Develop an intelligent supply chain framework for food sector to re use, recycle and redistribute the waste food from consumer Introduction

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Introduction:

This research aims to develop a intelligent software application for waste management in food sector. Numerous researches are conducted on waste management but these works remain in the database of the journals. Realistic implementations of these propositions and theories need tools for management to record, retrieve, transfer , process the data and measure and optimize the processes(waste management).
A U.K. study put the amount of household food loss at 33%. According to a 2005 study at the University of Arizona, food waste as a percentage of the total food used is 9.55% in fast food establishments and 3.11% in full service restaurants in the United States. That may not seem concerning, but, to put the statistics in perspective, the same study estimated that the total food loss per day amounted to 49,296,540 lbs in all full service restaurants and 85,063,390 lbs in all fast food restaurants. While this is a projected value based on collected data, it gives an idea of the sheer amount of food that is wasted on a daily basis in foodservice. Table 1.1 and 1.2 summarizes the waste and causes of food waste.

Table 1.1 Survey report on food waste(Relevance of research)

Roughly one third of the food produced in the world for human consumption every year — approximately 1.3 billion tons — gets lost or wasted(Food and Agriculture Organization)	Every year, consumers in rich countries waste almost as much food (222 million tons) as the entire net food production of sub-Saharan Africa (230 million tons). (Food and Agriculture Organization)
Over 97% of food waste generated ends up in the landfill. (Environmental Protection Agency)	33 million tons of food makes its way to landfills each year. (Environmental Protection Agency)
In 2008, the EPA estimated that food waste cost roughly $1.3 billion to dispose of in landfills. (Journal of Consumer Affairs)	Food waste that goes to the landfill breaks down an aerobically and produces methane; methane is 21 times more potent than CO2 as a greenhouse gas. (Environmental Protection Agency)
The aggregate food supply in 2000 provided 3,800 calories per person per day...of that 3,800, an estimate 1,100 calories were lost to spoilage, plate waste, cooking, and other losses, putting dietary intake of calories in 2000 at 2,700 calories per person per day. USDA Economic Research Service	Consumer and foodservice food waste is the largest source of food loss in the marketing chain(Economic Research Services) Municipal solid food waste accounts for ~30% of the total wasted food energy.(National Institute of Diabetes and Digestive and Kidney Diseases)
On average, diners leave 17 percent of meals uneaten and 55 percent of these potential leftovers are not taken home. Natural Resources Defense Council. Reducing food waste by 20 percent would provide enough food to feed 25 million people. Natural Resources Defenses Council	Every ton of food wasted results in 3.8 tons of greenhouse gas emissions. Waste & Resources Action Programmed (WRAP)

Table 1.2 Causes of consumer waste

No pre-planning.	oversized portions to eat	Calorie counting
Too much food.	abundance of buffets and cafeteria-style eating	“green guilt”
Cooking too much	Forgetfulness.	Busy lifestyle.
Unknown Amount of ingredient needed.	Impulse buying.	Over shopping
	Not knowing when food has gone bad	Frequency of shopping.

Literature survey:

Carlos Mena et[24] al has investigated UK food supply networks to identify the dominant causes of food waste across 15 networks and identified the management practices that lead to the food waste. Sven Lundiea et. al[25] proposed that home composting is more environment friendly and best food waste management option . M. Feh et. al[26] tested a separate collection of food waste and this resulted in a diversion potential of 100% for biodegradables alone and 77 wt.% for all collected household waste. Karen Refsgaard et al.[27] studied the peoples attitude on food recycle and found that people's recycling behaviour does not only depend on technical and organisational aspects, but also on institutions. Katherine Hyde et al [28,29] discussed challenge of waste minimisation in the food and drink industry and minimizing waste in the food and drink sector using the business club approach: a demonstration project in East Anglia, UK. R. Darlington et al [30] discussed analytical methods for food waste minimization. Gerald Reiner et. al. suggests that universally valid statements based on the behavior of specific supply chains can be quite doubtful, e.g., in our simulation environment the bullwhip effect cannot

always be reduced by a shorter supply chain. Philip Beske et al. concluded that eight capabilities for efficient dynamic control of food supply chain. These are:(1)Knowledge Assessment, (2)Knowledge Acquisition,(3)Ability Development, (4) Search, Selection and Integration of Partners,(5)Supply Chain Link Foundation,(6) Product and Process Development,(7)Relationship Management, and (8)Reflexive Control. Dimitris Folinasa et. al. proposed the lean thinking ,the Value-Stream Mapping (VSM) tool is proposed for determining waste. There are numerous methodologies for food consumer waste, household weighing, kitchen diary or studying behavioral study(WRAP 2008, 2009*a*). Contemporary archaeological excavations of landfill sites are also used to determine historical levels of food waste (Jones 2006); estimated household food waste indirectly from loss coefficients based upon existing research (Sibrián *et al*. 2006); or estimated wastage using statistical models relating population metabolism and body weight (Hall *et al*. 2009).Some studies have measured household food waste as a percentage of total consumed calories, others as a percentage of the total weight of consumed food or of the consumed food items. Some studies have sought to estimate the environmental impact of food waste, including the embodied greenhouse gas emissions (WRAP 2008, 2009*a*) or water (Lundqvist *et al*. 2008). Since then, technological progress resulting in fast changes in markets, distribution systems and household storage facilities have rendered these estimates outdated (Kantor 1998; Naska *et al*. 2001). Increased consumer choice and a decrease in the proportion of disposable income spent on food have tended to increase wasteful behaviour. As such, any study where waste was measured over time as a constant proportion of food consumed is in danger of being inaccurate (Sibrián *et al*. 2006).In many studies, food scraps fed to domestic animals and sink disposals were not included, thus yielding inaccurate estimates for total food waste (Harrison *et al*. 1975; Wenlock & Buss 1977; T. Jones 2003, unpublished data). In some cases, the wastage owing to feeding to pets reached 30 per cent of the total food wastage in dietary energy terms (Mercado-Villavieja 1976;Wenlock *et al*. 1980; Osner 1982)

Performance measures in supply chain modeling		
Cost	Minimize cost	Camm et al. Lee et al. Lee and Feitzinger Tzafestas and Kapsiotis Pyke and Cohen Pyke and Cohen Lee et al. Svoronos and Zipkin Cohen and Moon Cohen and Lee ,Ishii et al. Williams
	Minimize average inventory levels	Altiok and Ranjan, Towill and Del Vecchio
	Maximize profit	Cohen and Lee
	Minimize amount of obsolete inventory	Ishii et al.
Customer	Achieve target service level	Lee and Billington , Lee et al. Towill and Del Vecchio
Responsiveness	Minimize stockout probability	Altiok and Ranjan , Ishii et al.
Cost and customer responsiveness	Minimize product demand variance or demand amplification	Newhart et al. , Towill et al., Wikner et al.
	Maximize buyer—supplier benefit	Christy and Grout
Cost and activity time	Minimize the number of activity days	Arntzen et al.

and total cost

Flexibility Maximize available system capacity Voidouns

EXISTING FOOD WASTE QUANTIFICATION LITERATURE

Mary Griffin, et al. (2009) -. Publications and personal interviews **Schneider et. al. 2011- findings from the literature are analysed and the approach and results of a composition analysis of residual waste of a stratified sample (urban, rural area) are presented.**	Nahman et. al 2012 – cost is quantified based on estimates of the financial and external costs associated with landfilling(SA)
Sonesson et. al - by questionnaire, diary, and interviews(Switzerland)	Hall et. al 2009 - calculate the energy content of nationwide food waste from the difference between the US food supply and the food consumed by the population.
Suzan et. al (2013)- **available food supply data for South Africa and on estimates of average food waste generation**	Claudio Beretta et. al. 2013- energy balance

FOOD SUPPLY CHAIN REVIEW

Planning of Logistics Operations Fleet management, vehicle routing planning and scheduling

Ahumada and Villalobos (2011); Berruto and Busato (2008); Bochtis and Sørensen (2009); Bochtis and Sorensen (2010); Bochtis and Vougioukas (2007); Jensen et al. (2012);Busato et al. (2007); Grunow et al. (2007);Guan et al. (2008); Han and Murphy (2012);Hansen et al. (2001); Higgins and Davies (2005); Higgins (2006); Higgins et al. (2004); Milan et al. (2006); Ravula et al. (2008a); Ravula et al. (2008b); Sigurd et al. (2004);Sorensen and Bochtis (2010); Tarantilis and Kiranoudis (2001); Zanoni and Zavanella (2007)

Determination of key-performance indicators(KPIs) Aramyan et al. (2006); Aramyan et al. (2007)

Development of data handling processes and mechanisms Neely et al. (2005); Sorensen, Fountas et al.(2010); Sorensen, Pesonen et al. (2010);

Selection and development of measuring methods Neely et al. (2005)

Establishment of stakeholders' collaboration structures Van der Vorst (2006)

Design of transportation networks Akkerman et al. (2010); Higgins et al. (2004)

Design of the retailers' networks -Higgins et al. (2004)

Selection of markets Burch and Goss (1999); Ulaga et al. (2002)

Ensuring Sustainability Adoption of CSR business practices

Klerkx et al. (2012); Maloni and Brown (2006); Mariani (2007); Marsden and Smith (2005); Marsden et al. (1999); Stonehouse (2003); Vorley (2001)

Fostering Supply Chain Partnering Relationships Determination of partners' roles

Beulens et al. (2005); Burch and Goss (1999);Cechin and Bijman (2009); Hobbs and Young (2000); Matopoulos et al. (2007); Wever et al. (2009)

Identification of inventory management and control systems

Akkerman et al. (2010); Bakker et al. (2012); Karaesmen et al. (2011); Van Beek et al. (2003);Van der Vorst et al. (2011); Yu et al. (2012)

Selection of packaging conditions and techniques

Appendini and Hotchkiss (2002); Hertog et al.(1999); Restuccia et al. (2010); Sothornvit and Kiatchanapaibul (2009); Van Beek et al.(2003); Vitner et al. (2006); Zhang et al . 2006

Development of waste management policies

Ajila et al. (2012); Bernstad and Jansen (2012);Briassoulis et al. (2012); Di Blasi et al. (1997);EA-UK (2001); El-Haggar (2007); Hall and Howe (2012); Iakovou et al. (2010); Kosseva (2011);Nagendran (2011); Polprasert (2007); Schaub and Leonard (1996); Thanarak (2012);US Department of Agriculture (2012);Van Donselaar et al. (2006)

Assessment of system's sustainability

Akkerman et al. (2010); Hellweg et al. (2005);Mintcheva (2005); Neto et al. (2008); Neto et al. (2009); Saunders et al. (2006); Sim et al. (2007); Van der Vorst et al. (2009);Zhu (1996)

Development of efficient procurement channels Boudahri et al. (2011)

Supporting Food Safety via Transparency and Traceability

Akkerman et al. (2010); Beulens et al. (2005);Hoogland et al. (2005); Sperber (2005); Stor et al. (2012); Trienekens et al. (2012); Van der Vorst et al. (2011);Wilson and Clarke (1998); Zhang and Li (2012)

Allocation of intermediate warehouses Demirel et al. (2010)

Adoption of innovative tracking and tracing technologies

Bollen et al. (2007); Piramuthu et al. (2013);Riden and Bollen (2007); Trienekens et al.(2012); Wang and Li (2012); Wognum et al. (2011); Zhang and Li (2012)

Allocation of processing/ production facilities -Bhatnagar and Sohal (2005); Ulaga et al. (2002) **Determination of integration level** Karantininis et al. (2010); Mintcheva (2005); Netland et al. (2008); Shepherd et al. (2006);Van der Vorst et al. (2009) **Establishment of collaborative schemes and contract typesDa** Silva (2005); Fischer and Hartman (2010);Higgins et al. (2004); Hovelaque et al. (2009);Ligon (2003); Zanoni and Zavanella (2007)

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Food Recovery

City Harvest has been redistributing food waste from restaurants to hungry and food-insecure New Yorkers for over three decades and is the world's first food rescue organization. To date they have recovered over 300 million pounds of food (42 million.

Feeding Empty Bellies is a group of Sarah Lawrence College students who rescue food from Bronxville food establishments and donate it to Part of the Solution (POTS), a Bronx soup kitchen feeding 350 people a day.

Feeding America is dedicated to feeding America's hungry through a nationwide network of food banks and actively works to engage Americans to help end hunger. Feeding America's network feeds over 37 millions American every year.

Faith Feeds of Kentucky is an organization that seeks to alleviate hunger in Lexington, KY. They teach people how to glean crops, grow food, preserve harvests, and donate the produce and preserved food to agencies and institutions involved in feeding the hungry.

Campus Kitchens partners with 31 high schools, colleges, and universities across the country to engage students in food recovery and redistribution.

The 3000 Club is an Arizona-based food rescue program that partners with local food banks to distribute rejected and excess produce to food-insecure individuals and families.

Second Helpings rescues 1.9 million pounds of food each year, transforming would-be waste into nutritious meals that it redistributes to food pantries to feed thousands of individuals in Central Indiana. Those meals are prepared by students in the organization's Culinary Job Training Program, from which over 480 disadvantaged adults have graduated.

Second Helping was created to collect perishables and non-perishables from departing vacationers in Holden Beach, NC. They collect from June until Labor Day.

Foodshare is a member of Feeding America's food bank network and is working to fight food waste and enable self-sufficiency for the hungry and food-insecure in Hartford, Connecticut

Proposed research objective

Module1: Consumer waste quantification and categorization.

Module2: Modelling and simulation of the process and optimizing the food consumed by customer.(edible food to food bank, semi edible to animal feed and waste to methane as fuel for company use)

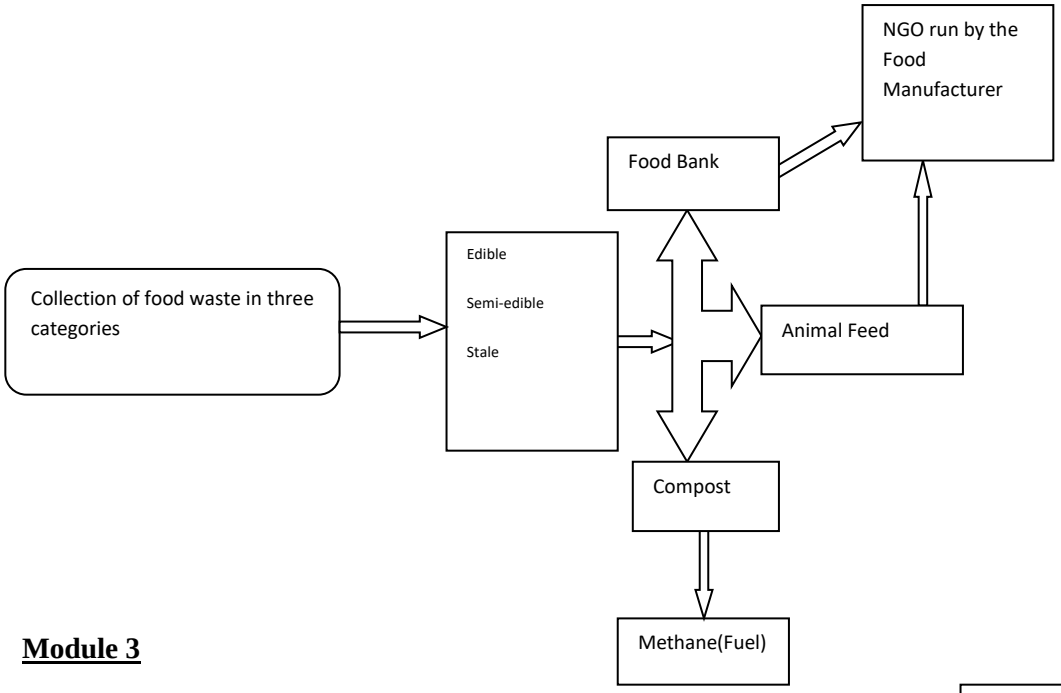
Module 3: Integrate this network of customers and food companies and test the framework in a particular town. Develop an expert system for food waste real time management.

Module 1:

Consumer waste quantification will be done by creating separate bin for food waste in a small locality. Container will have three sections 1. *Edible waste(used for animal feed) 2. Stale waste (compost). At the end of the day first weighing and followed by collection of food waste. This process will provide the collective weight of food waste in a particular locality.* From this average weight of waste generated by each household calculated. Recycle workers will categorize the food waste. Daily a record of food waste generated in each area will be recorded. From this using collaborative forecasting method(Can Eksoz et. al. 2014) an estimate of food waste will be made ,which required for further planning. Each company will create food bank for needy and animals. This will boost the brand value. At the community centres or at parks , people will be encouraged to donate edible food waste , which will be collected by volunteers or retired senior citizen. Orphanage and old age homes will also be linked to this program.

Module 2:

Then a transportation ,storage and disposal network for this waste is designed. Numerous supply chain models for recycle of products have been proposed . Most optimum and efficient model will be implemented for food supply chain. Dwi Agustina et al. 2014 proposed the vehicle scheduling and routing framework for food supply chain . Sahar et al. 2014 used the GA based optimizers to propose a distribution system which minimized the CO_2 emissions. An integrated framework will be developed for planning, distribution and control of this waste management supply chain. Using MATLAB this model will be simulated and GUI will be developed further use by food manufacturers.



Module 3

Gross annual profit
Total sales
Revenue
Customer good will
Market share (in %)
Loss of customers
Brand image
Dividend paid to shareholders (in%)
Return on assets
Price of the product
Customer satisfaction
Lost sales
Time-based competitiveness

Scrap and rework cost
Operating cost per unit
Overall plant investment
Inventory investment
Warranty cost
Other cost of poor quality
Purchase cost
Maintenance cost
Transportation cost
Vessel cost
Design and establishment cost
Personnel cost
Operating cost
Scrap and rework cost
Patent and technology cost

Manufacturing cycle time (in hours)

Labour productivity (in %)
Number of inventory or stock rotations (in Nos.)
Production capacity (in number of units per year)
Total floor space (in m2)
Overall Equipment Efficiency (OEE) (in %)
Equipment utilisation (in %)
Overall productivity
Labour utilisation (in %)
Utilisation of capacity
Production rate
Production volume
Number of stages in the overall material flow (in Nos.)
Material productivity (in %)
Process productivity (in %)
Maintenance time (in hours per week)
Value added time (in hours)
Non value added time (in days)
Reliability of system (%)
Percentage of unscheduled downtime or equipment breakdown time (in %)
Takt time (in hours)

Planning of Logistics Operations
Fleet management,
vehicle routing planning
Scheduling
Fostering Supply Chain Partnering
Relationships Determination of partners' roles
Transparency
Traceability
Determination of key-performance indicators(KPIs)
Development of data handling processes and mechanisms
Selection and development of measuring methods
Establishment of stakeholders' collaboration structures
Design of transportation networks
Design of the retailers' networks
Selection of markets

Intelligent database

Expert System

Component

Knowledge base

Inference engine

Working memory

Method

Knowledge acquisition

Rule based

Fuzzy expert system

Forward chaining

Backward chaining

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