark room for the spores to grow. After this stage, the containers are moved to a warmer location for the mushrooms to continue growing until they are ready to be harvested. These mushrooms are then sold back to local community restaurants and cafés. The used feedstock can be composted on site or donated to a local composting organization.

TABLE 15. SWOT ANALYSIS OF THE MUSHROOM CULTIVATION MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Abundant waste stream • Operation close to supply sources • Strong partnerships • Good coordinator or platform to organize collection times • Limited operational costs, if bicycles are used for collection 	<ul style="list-style-type: none"> • Space requirements • Suitable climatic conditions • Operational costs • Specific knowledge and skills requirements
EXTERNAL	<ul style="list-style-type: none"> • Creation of trends/markets • Low cost alternative for waste disposal 	<ul style="list-style-type: none"> • Competition for waste streams from other collectors • Unwillingness of suppliers to separate waste streams

Case Examples

GroCycle (United Kingdom)

Started in 2011 in Exeter, the UK, GroCycle has recycled over 60 tons of coffee grounds, trained 900 people in mushroom cultivation and sold mushroom-growing kits to thousands of households. GroCycle collects coffee grounds daily from local food retailers and uses converted office space to cultivate the mushrooms which are then sold back to local retailers. The business also offers free training materials through its website. As a social enterprise it promotes knowledge sharing and education on how to cultivate mushrooms using coffee grounds as well as advice on how to start an urban mushroom farm (<https://grocycle.com>).

Pilzliebe (Germany)

In Germany, the initiative “Pilzliebe” (in English: mushroom love) has been raising money for starting its urban mushfarming via crowdfunding. It has achieved its first goal of EUR 2,110 for buying the basic equipment and was aiming for another EUR3,800 in 2020 (ca. USD 4,300) to purchase a load-carrying service bicycle for transportation. The two entrepreneurs with an environmental science background follow ‘think global, act local’ as well as ‘cradle-to-cradle’ principles. They not only grow mushrooms without soil on coffee grounds but also engage the community in educational programs on mushroom cultivation or Kombucha tea preparation (<https://pilzliebe.com>).

Model Variations

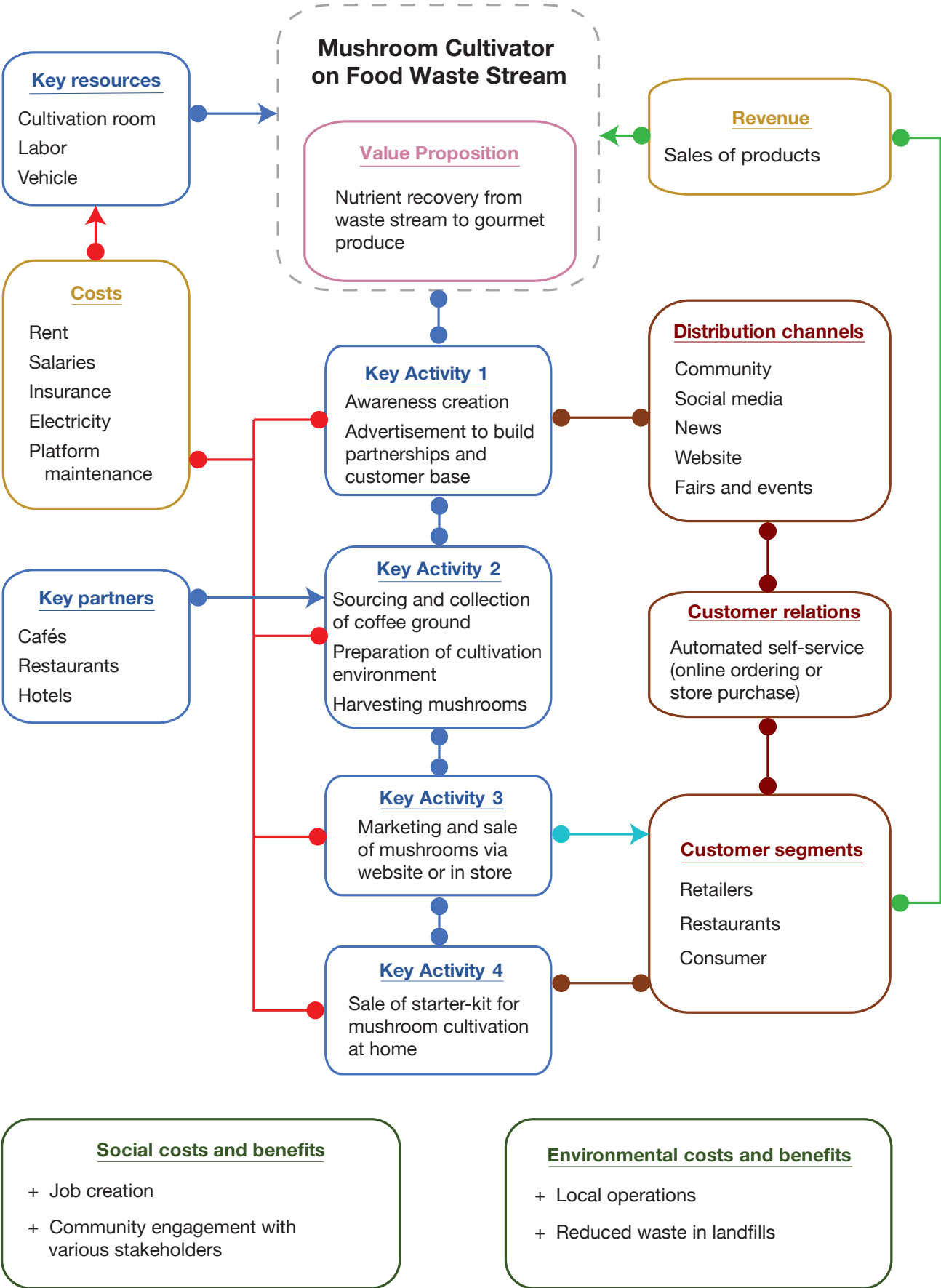
- Creating grow-at-home mushroom kits for customers to order and grow fresh mushrooms in their own homes for an additional revenue stream (Figure 17).

- Used tea leaves can be an alternative growing medium for mushrooms, so the model can be adjusted to utilize available resources.
- Using alternative modes of transport, for example trucks, cars.
- Creating compost from the used coffee ground mix for an additional revenue stream.

As the two cases show, most businesses are found in Europe (Figure 18).



FIGURE 17. GRO-SET FOR MUSHROOM CULTIVATION AT HOME, SOLD BY BEYOND COFFEE. SOURCE: <https://beyondcoffeeshop.dk>



BUSINESS MODEL CANVAS 12. MUSHROOM CULTIVATION.

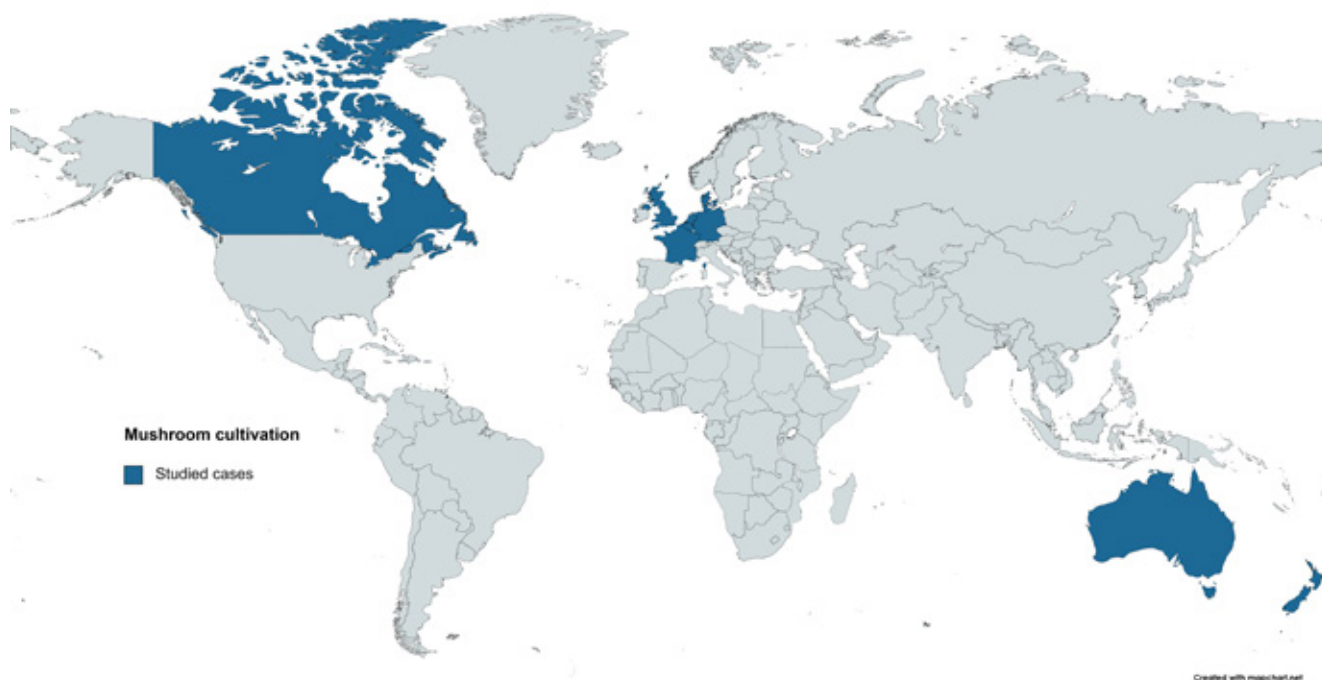


FIGURE 18. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XII.

4.6.2 Model XIII: Rearing Insects

Brief	Using food waste to rear insects for animal feed, pharmaceutical or food production (Business Model Canvas 13)
Waste stream	Unavoidable food waste, inedible food parts
Value-added product	Alternative protein source, animal feed, bio-oil, fertilizer, medicine
Key stakeholders	Municipalities, manufacturers, retailers
Geography	Urban, peri-urban (see also Figure 19)
Profit objective	For-profit
Organization type	Private, PPP

The Business Model

An entrepreneur utilizes food waste as feedstock for insects. The food waste is sourced from urban hotspots such as households, manufacturers and food retailers. The waste is no longer fit for human consumption and may include consumer plate waste or other uneaten foods which are no longer safely edible. The food waste is transported from the waste sites to a central insect-rearing facility. The insects are produced there, where they are fed with food waste before being killed, sterilized and converted into various products. These include dried larvae as animal feed for poultry, swine and aquaculture farms; bio-oil

to be used as a feed additive; medicinal ingredients for the pharmaceutical industry; and finally, as a fertilizer for soils. The model is self-sustaining; a percentage of the larvae is left to develop into adult insects, which lay eggs for the following cycle. Research partnerships with universities and institutes are common, if not necessary requirements for this model, in order to monitor the production process as well as to develop innovative uses or improved production methods for the end-products.

The primary product created is animal feed to address the growing need for alternative, sustainable feeds for animals; however, the type of insect raised

determines the end-products produced. Common types of insects used are crickets, black soldier flies, cockroaches and mealworms.

Black soldier flies have been widely propagated as their mating stage is not a vector for diseases. The larvae can

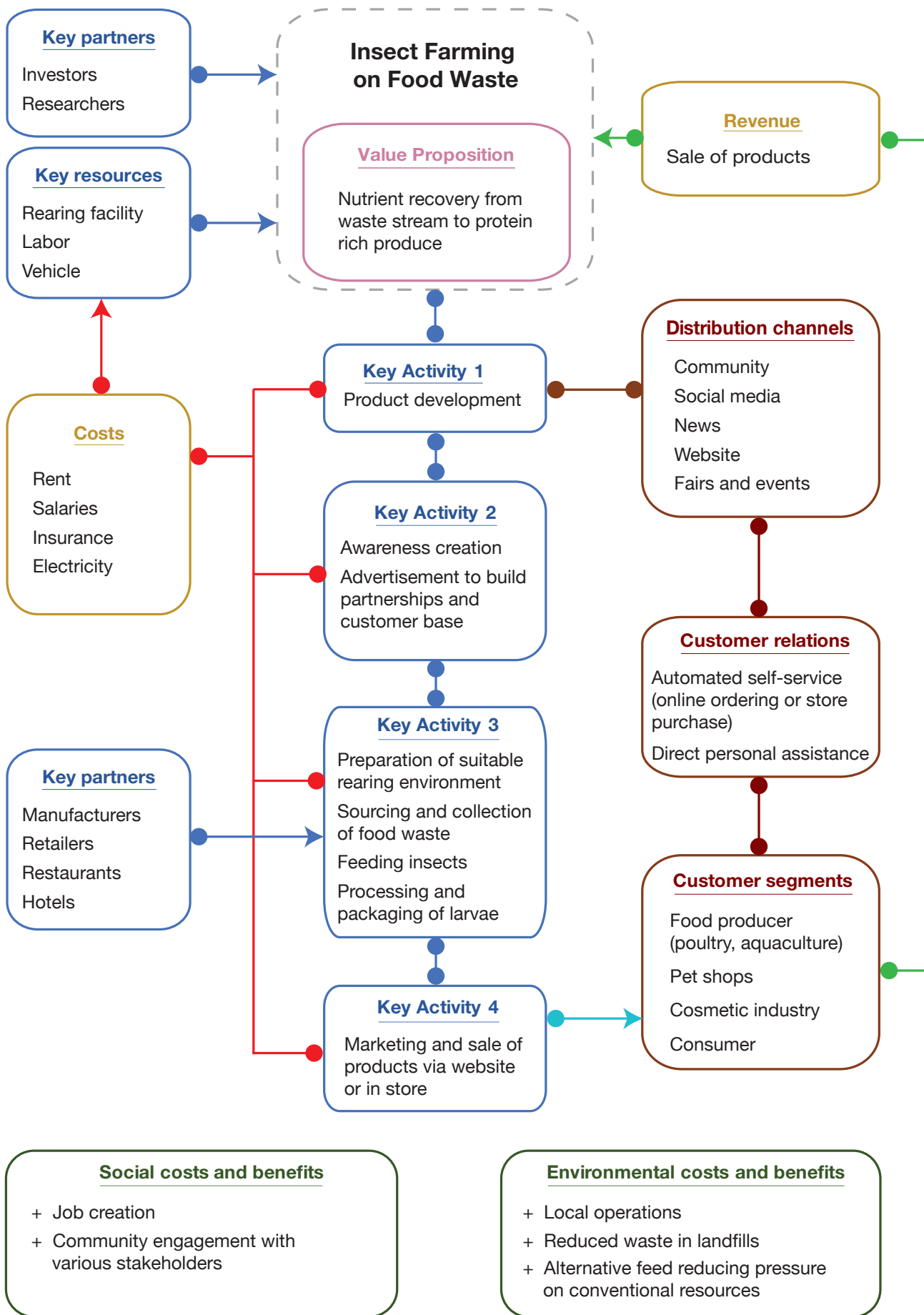
be processed into multiple end-products, e.g. dried larvae, oil and fertilizer. Cockroaches are most commonly raised in Asia for human consumption and medical purposes but are also sold as animal feed for livestock. Mealworms are generally converted into animal or fish feed (e.g. <https://agriprotein.com>).

TABLE 16. SWOT ANALYSIS OF THE REARING INSECTS MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Abundant waste stream • Research and innovation in new product potential and production techniques • Strong partnerships with clients • Marketing 	<ul style="list-style-type: none"> • Unsuitable climatic conditions • Operational costs • Specific knowledge and skills requirements
EXTERNAL	<ul style="list-style-type: none"> • Creation of trend/market • Landfill taxes or incentives for recycling • Support from governments and researchers • Consumer knowledge • Growing markets for livestock 	<ul style="list-style-type: none"> • Risk of insects escaping • Lack of acceptance for human consumption



Source: Gabrielle Joly



BUSINESS MODEL CANVAS 13. REARING INSECTS.

Case Examples

Insectta (Singapore)

Insectta uses food waste to feed black soldier flies, which are then harvested for various uses such as animal feed, pharmaceutical products and food for humans. The larvae leave behind a material called frass which can also be used as a bio-fertilizer. Insectta hopes that its black soldier fly protein can alleviate some of the problems associated with current commercial cattle feed production and reduce antibiotic use for cattle in the industry. The Agri-Food and Veterinary Authority and the National Environment Agency ensure that the insects are a safe way to convert food waste into valuable resources like compost and insect protein for human consumption. It is collaborating with Nanyang Polytechnic on food safety, Republic Polytechnic on animal feed and the National University of Singapore on improving fly breeding. *Insectta* is also researching protocols and procedures for insect farming and hopes to use Singapore as a benchmark for such farming on a global scale (<https://www.insectta.com>).

Cultivating cockroaches (China)

The ban on feeding food waste to pigs after outbreaks of African swine fever has created a new market for utilizing the waste. For most people, the world would be a more hospitable place without cockroaches; however, for some entrepreneurs in China, they are a multimillion dollar industry. The insects are bred on inedible food waste such as that from households and the municipal solid waste stream through partnerships between farmers and the local municipality. Rising populations and lack of space in landfills have created the need for alternative waste management practices, for which raising cockroaches is one solution¹. On the outskirts of Jinan, capital of eastern Shandong province, a billion cockroaches are being fed with 50 tonnes of kitchen waste a day - the equivalent in weight to seven adult elephants. And this is not the largest facility. Gooddoctor, a producer of Chinese traditional medicine, breeds 6 billion insects annually. Aside medicine, the insects are used for pharmaceutical products and animal feed².

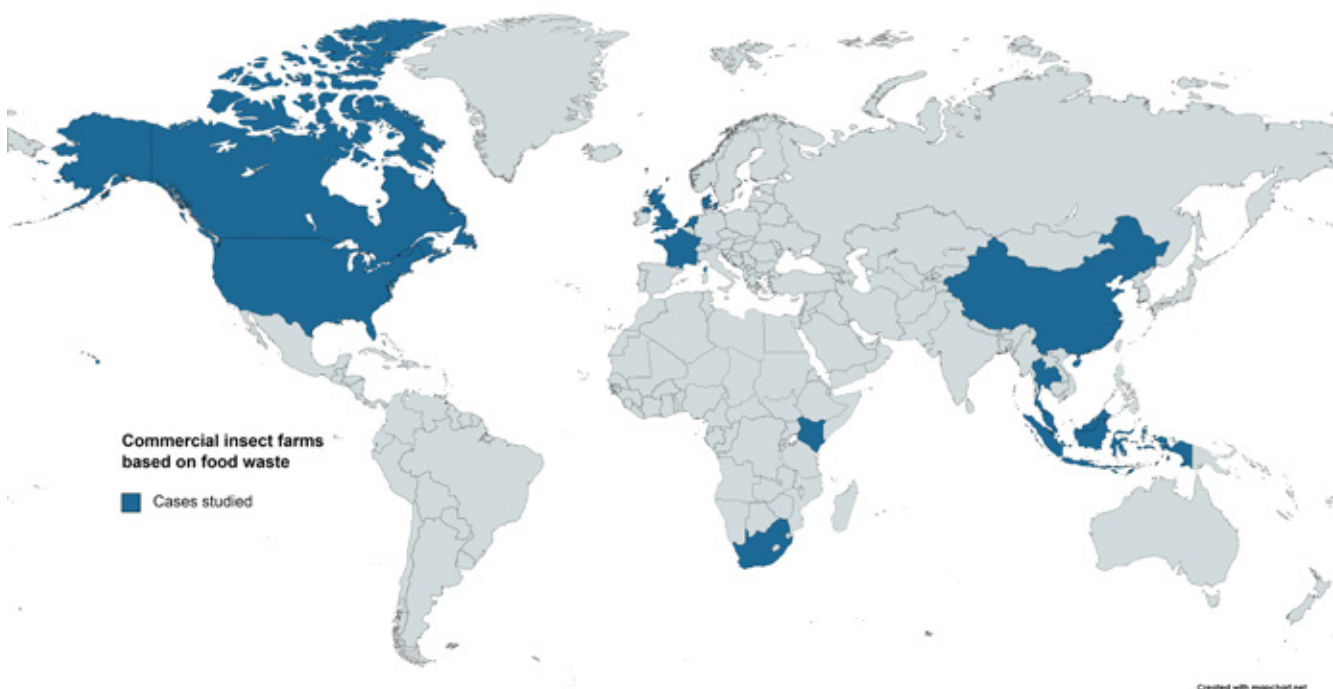


FIGURE 19. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XIII.

¹ <https://www.reuters.com/article/us-china-cockroaches-idUSKBN1O90PX>

² <https://qz.com/1257583/a-chinese-farm-is-breeding-6-billion-cockroaches-a-year-to-make-medicine/>

4.6.3 Model XIV: Swine Feed

Brief	Using food waste to feed mostly pigs and poultry (Business Model Canvas 14)
Waste stream	Unavoidable food waste, inedible food parts
Value-added product	Alternative feedstock for pigs, poultry and other animals
Key stakeholders	Municipalities, manufacturers, retailers, hotels
Geography	Peri-urban
Profit objective	For-profit
Organization type	Private, PPP

The Business Model

This model comprises the archetypical practice (Salemdeeb et al. 2017) of feeding food waste to pigs (Figure 20). Common sources include by-products and trimmings from processing, large-scale kitchen preparation waste, consumer leftovers and household food waste (Sugiura et al. 2009).

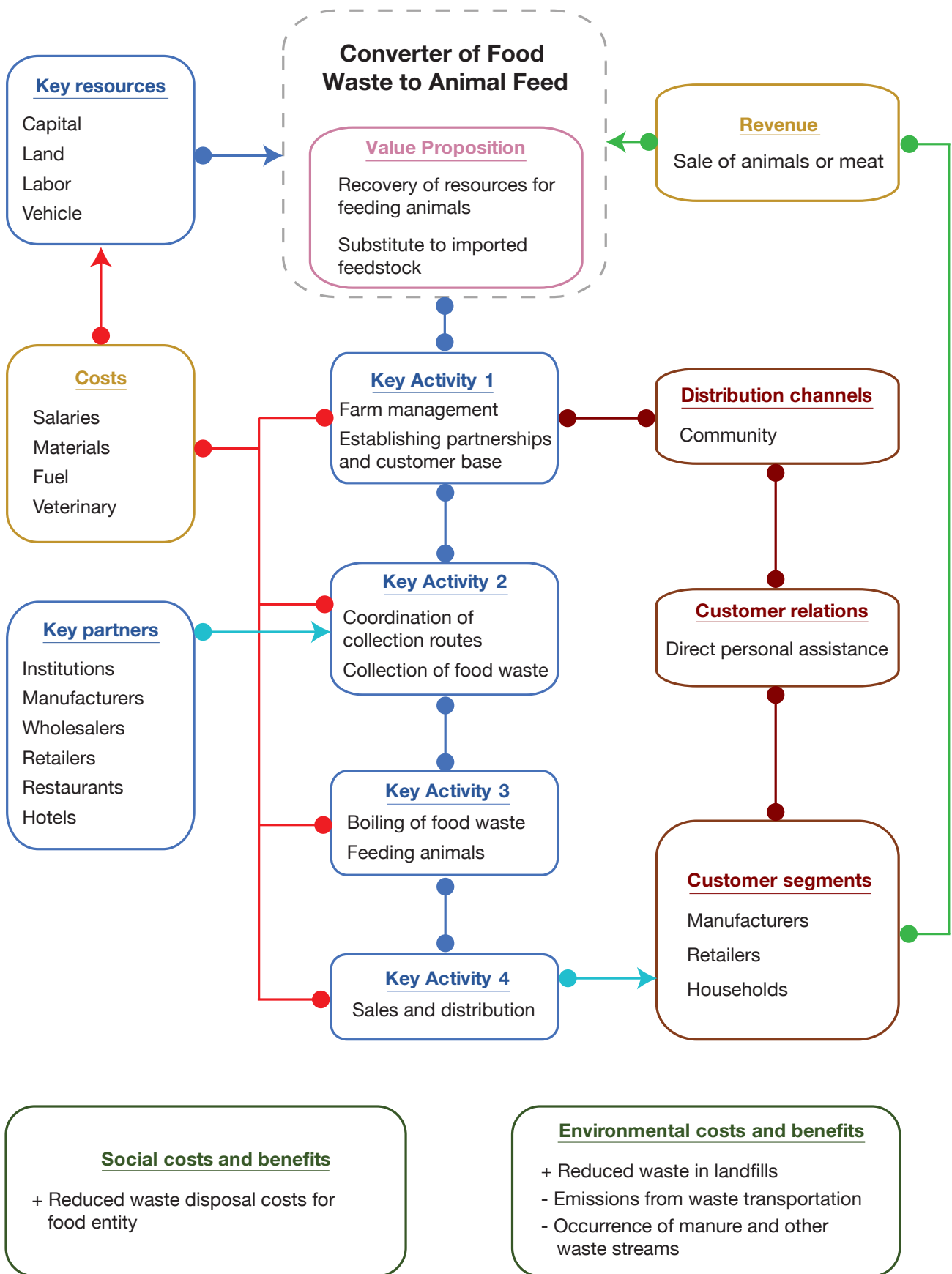
This practice was banned in the European Union as a result of the Bovine Spongiform Encephalopathy (BSE) outbreak in the UK in 2001 (FAO 2013; Salemdeeb et al. 2017). When food waste is heat-treated, any disease-causing organisms are killed, making it safe to feed to animals (FAO 2013). As reported by FAO (2013), there had been a law on boiling food waste for an hour to kill off pathogens, which was not observed by the farmer in the UK on whose farm BSE occurred.

In 2009, the Japanese government developed a certification system to give incentives to and promote recycling of food waste (Liu et al. 2016; Sugiura et al. 2009). By July 2014, 21 companies had been certified for 50 types of products under the 'Eco-feed' label for animal feed comprised of food waste (Liu et al. 2016). This certificate includes guidelines on preventative measures regarding the spread of BSE (Sugiura et al. 2009). South Korea and Taiwan have introduced similar food waste recycling systems. The model's geographical spread is thus stronger than other models reflecting national regulations (Figure 21).

Related models comprise the transformation of food manufacturing by products like brewery waste e.g. into dog biscuits.

TABLE 17. SWOT ANALYSIS OF THE SWINE FEED MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Abundant waste stream • Traditional practices • Strong partnerships with clients 	<ul style="list-style-type: none"> • Space requirements • Odors from manure • Operational costs
EXTERNAL	<ul style="list-style-type: none"> • Existing market • Landfill taxes or incentives for recycling • Support from governments • Controlled standards on environmentally friendly operations 	<ul style="list-style-type: none"> • Regulations banning the use of food waste as animal feed • Competition for waste for other uses, e.g. compost, anaerobic digestion



BUSINESS MODEL CANVAS 14. SWINE FEED.

Case Examples

Swine farming (Sri Lanka)

According to Reitemeier (2019), there are 159 swine farms in the Colombo District, raising about 12,750 pigs which consume about 58 tons of food waste per day taking advantage of partnerships with hotel operators, markets, factories or governmental canteens that have existed for up to ten years. For sourcing the generated food waste, the distances travelled daily range between 20 and 60 km per farm. Logistics, including the driver's salary, is a key cost for the farmers. Yet, receiving food waste as a free resource makes the business model profitable. Purchasing commercial feed would be too expensive to run and maintain the farm operations. The government regulation for businesses to store their food waste in air-conditioned rooms slows down spoilage of the feedstock. Even though there is no legal instruction on food waste sterilization, certain farmers apply heat treatment methods that are commonly used in Southeast Asia to prevent the risk of food-and-mouth disease.

SugaRich (United Kingdom)

As an intermediary between food entities and farmers, manufacturers can collect and process the food waste into animal feed. The method used will depend on national regulations (<http://www.sugarich.co.uk>).

SugaRich is the UK's market leader in reprocessing excess food by recovering and upcycling it into quality feed for livestock. Their supply is based on unsaleable fresh products from food factories, which cannot reach the



FIGURE 20: PIGLETS FED ON FOOD WASTE ON A FARM IN PERI-URBAN SRI LANKA.

shelves of supermarkets because of damage or aesthetical imperfections. Their manufacturing process includes separating the food from its package and ensuring every fraction is recycled appropriately. Dry food items, such as bread, cookies, chocolate and cereals, are ground and converted into animal biscuits and directly sold to farmers.

SugaRich operates in a transparent and environmentally friendly way within the circular economy. The company is a member of the Chartered Institute of Waste Management and is a licenced waste carrier, operating nine processing and four storage sites across England, Scotland and Northern Ireland.

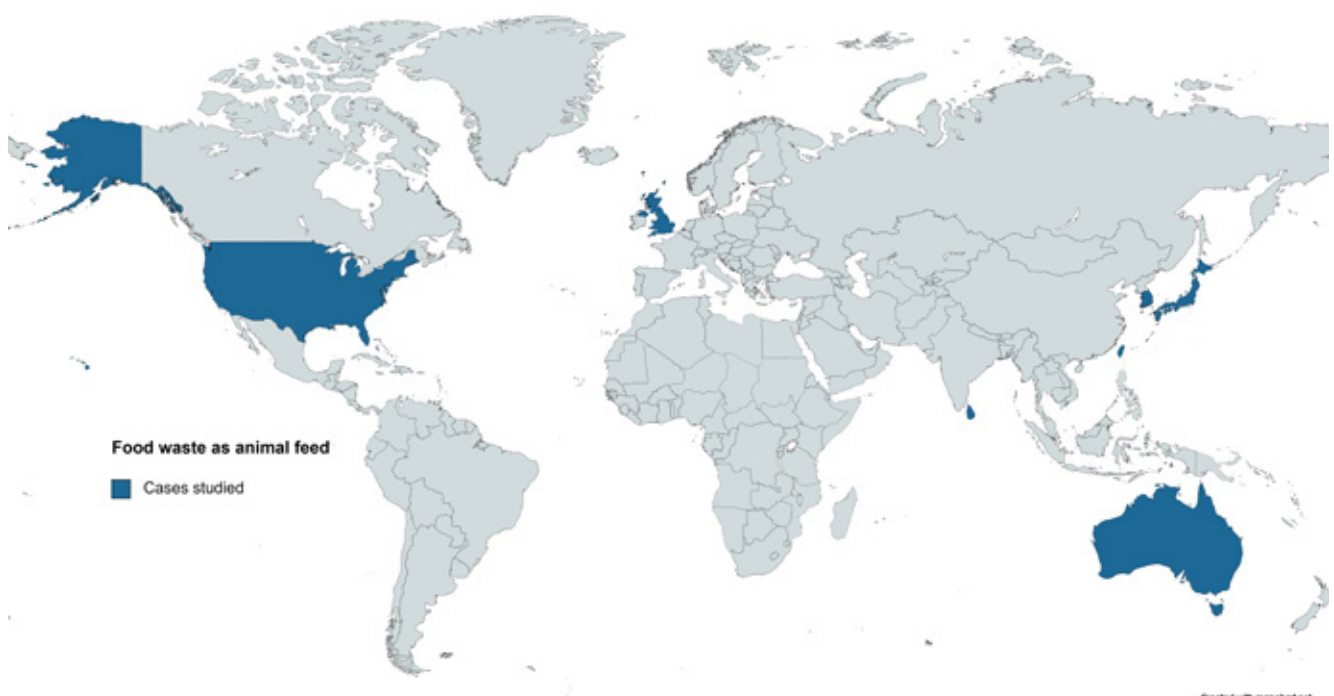


FIGURE 21. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XIV.

4.6.4 Model XV: Nonfood Products

Brief	Using food waste as an input to produce value-added products (Business Model Canvas 15)
Waste stream	Inedible food parts
Value-added product	Organic materials (paper, fabrics/textiles, leather, containers,)
Key stakeholders	Municipalities, manufacturers, retailers
Geography	Urban (see also Figure 22)
Profit objective	For-profit
Organization type	Private

The Business Model

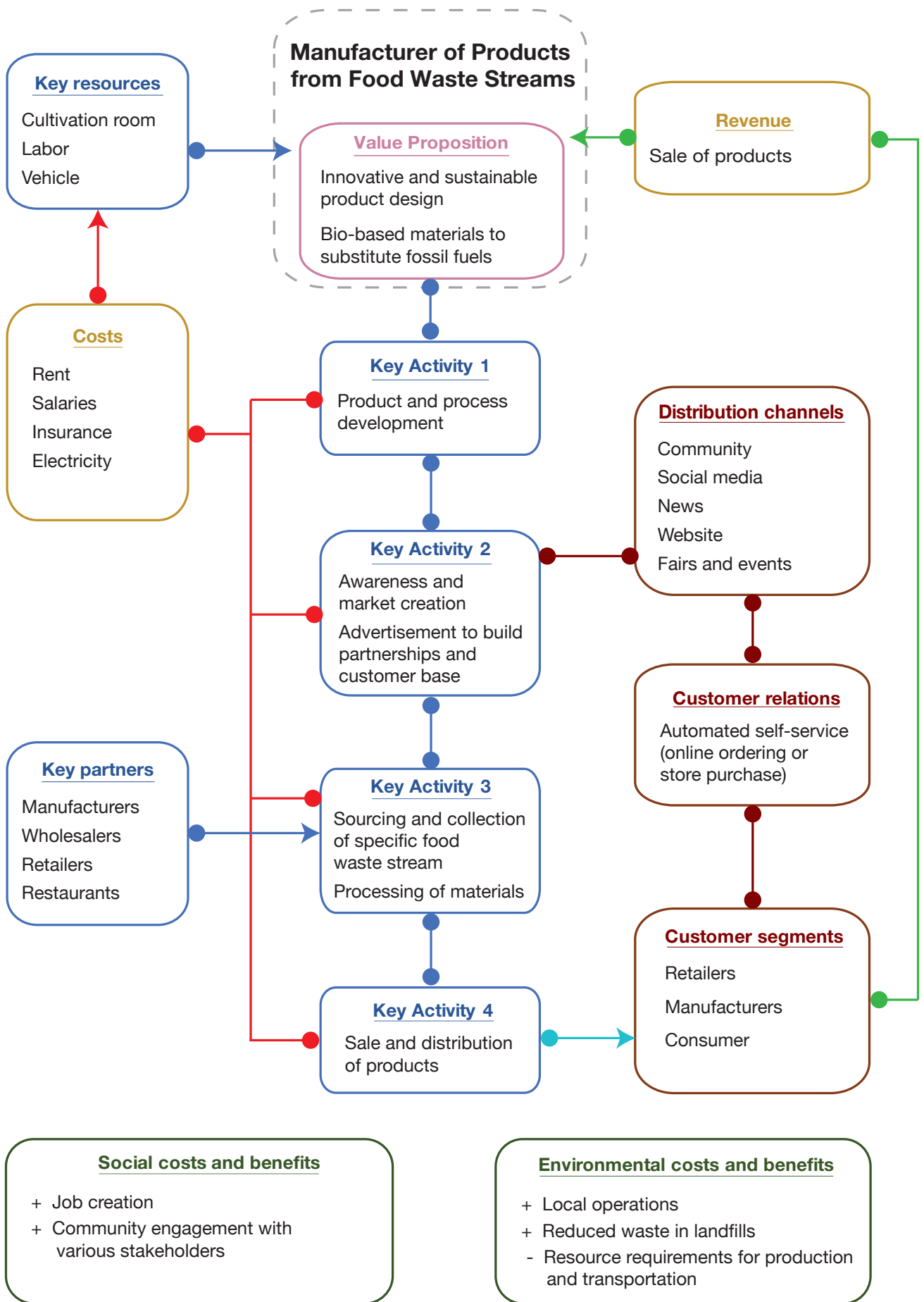
The cases summarized under this business model are often start-up enterprises manufacturing novel products from a food waste stream. These waste streams are derived from a particular origin and constitute a limited amount of compartments, e.g. one specific manufacturing side stream. Thus, the selected stream has to be received purely segregated to obtain the desired properties. For this reason, strong partnership with the waste generator – who is the resource supplier for the model – is essential. After collection, the waste/ input material is transported to a processing facility,

varying in size and equipment needed. Being an innovator, research and development are common key activities in both the design of the product and the method used. In certain cases, a market for the product has to be established. The companies might distribute their products through their own websites and have a strong social media presence to raise awareness of the food waste problem.

A potential avenue for revenue is the disseminating of the developed process in the form of a ‘toolkit’ to manufacturing plants around the world, which could use the particular waste type.

TABLE 18. SWOT ANALYSIS OF THE NONFOOD PRODUCTS MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • New technological processes for producing the product • Strong partnerships with waste producers 	<ul style="list-style-type: none"> • Space requirements • Start-up and operational costs • Unsegregated waste streams
EXTERNAL	<ul style="list-style-type: none"> • Creation of trend/market • Landfill taxes or incentives for recycling • Support from governments and researchers 	<ul style="list-style-type: none"> • Cheaper alternative (plastic) • Competition for waste for other uses, e.g. compost, anaerobic digestion • Negative attitudes towards waste products by consumers



BUSINESS MODEL CANVAS 15. NONFOOD PRODUCTS.

Case Examples

Fruitleather (The Netherlands)

Fruitleather Rotterdam is a start-up business operated by two young entrepreneurs who are currently developing a new, ecofriendly process that converts leftover fruits into durable, leather-like material. Their goal is for Fruitleather to be used for footwear and fashion accessories as well as by the interior decoration and furnishing industry. The vision at Fruitleather Rotterdam is not only to spread awareness about the food waste issue but also to show how waste in general can be used in a positive way. Besides the problem of food waste, the production of animal skin is also an environmental problem (<https://fruiteather.nl>).

Tidal Vision (United States)

Tidal Vision is helping to combat waste in the fishery sector and encouraging sustainable fishing practices by purchasing discarded by-products from sustainably managed fisheries. They use the typically wasted ocean by-product chitosan from shellfish to create products like

textiles (coating, leather, etc.) but also as a soil amendment (<https://tidalvisionusa.com>).

Kaffeeform (Germany)

From the idea of generating something new out of waste, a German product designer founded the enterprise Kaffeeform. To date, the start-up from Berlin has grown into a team of five people. They focus on the recovery of used coffee grounds, which are transformed into a new material in a combination with other biopolymers. It took three years of R&D and collaborations or discussions with experts before the new material was created and before the products were launched. Their product line consists of mugs of different sizes and take-away coffee cups. All products can be used over the long term and are dishwasher safe. The coffee grounds are collected from nearby cafés and restaurants through a partnership with a social organization that helps with drying and logistics. The cups are fully recyclable, the material breaks down in an industrial composting plant or can be burned in a carbon neutral manner. The social business also offers to take back used mugs for recycling problem (<https://fruiteather.nl>).

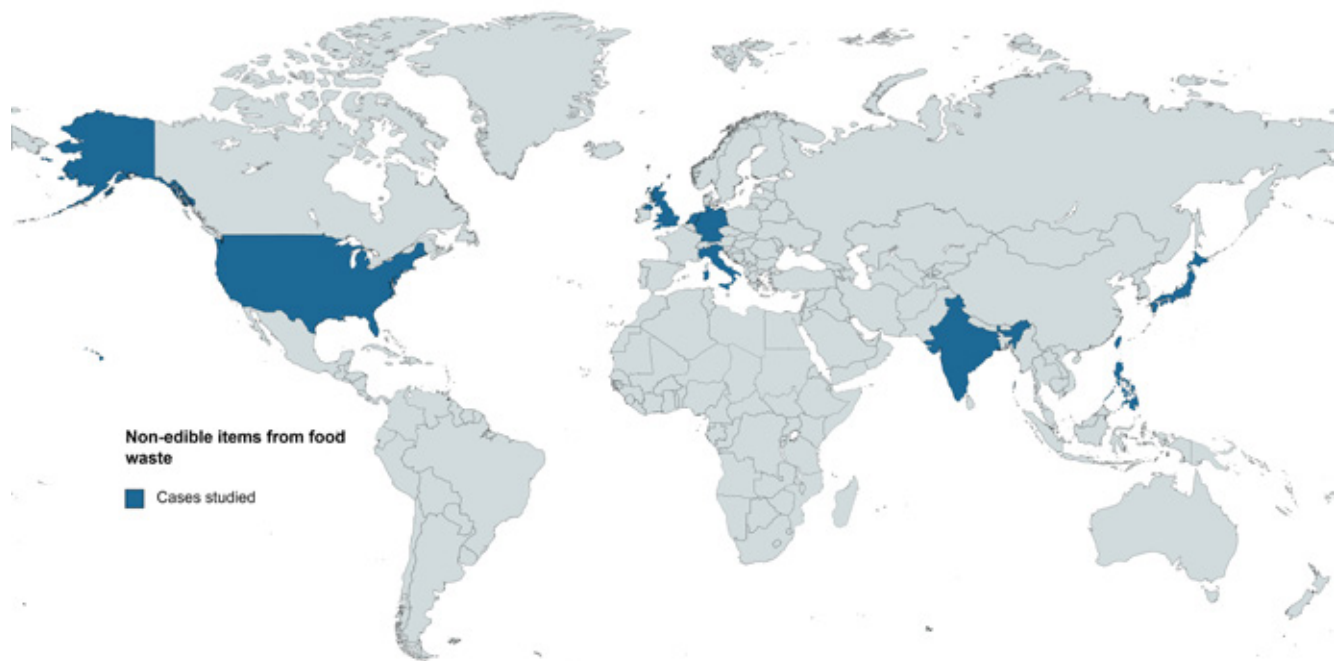


FIGURE 22. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XV.

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4.7 Recycling

Cities constitute waste sinks for food waste and the nutrients and energy the waste contains. Depending on city size and the efficiency of waste collection, centralized and/or decentralized food waste recycling options might be viable. Ideally, waste gets already sorted and recycled at the place of consumption, i.e. on-site. On-site waste treatment systems for food businesses and households offer a solution to limit the pressure on waste collection services.

For any recycling purposes, food waste must be segregated from other waste materials, such as plastic, glass or aluminum food packages. To do so, both at household and retail levels, incentives, regulations and education

are required. Globally, policies for segregating waste are becoming increasingly common, and are the keys to successful waste management.

This section describes three business models. The first is based on on-site food waste treatment; it includes the perspectives of waste producers as well as entrepreneurs who develop and sell technology systems.

The collection and off-site treatment of food waste is generally executed by the municipality. Alternatively, cases are identified where recycling composting plants are operated by community groups (the second model) or businesses are created that generate profit from biogas, fertilizer or compost production (the third model).

4.7.1 Model XVI: On-site Compost or Energy Recovery

Brief	Supporting the conversion of food waste to bioenergy or compost within food businesses (Business Model Canvas 16)
Waste stream	Unavoidable food waste, inedible food parts
Value-added product	Organic fertilizer, energy
Key stakeholders	Manufacturers, large retailers, hotels
Geography	Urban, peri-urban, rural (see also Figure 23)
Profit objective	For-profit
Organization type	Private, PPP

The Business Model

In this business model, food waste is treated on site with an installed unit. Entrepreneurs manufacture, market and deliver these units. Most common are composter and anaerobic digesters.

- On-site composting: Unit converts food waste into compost.
- On-site anaerobic digestion: Unit converts food waste into biogas and a digestate which can be used as fertilizer by-products.
- Bokashi system: The process which generates fertilizer through the fermentation of organic matter under aerobic or anaerobic conditions.

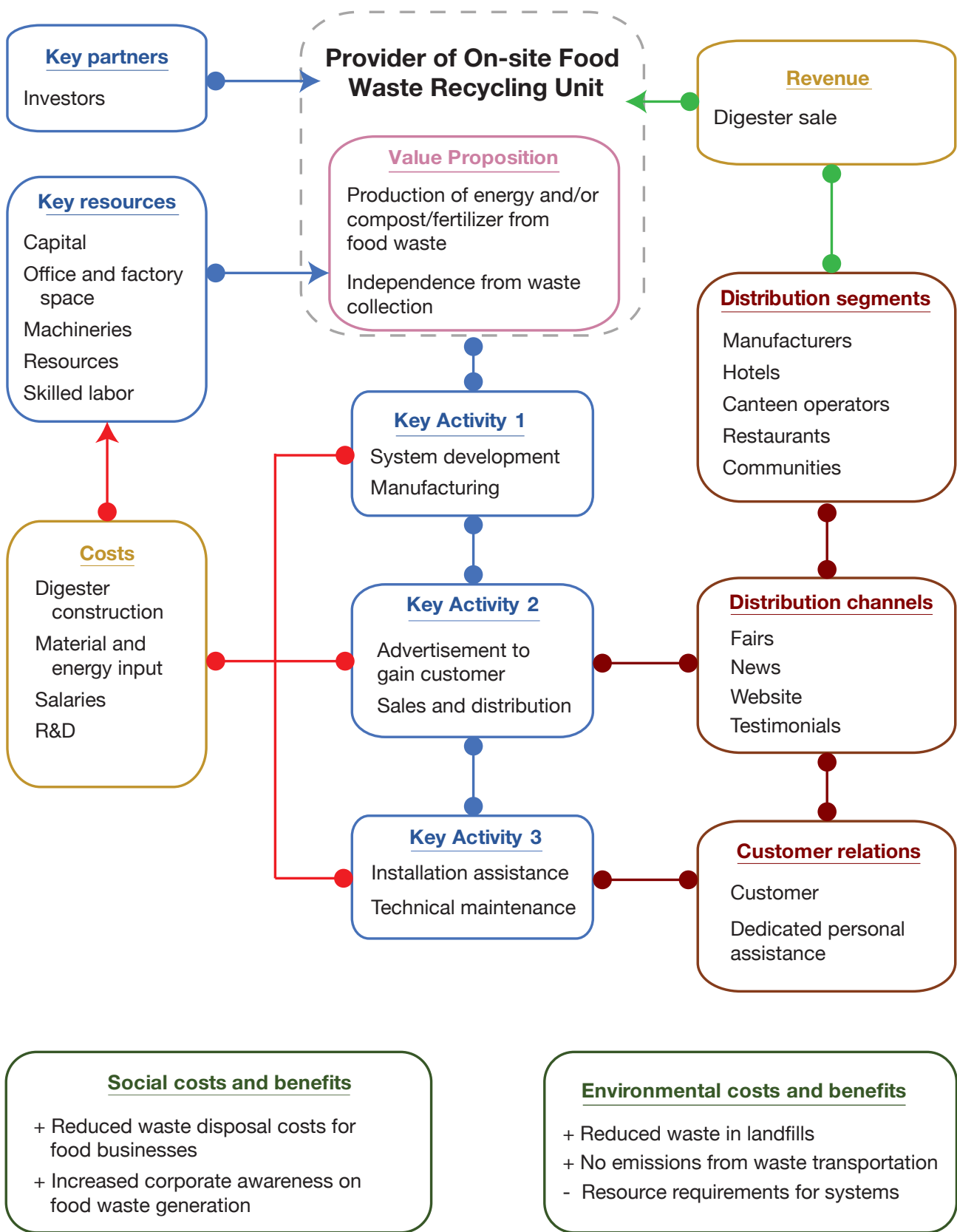
The model is best suited for large retailers or food processors where adequate space is available on site and the level of waste generated is high. As described in the examples, compact technologies are available which can serve kitchens from the size of a normal household up to the size of a hotel. The use of the units offers independence from collection services, leading to savings from waste disposal costs in the long term. Depending on the scale and technology application, the material and manufacturing costs are rather high for this model (Table 19). This requires investment capital for both the providers of the units and their clients. The sales of the units are the main revenue streams for the provider while additional revenues may derive from services such as maintenance, training or awareness workshops.

For the user of the unit, the generated biogas or compost offers an additional benefit, either for direct use internally or as potential revenue stream from selling.

TABLE 19. SWOT ANALYSIS OF THE ON-SITE COMPOST OR ENERGY RECOVERY MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Abundant waste stream • Traditional practices used for new technologies • Strong partnerships with clients to customize units 	<ul style="list-style-type: none"> • Space requirements • High investment costs • Degree of efficiency, depending on the scale and system
EXTERNAL	<ul style="list-style-type: none"> • Landfill taxes or incentives for recycling • Influential investors from hotel or wholesale sectors • High replicability in different parts of the world 	<ul style="list-style-type: none"> • Perceptions on odors from composting • Hygienic standards prohibiting waste treatment close to food preparation areas





BUSINESS MODEL CANVAS 16. ON-SITE COMPOST OR ENERGY RECOVERY.

Case Examples

Bokashi Myanmar Company Limited (Myanmar)

The initiative was founded in March 2019 with the motivation to contribute to a greener, cleaner and healthier Myanmar by reducing the amounts of organic waste dumped in landfills. It supports electricity-free, natural composting with effective microorganism cultivated on rice bran and husk. It follows three key strategies (i) developing a replicable model in any location, (ii) establishing community-based waste management through working together with local projects and different stakeholders, and (iii) providing training to change perceptions on waste and to raise awareness about the environmental benefits of Bokashi composting. On its website, materials and guidelines on the use of *Bokashi* are provided for households, restaurants, communities and schools (<https://bokashimyanmar.com>).

Oklin International (Hong Kong)

Oklin provides electrical composters for households and a variety of commercial uses, from restaurants

to large-scale institutions. Utilizing microbial technology, its composting machines reduce waste volume by up to 90%, decrease disposal costs, and create within 24 hours a nutrient-rich, reuseable end product. The company offers mechanical composters for household kitchens (transforming up to 4 kg of organic waste per day) as well as for commercial operations which are generating between 25 and 1,350 kg of organic waste a day (or 10 to 500 tons per year). Oklin works with supermarkets, restaurants, schools, and some of the world's leading hotel brands to implement zero organic waste solutions in their operations (<http://oklininternational.com>).

Household-based options

At household level, various high- and low-tech units are available from self-made or purchased compost bins to, for example, a 'Zera Food Recycler' which produces a compost-like product within 24 hours. Traditional compost bins require longer periods and sufficient feedstock to develop without electricity the required temperature (<https://wlabinnovations.com/pages/zera>).

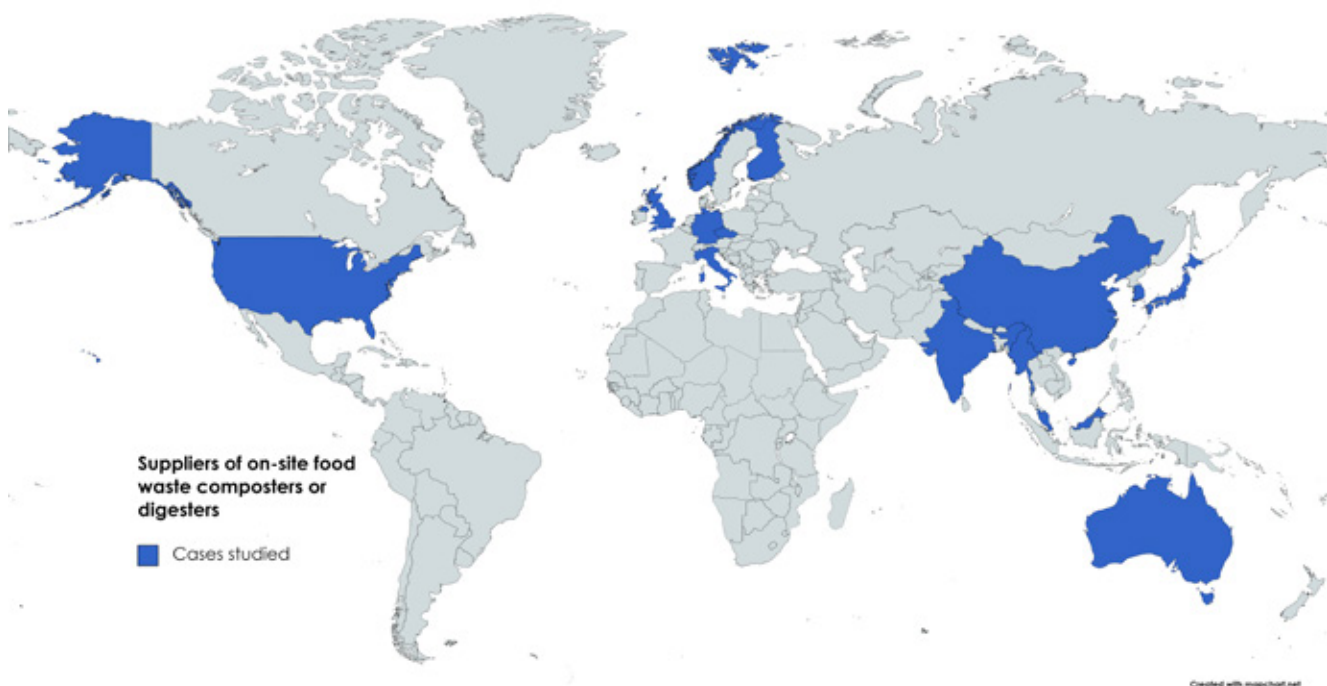


FIGURE 23. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XVI.

4.7.2 Model XVII: Social Community Composting

Brief	Conversion of food waste to compost in a community compost plant managed by the private sector (Business Model Canvas 17)
Waste stream	Unavoidable food waste, inedible food parts
Value-added product	Compost, community engagement
Key stakeholders	Municipalities, manufacturers, retailers
Geography	Urban, peri-urban (see also Figure 24)
Profit objective	Nonprofit, social enterprise
Organization type	NPO

The Business Model

The activities of community composting models are twofold: to produce compost as well as to achieve social objectives. These could include employment for disadvantaged individuals, social inclusion, community education, environmental awareness and urban farming which complement the production of compost. Meeting these objectives provides community benefits such as upskilling, youth employment and engagement in socially and environmentally conscious behavior. The relative importance of each objective in the model determines the mix of activities used to achieve them (Clark 2015).

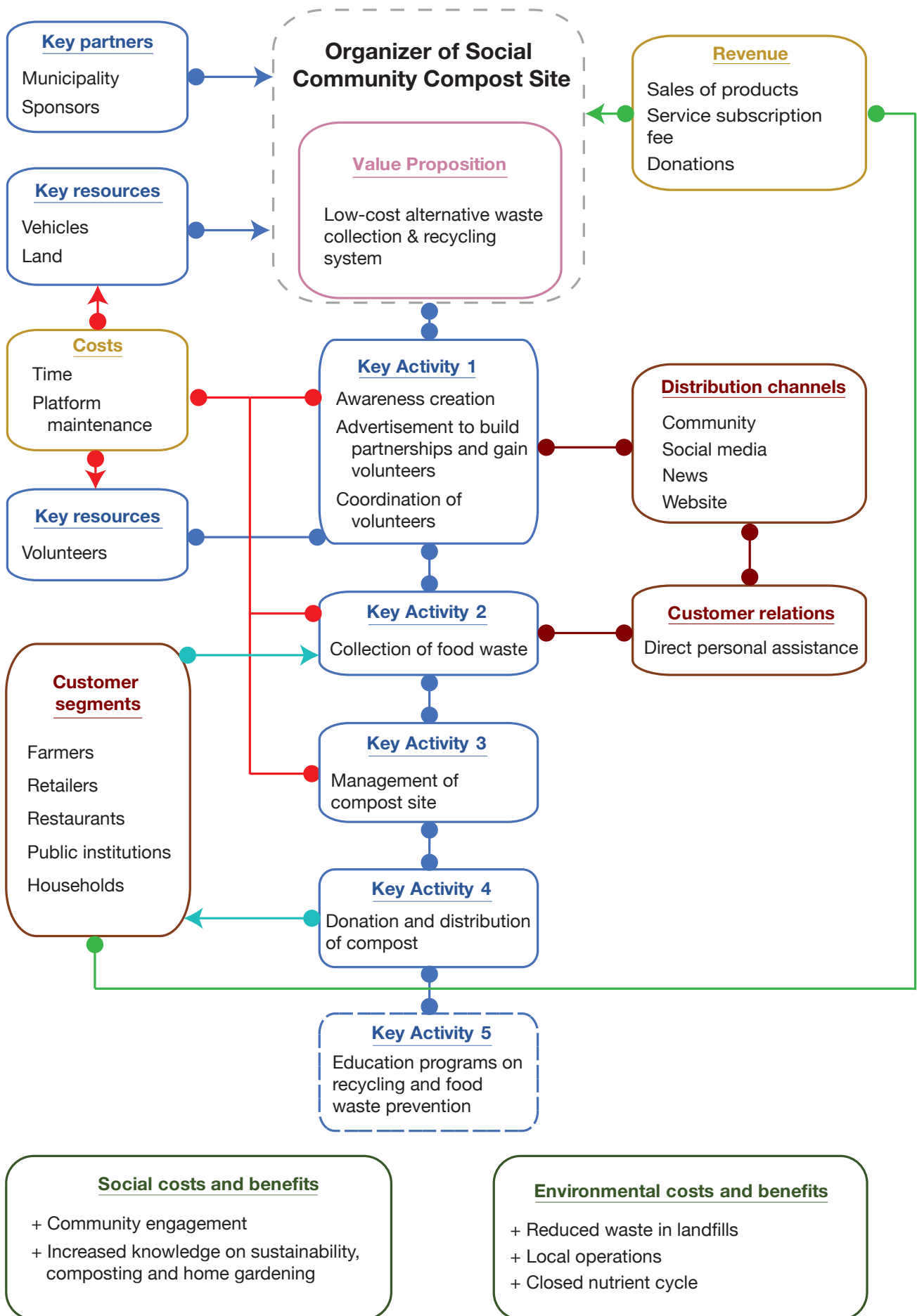
Influenced by the availability of volunteers (Table 20) or sponsors to pay drivers, initiatives either coordinate the collection of food waste from participating entities or function on a drop-off system (see first model variation below).

The food waste is mixed with garden waste, wood chips or sawdust and left to decompose before being used, sold or donated to consumers, farms, community organizations and so forth (Otoo and Drechsel 2018).

The sale of the compost can be a way of financing the initiative (see second model variation below). Otherwise, the model can be supported by public grants or subsidies aimed at reducing waste in landfills as well as for educational or other social purposes. In addition, in-kind donations such as land provided by the local authority can reduce operational costs. In the same way, space such as schools, parks, allotment sites and offices could be used for the operations, assuming compliance with local regulations (<http://www.carryoncomposting.com/142941492>).

TABLE 20. SWOT ANALYSIS OF THE SOCIAL COMMUNITY COMPOSTING MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Revenue streams (e.g. sales of compost or fees for collection) • Knowledge about composting • Community engagement • Partnerships with other community groups • Paid staff or highly committed, long-term volunteers 	<ul style="list-style-type: none"> • Space requirements • Reliance on volunteers • Risks of diseases from contaminated material (plant, animal or human pathogens) entering the compost site
EXTERNAL	<ul style="list-style-type: none"> • Existing market • Landfill taxes or incentives for recycling • Support from governments • Controlled standards on environmentally friendly operations 	<ul style="list-style-type: none"> • Reluctance of community to separate waste • Competition from larger waste collectors • Cheap fertilizer • Lack of support from the local authority • Time and resources for legislation compliance



BUSINESS MODEL CANVAS 17. SOCIAL COMMUNITY COMPOSTING.

Case Examples

BK ROT (United States)

Using bicycles, BK ROT offers a community-supported year-round composting service. BK ROT employs young adults on living wages to collect organic waste from businesses and organizations in Brooklyn (BK), New York City. The material is processed locally at BK ROT's composting site (which also accepts drop-offs). Transforming about 15,000 pounds of food waste a month, the finished compost is used in gardens, for house plants and soil remediation projects. According to 2020 records, BK ROT generated in 2019 about 50 tons of compost of which a significant share was donated to local farms and about USD 100,000 in income was generated for young workers so far (<https://www.bkrot.org>).

Model Variations

Food waste drop-off scheme

In comparison to the collection service by volunteers, certain initiatives request participants in community compost schemes to transport their own waste. Collection services can be easily managed with a

high density of waste generators and short distances. Yet, especially with a larger community radius or in remote areas, a drop-off scheme is beneficial for the operators due to the lower workforce required. Through this variation, the engagement of the participating members might increase. If a drop-off model is chosen, the site should be convenient and easily accessible for everyone.

For-profit/cost recovery scheme

Certain cases like Community Composting (<http://www.communitycomposting.ca>) follow the primary goal of producing and selling compost, compared to achieving social objectives. They operate on a larger scale with the use of trucks for collection. A revenue stream is generated through flexible subscription fees for their services, which can include cleaning of bins or a 'yard clean-up'. Revenue from compost sales complements this. The for-profit model requires higher investments in heavy equipment to process greater amounts of waste. Sales of compost are to the community (including a free 20L bag for those subscribing to the waste collection service), while larger users such as farmers or developers are also included.

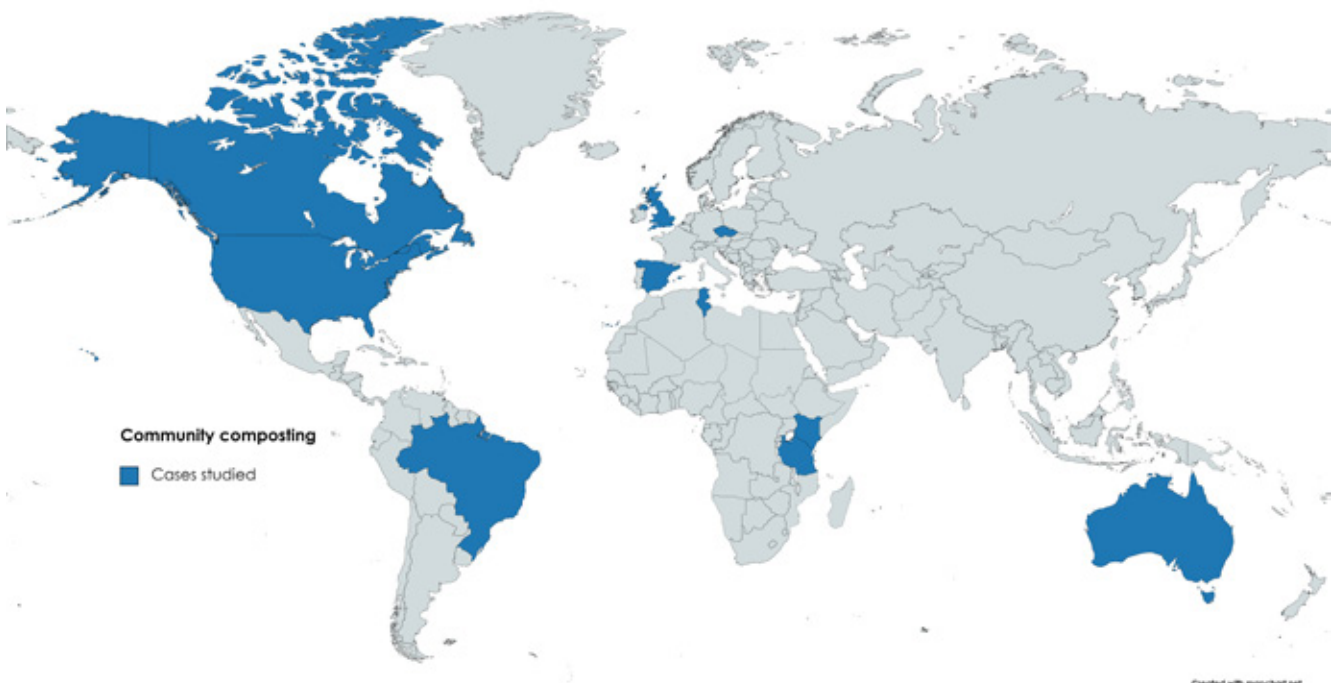


FIGURE 24. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XVII.

4.7.3 Model XVIII: Off-site Compost and Energy Recovery

Brief	Conversion of food waste to bioenergy or compost in an externally located plant managed by the private sector (Business Model Canvas 18)
Waste stream	Unavoidable food waste, inedible food parts
Value-added product	Compost, energy, fertilizer
Key stakeholders	Municipalities, manufacturers, retailers
Geography	Urban, peri-urban (see also Figure 25)
Profit objective	For-profit
Organization type	Private, public, PPP

The Business Model

This model recycles inedible food waste using composting or anaerobic digestion to create valuable products such as compost, energy and fertilizer. Large sources of waste are utilized such as from food businesses or the municipal solid waste stream because the feedstock requirement for the model is high. Revenue streams are the sale of these products and additional streams may include the sale of recyclables and carbon credits (Otoo and Drechsel 2018). Waste is transported to the site where the plant is operated and processed into products and either used on site or sold. There are three technical options which all require source segregation of organic waste.

a) Windrows: For windrow composting, food waste is mixed with high carbon-based materials and left in long windrows to decompose. A large area of land is necessary

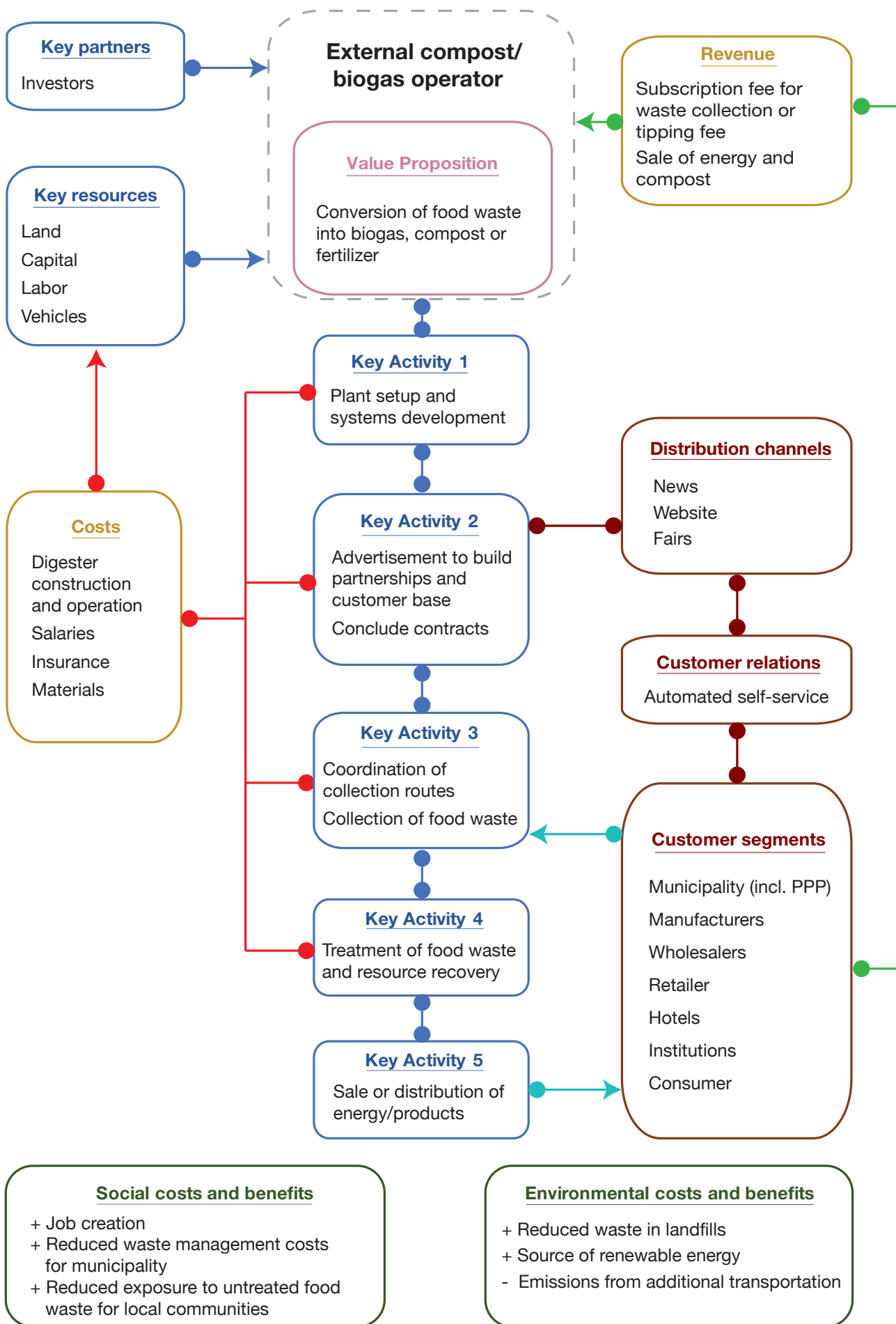
as well as equipment to turn the windrows as required. The process can produce a leachate that may contaminate groundwater or surface water if not controlled correctly.

b) In-vessel: Once transported to the composting site, the food waste is placed in a large container, in which the air flow, temperature and moisture levels are controlled. The contents are mixed to aerate the compost as it decomposes.

c) Anaerobic digestion (AD): The AD process converts food waste to energy and a fertilizer by-product. The energy can be sold as a revenue stream or energy used on site. The organic fertilizer is the second revenue stream. Potential food waste streams include household waste, retail waste and manufacturing wastes such as spent grains from breweries. Agricultural waste, manure, yard waste and wastewater can be additional feedstock. For successful AD plants, sufficient feedstock is required to produce electricity for profit generation (Table 21).

TABLE 21. SWOT ANALYSIS OF THE OFF-SITE COMPOST AND ENERGY RECOVERY MODEL.

	HELPFUL	HARMFUL
INTERNAL	<ul style="list-style-type: none"> • Interest in joining a PPP • Good relationships with suppliers and the municipality • Sales stream to market and distribute compost 	<ul style="list-style-type: none"> • High investment costs • Significant land requirement • Lack of available finance • Unskilled labor • Operational costs
EXTERNAL	<ul style="list-style-type: none"> • Existing market • Landfill taxes or incentives for recycling • Support from governments • Controlled quality standards on compost 	<ul style="list-style-type: none"> • Unenforced waste segregation • Polluted feedstock (unclean segregation) • Insufficient feedstock volume



BUSINESS MODEL CANVAS 18. OFF-SITE COMPOST AND ENERGY RECOVERY.

Case Examples

ReFood (UK, Germany, France)

The target customer groups are the food service and retail sector where large amounts of food scraps and leftovers but also frying fats/oils occur. ReFood offers individually agreed times for collection with dedicated containers that are replaced with clean disinfected ones. In addition, the company collects data on collection frequencies and amounts of waste for the customer. On its premises, the food waste is removed from packaging material, ground and heated. The obtained liquid is treated in its biogas plants to generate energy and digestate which is used as organic fertilizer for agricultural purposes. Recycling food waste with ReFood can save a company up to 50% on food waste disposal costs at landfills (<https://www.refood.de>).

Biffa (United Kingdom)

Biffa recycles about 315,000 tons of food waste annually. The largest of their three AD facilities, built at an investment of GBP 24 million (ca. USD 37 million in 2011) can handle up to 120,000 MT of food waste per year. The

plant is the most efficient food waste processing AD plant in the UK generating up to 6.5 million MW of electricity – enough to power 15,000 homes. Biffa accepts 24/7 food waste at its plant or transfer stations, or offers a food waste collection service including container to dispose of food waste. Biffa partners with WasteAid to bring equal access to waste services in developing countries (<https://www.biffa.co.uk>).

Blue Sphere (United States)

Offering a cost-effective, environmentally safe alternative to landfill sites, the international independent power producer is helping food processors and municipalities to turn food scraps, rejected produce, agriculture straw, livestock manure, and municipal waste through industrial digesters into electricity. The company supports, develops or acquires facilities that use technologies which generate long-term revenue streams by selling electricity to local utilities through power purchase agreements. Solid materials are converted to soil amendments and sold to landscapers of farms. Another income stream is tipping fees (<http://bluespherecorporate.com>).

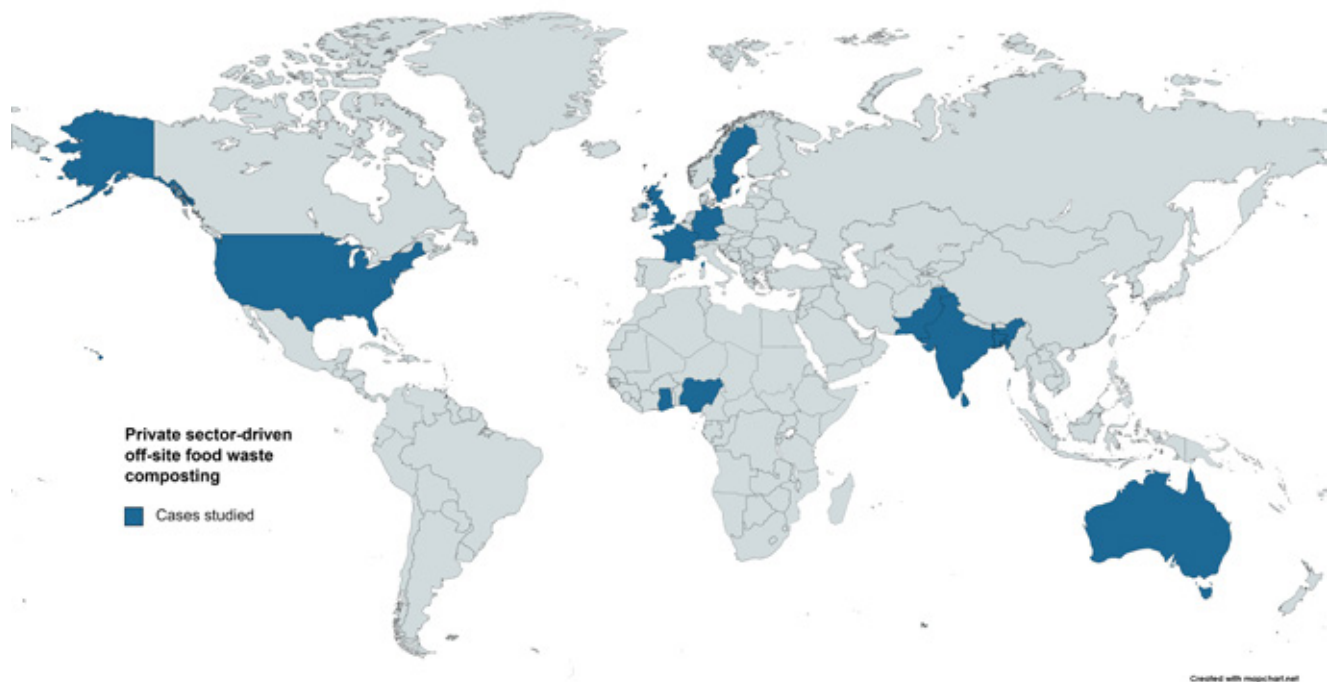


FIGURE 25. IDENTIFIED EXAMPLES OF BUSINESS CASES OF MODEL XVIII.

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5. APPLICATION POTENTIAL TO THE GLOBAL SOUTH

While public policies and strategies about food waste reduction are still emerging in support of SDG 12.3 (Figure 26), many private sector entities have started setting their own targets. While these are in part linked to corporate social responsibility (CSR) efforts, they also reflect that there is a robust business case for companies to reduce food loss and waste (Hanson and Mitchell 2017). Thus, companies continue to lead the global efforts on measurement of food loss and waste. Given the global outreach of large food companies in particular, their example, drive and impact can be significant, especially if extended to their supply and retail chains in the Global South. These efforts are being monitored by Champions 12.3 (www.champions123.org) which has formulated related annual milestones.

Thus, to address the global food waste challenge, commercial food companies have an important role to

play aside from local, regional or international initiatives, start-ups and already established companies which directly focus on food waste.

5.1 A Closer Look at the Food Sector Giants

By the end of the calendar year 2018, two-thirds of the world's 50 largest food companies (by revenue) had a food loss and waste reduction target. These companies included AEON, Kellogg's, Nestlé, Walmart, and Woolworths. Therefore, the 2018 SDG milestone "Sixty percent of the world's 50 largest food companies by revenue have set specific food loss and waste (FLW) reduction targets aligned with Target 12.3" was exceeded. However, just under one-fifth of the world's largest companies have also set targets for their suppliers missing the related milestone (Flanagan et al. 2019). Examples of some of the ongoing initiatives are presented in Table 22.

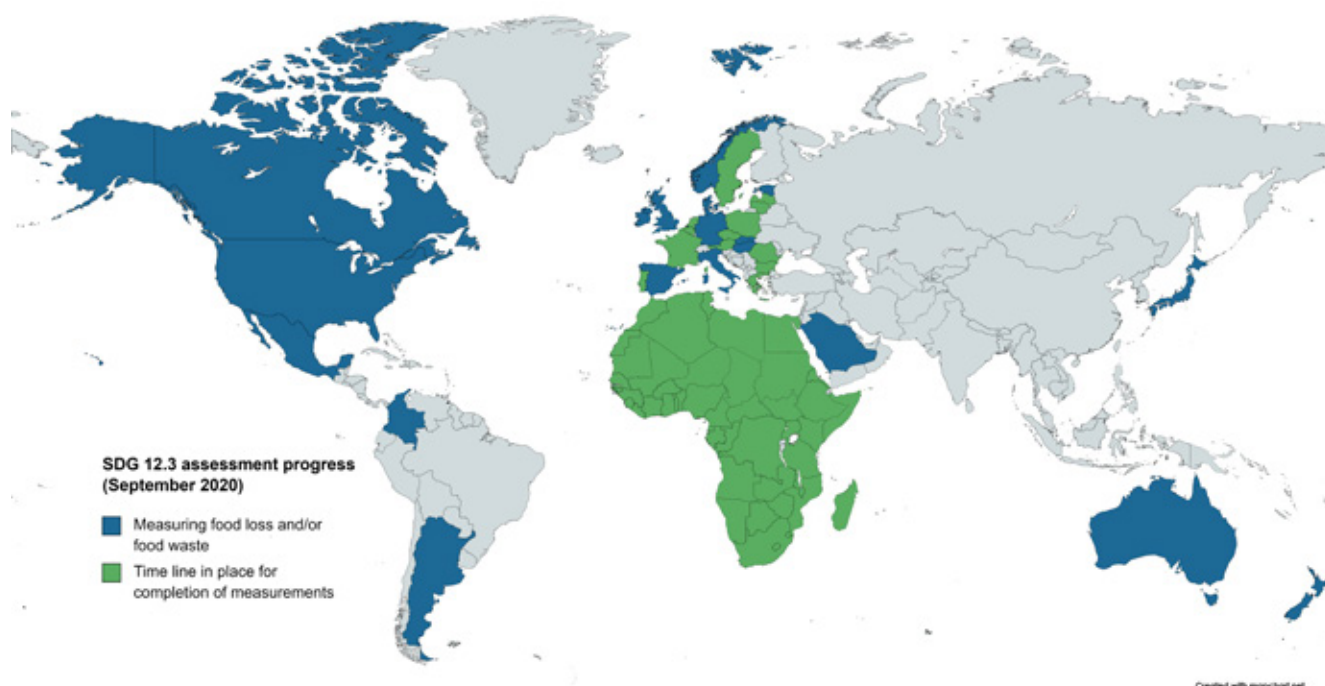


FIGURE 26. NATIONAL AND REGIONAL GOVERNMENTS MEASURING FOOD LOSS AND/OR FOOD WASTE.
SOURCE: LIPINSKI 2020.

TABLE 22. PROSPECTIVE PRIVATE SECTOR-DRIVEN FOOD WASTE MANAGEMENT INITIATIVES FROM INTERNATIONAL EXPERIENCES (NON-EXHAUSTIVE).

Initiative examples	Company examples	Description
National alliances		
National Food Waste Reduction Pacts (I) (UK 2018)	The UK Food Waste Reduction Roadmap, with more than 150 companies, including all main grocery retailers in the UK	To help food and consumer goods companies reduce their food waste, the companies are committed to Target, Measure and Act on their food waste, with 121 already reporting on progress. These 121 companies have a combined turnover of half of the overall turnover for UK food manufacture, retail and hospitality food services.
National Food Waste Reduction Pacts (I) (Canada 2019)	Kraft Heinz (Canada), Loblaw Companies Ltd., Maple Leaf Foods, Metro Inc., Save-on-Foods, Sobeys Inc., Unilever (Canada), Walmart (Canada)	These 8 companies are committed to reducing food waste in their Canadian operations by 50% by 2025.
National Food Waste Reduction Pacts (II) (USA 2016)	U.S. Food Loss and Waste 2030 Champions	With support from the U.S. Department of Agriculture and the U.S. Environmental Protection Agency this group of businesses and organizations has made a public commitment to reduce food loss and waste in their own operations in the US by 50% by 2030.
Multinational alliances		
Global alliances I (2015)	The European Union-based International Food Waste Coalition (with members like Accor, Eloor, General Mills, Sodexo. etc., and partners like, e.g., FAO)	The coalition uses a farm-to-plate value chain approach for impacting local, national and international regulations as well as conducting specific projects (e.g. with FAO on schools) aimed at the end-users. The goal is to achieve measurable results and create momentum in society.
Global alliances II (2016)	The Consumer Goods Forum of about 400 retailers, manufacturers, service providers and other stakeholders across 70 countries	In June 2016, the first-ever global standard to measure food loss and waste, the FLW Standard, was introduced through an international partnership. The standard is a set of global definitions and reporting requirements for companies, countries and other entities to consistently and credibly measure, report on and manage food loss and waste.
Global alliances III (2017)	Global Agri-business Alliance	Supports SDG 12.3, including measuring food loss and waste as part of the Food and Agricultural Loss Resolution (using a common Food Loss and Waste Accounting and Reporting Standard).
Global alliances IV (2018)	Ten of the world's largest food brands including Mars, PepsiCo, Tesco and Unilever	Committed to halving their food waste by 2030, publishing food waste data on their operations and taking concrete steps to reduce food waste in the supply chain and in customers' homes.

(Continued)

TABLE 22. PROSPECTIVE PRIVATE SECTOR-DRIVEN FOOD WASTE MANAGEMENT INITIATIVES FROM INTERNATIONAL EXPERIENCES (NON-EXHAUSTIVE). (CONTINUED)

Initiative examples	Company examples	Description
Global alliances V (2019)	Sustainable Rice Platform	Represents some of the largest rice producers in the world; the platform is committed to implementing the Target-Measure-Act approach and to halving on-farm and near-farm rice losses by 2030.
Global alliances VI (2019)	“10x20x30” Food Loss and Waste Initiative by AEON, Ahold Delhaize, Carrefour, IKEA Food, Kroger, METRO AG, Pick n Pay, The Savola Group, Sodexo, Tesco and Walmart	An initiative to engage the supply chains in the fight against food loss and waste. The initiative brings together 10 of the world’s biggest food retailers and providers to each engage with 20 of their priority suppliers in a bid to halve rates of food loss and waste by 2030.
Individual companies		
Company commitments (I)	Sysco	Committed to divert 90% of food waste from landfills by 2025 from the current level of 65%. To help meet this goal, Sysco is working on repurposing and donating excess food and redirecting food waste through agricultural feed.
Company commitments (II)	Google	Since 2014, over 2,700 tons of food waste had been avoided by implementing Leanpath technology across 189 cafés and using the information to: alter menus and purchasing habits, repurpose items of food that would otherwise have been wasted into other products and donate any surplus food to those in need.
Company commitments (III)	Kellogg’s, Morrisons, Co-Op	Since 2016, a 12% reduction in organic waste (food waste plus animal feed and biomaterial/processing) across its global manufacturing plants (Kellogg’s). Since 2016, a 13% reduction in its food waste (Morrisons). Since 2015, a 29% reduction in food waste (Co-Op).
Company commitments (IV)	Tesco	Between 2017 and 2019, Tesco UK had achieved a 63% increase in the amount of surplus food redistributed to charities, community groups, colleagues and for use as animal feed. This resulted in a 51% decrease in the amount of food safe for human consumption going to waste (energy recovery) and a 17% reduction in total food waste in tonnage. Between 2016 and 2019, Tesco Central Europe had reduced its total food waste by 47% through reducing surplus and increasing the amount of surplus food redistributed to charity partners.
Company commitments (V)	Nestlé	Between 2017 and 2018, Nestlé reduced milk losses during transportation from the farms to factory by nearly 40%.

(Continued)

TABLE 22. PROSPECTIVE PRIVATE SECTOR-DRIVEN FOOD WASTE MANAGEMENT INITIATIVES FROM INTERNATIONAL EXPERIENCES (NON-EXHAUSTIVE). (CONTINUED)

Initiative examples	Company examples	Description
Company commitments (VI)	Sodexo	In June 2019, Sodexo, which serves more than 100 million meals a day, announced new food waste reduction activities with a data-driven waste management program called 'WasteWatch powered by Leanpath', to be deployed across 3,000 sites worldwide.
Company commitments (VII)	Kroger	Kroger, the second largest food retailer in the US, estimated that in 2017, 27% of retail store food waste was diverted from landfills, and in 2018, 40% was supported by better store engagement and execution.

Company example (IKEA)

IKEA, a global furniture retailer, has over 400 stores and almost 1 billion visitors each year, including 680 million visitors in 2018 who spent EUR 2.15 billion in IKEA's food outlets. In 2016, IKEA launched the 'Food is Precious' initiative, setting a target to reduce its food waste by 50% by August 2020. Notable actions included: 1) using a smart scale system to monitor food waste in four IKEA stores, resulting in a 23 to 54% decrease in food waste over six months; 2) appointing 'Food Waste Champions' in each store to motivate colleagues at work and home; and 3) appointing a 'Country Implementation Responsible' person for targeted markets to lead implementation and to support co-workers. IKEA experienced a 20% reduction in food waste within 12 weeks of starting the food waste reduction initiative and found that additional investments mostly had a 20-week payback period. IKEA plans to also address food loss and waste with its suppliers and to encourage consumers to reduce food waste at home (Hanson and Mitchell 2017).

5.2 Requirements for Adaptation to the Global South

While CSR as well as cost savings can be strong drivers to reduce waste within already established companies, start-ups targeting food waste as an opportunity have to address a broader spectrum of internal and external criteria for their own development and viability.

It is important to understand the incentive mechanisms and needs of the identified business models to recognize geographic (regulatory, economic) areas in which models can thrive and areas in which there is lack of support.

Figure 27 shows that North America and Europe are the continents with the highest case numbers recorded for

this study. This is, however, only an indication of the geographical spread as the research did not capture food waste reduction initiatives presented in languages other than English, or which operate without web presence. Most captured cases were in the resell, reuse and redistribution category. This category has the most significant proportion of cases in each continent with dominance in North America and Europe.

One reason for the high incidence of cases in North America and Europe could be the advanced level of public awareness about food waste issues. Conversely, in the Global South awareness overall is lower, which could explain the lower incidence of cases.

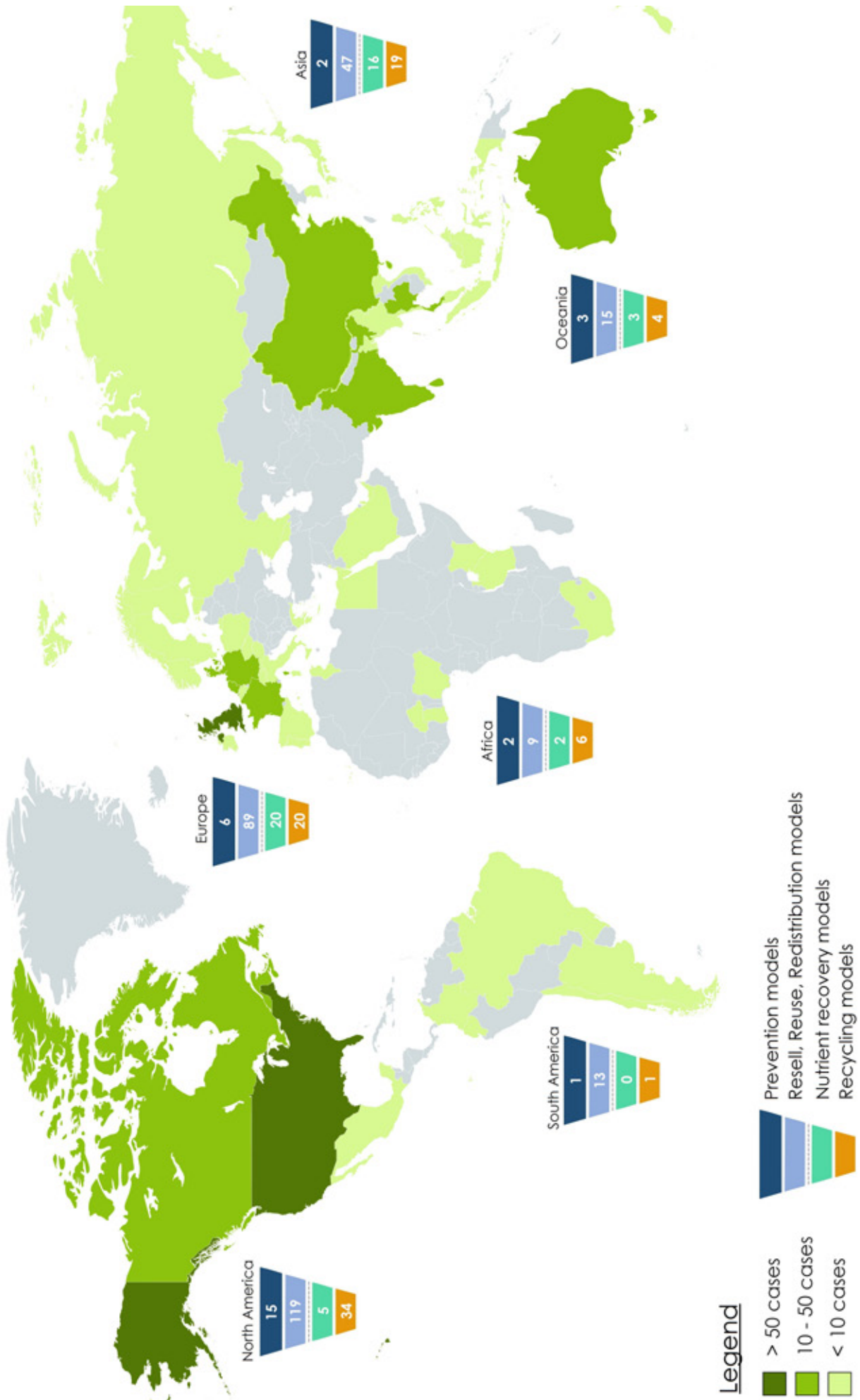


FIGURE 27. MAP OF THE DISTRIBUTION OF STUDIED CASES CATEGORIZED BY THE FOOD RECOVERY HIERARCHY.

Overall, the transferability mechanisms needed most for adapting food waste reduction models to the Global South are public awareness, infrastructure and regulations (Table 23).

The prevention models analyzed require digital access and digital literacy but are less dependent on regulations and infrastructure compared to other categories. The majority of cases under the prevention category presented in Figure 27 are from cases launched in Europe or North America. However, with increasing ICT and internet capacities, the models could spread fast, especially if the software prices go down.

Models in the resell, reuse and redistribution category require high levels of public awareness and infrastructure. These models are based on finding new markets for food waste and their uptake is dependent on overall public acceptability. In addition, adequate transportation and electricity are required for the models to achieve their value propositions. Therefore, the models could be more appropriate in countries in which public education campaigns have taken place or are possible and regions

in which infrastructure and constant electricity access are available.

While public awareness is also crucial for models in the nutrient recovery category, infrastructure and regulations are needed most. These models work with food unfit for human consumption and so generally require more regulations as they are dealing with the use and disposal of waste. Therefore, these models are likely more easily implemented in countries where infrastructure is available and regulations can be enforced as required.

Finally, recycling models differ in their requirements for transferability, where they are mostly dependent on public awareness, incentives (organic waste separation) and regulations in addition to infrastructure and skilled labor. Within a PPP, the models are less dependent on access to finance. However, for Model XVII (Social Community Composting), financial support is a requirement as it may not be possible to fully cover operational costs. These models are easier to implement in the context of countries with public awareness of food waste and skilled labor available, or the ability to train labor in order to operate the models.

TABLE 23. HEATMAP OF THE REQUIREMENTS OF MODELS IN THEIR TRANSFERABILITY TO THE GLOBAL SOUTH.

Hierarchy	Model	Name	Regulations	Infra-structure	Public awareness	Digital access	Digital literacy	Access to finance	Skilled labor
Prevention	I	Tracking and Analytical Software for Managing Food				High	High		Somewhat
	II	Measuring and Analyzing Food Waste			Somewhat	High	High		Somewhat
Resell, Reuse, Redistri-bution	III	Community Fridge	High	High	High	Somewhat	Somewhat	High	
	IV	Connection Platform			High				
	V(a)	Logistics Services (Profit)	High	High	High				
	V(b)	Logistics Services (Nonprofit)	High	High	High			High	
	VI	Box Subscriptions		High	High	Somewhat			
	VII	Online Secondary Market		High	High	Somewhat			
	VIII	Store Secondary Market		High	High				High
	IX	Restaurants Serving Rescued Food	Somewhat	Somewhat	High				
	X	Food Upcycling and Preservation	Somewhat	High	High				
	Nutrient Recovery	XI	Responsible Waste Collection	High	High	High			
XII		Mushroom Cultivation	Somewhat	High	Somewhat				
XIII		Rearing Insects	High	High	Somewhat				
XIV		Swine Feed	High	Somewhat	Somewhat				
XV		Nonfood Products	Somewhat	High					Somewhat
Recycling	XVI	On-site Compost or Energy Recovery	High		High				High
	XVII	Social Community Composting	High	High	High			High	
	XVIII	Off-site Compost and Energy Recovery	High	High	High			Somewhat	High



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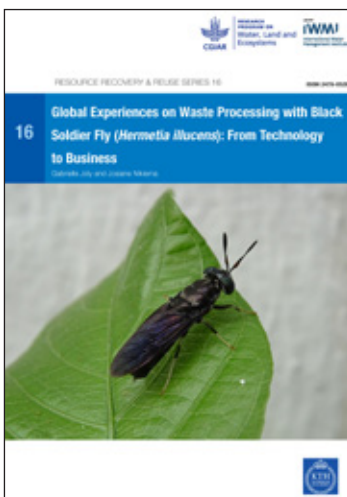
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ISSN 2478-0510 (Print)
ISSN 2478-0529 (Online)
ISBN 978-92-9090-915-6

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