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Identifying key trends in food loss and waste in the global food system using the material flow analysis approach

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, 30.05.2014

Affidavit

I, **TANYA MAYO-BRUINSMA**, hereby declare

1. that I am the sole author of the present Master's Thesis, "IDENTIFYING KEY TRENDS IN FOOD LOSS AND WASTE IN THE GLOBAL FOOD SYSTEM USING THE MATERIAL FLOW ANALYSIS APPROACH", 157 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Abstract

Food losses and wastes in the global food supply chain is not a new problem, but the gap of current, reliable information remains. The following paper aims to narrow this gap with a three part approach. First, this paper presents the global food system from a mass flow perspective using the most current statistics and methodology available. Highlighting the magnitude of losses and wastes at each stage of the food supply chain, from farm to feces. Next, the “average global diet” represents the ten most abundantly consumed foods on the planet in a mass flow perspective, in order to compare the losses and wastes between the two. Lastly, relevant trends in the global food mass flow and global diet mass flow are compared and discussed in order to assess the current state of global food loss and waste. Determining where the largest proporations of food loss and waste occure throughout the food chain allows for evidenced based decision making to address some of the unsustainable aspects of the current global food supply chain.

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List of Abbreviations/Acronyms

FAO	Food and Agricultural Organization of the United Nations
FBS	Food balance sheets
FLW	Food loss and waste
FSC	Food supply chain
LIC	Low income countries
MFA	Material flow analysis
MHIC	Medium and high income countries

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1. Introduction

"The global production of food occupies nearly one quarter of all the habitable land on earth. It is responsible for more than 70% of fresh water consumption, for 80% of deforestation, is the largest single cause of species and biodiversity loss and produces more than 30% of global greenhouse gas emissions. It continues to represent the single greatest cause of land-use change" (Moomaw et al, 2010).

And it is responsible for 100% of the food we eat.

"Unlike most other commodity flows, food is biological material subject to degredation" (Parfitt et al, 2010).

Chapter 1.1: Introduction

The first World Food Conference was held in 1974, at which time the reduction in postharvest food losses was put forth as a key part of solving the issue of world hunger; a reduction of 50% of food losses by 1985 was proposed (Parfitt et al, 2010). While poor intervention program adoption and a lack of reporting on progress towards the goal led in 2008 to the same target of 50% reduction in food losses and waste to be called by 2025 (Parfitt et al, 2010). Food losses and wastes in the global food supply chain is not a new problem.

Evidence based policy making requires accessible and reliable resources depicting the status and trends of food loss and waste in the world. There is currently an information gap regarding food loss and waste on the global scale, and the following paper aims to narrow this gap with a three part approach. First a global food mass flow using the most current statistics and methodology available. Next, a food mass flow for the 'global diet', or most abundantly consumed foods on the global scale. Lastly, relevant trends in the global food mass flow and global diet mass flow will be compared and discussed in order to assess the current state of global food loss and waste.

PART I presents the global food system from a mass flow perspective. Statistical data from the Food and Agricultural Organization of the United Nations (FAO), was assemble it into a material flow analysis (MFA) diagram illustrating the food supply chain from farm to feces. The MFA approach highlights the magnitude of losses and wastes at each stage of the global food supply chain. This gives a baseline of the global food mass flow.

Hypothesis: Current research regarding food loss and waste suggests that there are significant differences between each stage of the food supply chain for low income countries (LIC) when compared to medium and high income countries (MHIC). Such that, more food losses and waste (FLW) occur at the agricultural end of the food supply chain (FSC) for LIC and at the consumption end for MHIC. While the global food supply MFA is an aggregation of the whole food system, the results will likely show similar magnitudes of FLW for each stage within the FSC. The current focus of FLW campaigns targets the consumption end of the FSC, results from the MFA showing a similar magnitude of FLW at each stage of the FSC would be in contrast to this and therefore indicate a need for policy, action and funding to be placed at earlier stages. In other words, from a mass flow perspective, the current focus on FLW at the consumption stage may be in fact much too late, and the focus should be redirected to include all the stages of the global food supply chain.

Where and how FLW occurs is very much commodity and location dependant. While PART I provides a complete mass flow overview, identifying which foods make up the "average global diet", and how their mass flows compare to the global total is the focus of **PART II**. The "global diet" or "average global diet" represents the ten most abundantly consumed foods on the planet. In a time where globalization, trade liberalization and industrial corporate farming are changing food consumption patterns around the world, it is critical to establish a current baseline for food consumption. What has not yet been included in the disucssion about FLW is how the mass flow of the average global diet relates to that of the total food mass flow. The global diet MFA will show where the most significant food loss and waste happens for the ten most important staple foods that we eat today.

PART III will be a quantification and analysis of the two mass flows; a discussion along with relevant conclusions. The aim of this project as a whole is to identify areas in need of policy and technology measures to better address food losses and waste. From a moral perspective, the need to address food loss and waste issues is unquestionable, and therefore not the focal point of this project. Rather, the goal is to provide clear, reliable results that can be compared to past and future analysis of this type to evaluate global trends in food loss and waste. Moreover, taking the whole analysis one step further, to identify and measure how we associate with our most important foods. Are these ten most consumed staple foods treated differently in terms of loss and waste? Or do they follow the same trends as all the other foods. If the global diet shows different trends in terms of loss

and waste, why is that? Are these foods valued differently? What are the influences of changing diets on the way food is treated?

Chapter 1.2: State of the art

The FAO has been the global authority related to food and agricultural matters since its' founding as part of the United Nations in 1945 (Parfitt et al, 2010). FAO's involvement in food loss reduction dates back to the 1960's, when it launched the 'Freedom from Hunger' campaign and has continued to develop ever since (FAO, 2014). Today, one of the key services provided by FAO is the compilation, processing and distribution of global food and agricultural statistics provided by FAOSTAT and available online (FAO, 2014). Food balance sheets (FBS) provide statistical data by country or region and commodity or commodity group, regarding annual production, import, export and utilization. "A food balance sheet presents a comprehensive picture of the pattern of a country's food supply during a specified reference period" (FAO, 2014) There is a consensus in the literature, "[a]lthough food consumption data derived from such food balance sheets are subject to many uncertainties and limitations, they represent the best available source of data for international comparison" (GEMS/Food, 2003).

There is extensive literature available on the topics of food systems, agricultural production, food chain efficiency, etc., still there remain major gaps in the data available on food waste and loss. Of the information that is available, the majority of studies are very localized, micro level, though increasingly a global focus is being called for. In 2010, the FAO commissioned two studies by the Swedish Institute for Food and Biotechnology (SIK) (hereinafter as SIK studies) to summarise the extent, causes and prevention of global food losses and food waste in both low income and medium and high income countries (Gustavsson et al, 2013). The SIK studies were summarised in an FAO report "Global Food Losses and Food Waste- extent, causes and prevention", hereinafter as FAO Report (Gustavsson et, 2011). The SIK studies combined both extensive literature reviews as well as FAO statistical analysis; quantifying food loss and waste percentages on regional and commodity specific levels. The results of the SIK studies, the FAO Report, is based on 2007 FAO statistics and remains the most reliable, comprehensive source of global food loss and waste information. This FAO report is considered the baseline, from which the issues of food loss and waste can be addressed. As such, it is the methodology and waste percentage estimates from the SIK studies that will be used to calculate mass flow data for parts one and two of this project, using the statistics provided by food balance sheets for 2009.

In Baccini and Brunner's "Metabolism of the Anthroposphere", the stocks and flows of material through human settlements in time and space is described using the MFA method. Of particular importance for this project is thecase study provided the book's fourth chapter, to nourish, where all of the inputs and outputs related to human nourishment is analysed. An overall MFA for the production and consumption of food is provided. While Baccini and Brunner are analysing nourishment related to nutrient content, the principals and structure used are applied to this project for the total food mass flow analysis and the average global diet mass flow analysis (Baccini and Brunner, 2012).

PART I: Global Food Mass Flow

Chapter 2

Chapter 2.1: Definitions

Edible food represents the proportion of a commodity that is intended for human consumption, this is a cultural and commodity specific definition. For example, oranges grow on trees, but it is only the fruit which is considered food, moreover it is only the fruit itself and not the peel which is considered edible food. Another example is that of meat consumption in different cultures, there are many parts and types of animals which are considered edible food in one culture but not in another. Futher definitions and terms of used for allocation and conversion factors are provided in chapter 2.2.4.

Food losses are defined as a decrease in edible food mass that is available for human consumption, "in addition to quantitative losses, food products can also face a deterioration of quality, leading to a loss of economic and nutritional value" (Njie, 2012). Essentially, food losses are involuntary.

Food waste refers to a conscious decision to discard edible food, "food waste is most often associated with the behaviours of retailers, the food service sector and consumers" (Njie, 2012). Both food loss and waste take place at each state of the food supply chain (Njie, 2012).

While both the concepts of food loss and food waste refer to food that could have been used for human consumption but was discarded from the food supply chain, there remains a distinguishable difference between the two based on the underlying intent. For the purposes of this paper, food loss and food waste (FLW) will be referred to together unless otherwise specified. Further information regarding the activities considered when deriving food loss and waste percentages is outlined in Chapter 2.2.2: food supply chains.

Chapter 2.2: Methodology

The overarching methodology of this project is material flow analysis (MFA). While the name MFA dates back only to the 1990's, using the principal of conservation of mass to balance the stocks and flows of a system has long been a practice in the scientific community (Brunner and Rechberger, 2004). MFA is based on the movement of material through a system, where a system is a set of processes, flows and stocks defined in time and space (Brunner and Rechberger, 2004). Processes are the steps within a system where material is transported, transformed or stored. Stocks are the reservoirs of the material within the system, and flows are the links between processes (Brunner and Rechberger, 2004). For this project, the system is the global food supply chain.

In order to determine the components of the system and establish the baseline for current global food mass flow, the methodology developed by the SIK studies was used, which was published in an SIK report "The methodology of the FAO study: 'Global Food Losses and Food Waste- extent, causes and prevention'- FAO, 2011", (Gustavsson et al, 2013). In chapters 3.1-3.8, a detailed illustration is provided for how the mass flow was calculated for each commodity group using the example of the regional analysis for Africa. Regional analyses from all other regions can be found in appendices A-F.

Chapter 2.2.1: Data Collection

For the purposes of analysis, world was divided into seven geographic and economic regions; three high and medium income regions, and four low income regions (tables 1 & 2). These distinctions allow for a more accurate application of estimated FLW percentages for each commodity group, at each stage of the food supply chain. For example, the amount of food that is wasted at the consumption stage for cereals in Europe is significantly different than that of cereals in Africa, and therefore an accurate representation of FLW at each stage of the FSC requires these divisions.

Table 1: Regional divisions (FAOSTAT, 2013) - medium and high income countries (MHIC).

EUROPE		NORTH AMERICA & OCEANIA	EASTERN ASIA
Albania	Netherlands	Bermuda	China
Andorra	Northern Europe	Canada	Democratic People's Republic of Korea
Austria	Norway	Greenland	Japan
Belarus	Poland	Saint Pierre and Miquelon	Mongolia
Belgium	Portugal	United States of America	Republic of Korea
Belgium-Luxembourg	Republic of Moldova	American Samoa	
Bosnia and Herzegovina	Romania	Australia	
Bulgaria	Russian Federation	Australia & New Zealand	
Channel Islands	San Marino	Cook Islands	
Croatia	Serbia	Fiji	
Czech Republic	Serbia and Montenegro	French Polynesia	
Czechoslovakia	Slovakia	Guam	
Denmark	Slovenia	Kiribati	
Eastern Europe	Southern Europe	Marshall Islands	
Estonia	Spain	Melanesia	
Faroe Islands	Sweden	Micronesia	
Finland	Switzerland	Micronesia (Federated States of)	
France	The former Yugoslav Republic of Macedonia	Nauru	
Germany	Ukraine	New Caledonia	
Gibraltar	United Kingdom	New Zealand	
Greece	USSR	Niue	
Guernsey	Western Europe	Norfolk Island	
Holy See	Yugoslav SFR	Northern Mariana Islands	
Hungary		Pacific Islands Trust Territory	
Iceland		Palau	
Ireland		Papua New Guinea	
Isle of Man		Pitcairn Islands	
Italy		Polynesia	
Latvia		Samoa	
Liechtenstein		Solomon Islands	
Lithuania		Tokelau	
Luxembourg		Tonga	
Malta		Tuvalu	
Monaco		Vanuatu	
Montenegro		Wallis and Futuna Islands	

Table 2 Regional divisions (FAOSTAT, 2013) - low income countries (LIC)

AFRICA		SOUTHERN & SOUTHEAST ASIA	CENTRAL & WESTERN ASIA	LATIN AMERICA
Algeria	Mauritania	Afghanistan	Kazakhstan	Argentina
Angola	Mauritius	Bangladesh	Kyrgyzstan	Bolivia (Plurinational State of)
Benin	Mayotte	Bhutan	Tajikistan	Brazil
Botswana	Middle Africa	India	Turkmenistan	Chile
Burkina Faso	Morocco	Iran (Islamic Republic of)	Uzbekistan	Colombia
Burundi	Mozambique	Maldives	Armenia	Ecuador
Cabo Verde	Namibia	Nepal	Azerbaijan	Falkland Islands (Malvinas)
Cameroon	Niger	Pakistan	Bahrain	French Guiana
Central African Republic	Nigeria	Sri Lanka	Cyprus	Guyana
Chad	Northern Africa	Brunei Darussalam	Gaza Strip (Palestine)	Paraguay
Comoros	Réunion	Cambodia	Georgia	Peru
Congo	Rwanda	Indonesia	Iraq	Suriname
Côte d'Ivoire	Saint Helena, Ascension and Tristan da Cunha	Lao People's Democratic Republic	Israel	Uruguay
Democratic Republic of the Congo	Sao Tome and Principe	Malaysia	Jordan	Venezuela (Bolivarian Republic of)
Djibouti	Senegal	Myanmar	Kuwait	Belize
Eastern Africa	Seychelles	Philippines	Lebanon	Costa Rica
Egypt	Sierra Leone	Singapore	Occupied Palestinian Territory	El Salvador
Equatorial Guinea	Somalia	Thailand	Oman	Guatemala
Eritrea	South Africa	Timor-Leste	Qatar	Honduras
Ethiopia	South Sudan	Viet Nam	Saudi Arabia	Mexico
Ethiopia PDR	Southern Africa		Syrian Arab Republic	Nicaragua
Gabon	Sudan		Turkey	Panama
Gambia	Sudan (former)		United Arab Emirates	
Ghana	Swaziland		West Bank	
Guinea	Togo		Yemen	
Guinea-Bissau	Tunisia			
Kenya	Uganda			
Lesotho	United Republic of Tanzania			
Liberia	Western Africa			
Libya	Western Sahara			
Madagascar	Zambia			
Malawi	Zimbabwe			
Mali				

The world's total agricultural production was divided into eight aggregated commodity groups based on the data provided by FBS for 2009 (table 3).

Table 3: Commodity groups as divided by FAOSTAT FBS and SIK studies (FAOSTAT 2014, Gustavsson et al, 2013) - Commodities included within each group.

COMMODITY GROUP	COMMODITIES INCLUDED
Cereals	Wheat, rice (milled), barley, maize, rye, oats, millet, sorghum, other cereals
Roots & Tubers	Potatoes, sweet potatoes, cassava, yams, other roots
Oilseeds & Pulses (including nuts)	Soybeans, groundnuts (shelled), sunflower seeds, rape and mustard seed, cottonseed, coconuts (incl. copra), sesame seed, palm kernels, olives, other oil crops
Fruit & Vegetables (including bananas)	Oranges and mandarins, lemons and limes, grapefruit, other citrus, bananas, plantains, apples (excl. cider), pineapples, dates, grapes (excl. wine), other fruit. Tomatoes, onions, other vegetables
Meat	Bovine meat, mutton/goat meat, pig meat, poultry meat, other meat
Fish & Seafood	Freshwater fish, demurral fish, pelagic fish, other marine fish, crustaceans, other mollusk, cephalopods, other aquatic products, aquatic mammal meat, other aquatic animals, aquatic plants
Milk	The amount of milk available for human consumption as milk (but not as butter, cheese or any other milk product provided for separately in the FBS)
Eggs	Eggs

Chapter 2.2.2: Food Supply Chains

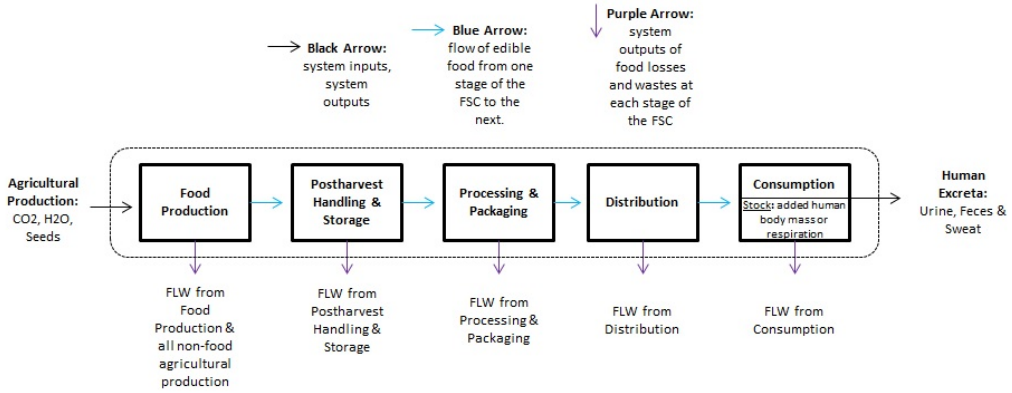

Figure 1: Simplified food supply chain.

Figure 1 represents a simplified global FSC, which is the basis for the this project. This diagram presents an outline for what the FSC will look like, and it is figures 2&3 which present accurate representation thereof. The dotted line represents the global food system boundary, which will be for the year 2009 and represent the aggregated food supply chains for all seven world regions. The five rectangles represent the five processes considered in this FSC and are further described in chapter 2.2.3 below. The arrows present flows of food from the initial agricultural production and then from one processes to another, as well as flows of food out of the system as FLW, urine, feces and sweat. Finally the stock present in the consumption stage will represent the remaining mass which enters the consumption process but is not acounted for in the output at FLW or human excreta.

FAOSTAT FBS data is provided in more detail than the simplified food chains that is presented in figure 1. Chapter 3 and appendices A-F show the detailed process by which the raw data collected by FBS for each region are transformed into the processes represented in the global FSC MFA. Below are the interpretations of the supply and utilization elements, as well as available food in the food supply chain as it is provided in regional food balance sheets (Gustavsson et al, 2013):

Table 4: Interpretation of FBS elements (Gustavsson et al, 2013).

SUPPLY ELEMENTS:	**E = A+B+C-D**
Production (A)	Reported in primary product of primary product equivalents, carcass weight for meat, live weight equivalent for fish and total production leaving manufacture for processed commodities.
Import Quantity (B)	All movement of a particular commodity into the region.

Stock Variation (C)	Changes in government stocks of a particular commodity.
Export Quantity (D)	All movement of a particular commodity out of the region. Where D is indicated as a negative number.
Domestic Supply (E)	Sum of A, B, C, and D
UTILISATION ELEMENTS	
Feed (F)	The amount of a particular commodity used to feed animals.
Seed (G)	The amount of a particular commodity used for reproductive purposes, for example, seeds for planting, eggs for hatching, fish for bait, etc.
Processing (H)	The amount of a particular commodity available for human consumption as a part of processed food products, with different types of commodities.
Other Utilities (I)	The amount of a particular product lost during handling, storage and transport between production and distribution as well as amounts of the commodity used for non-food purposes, for example wheat for bio-energy.
AVAILABLE FOOD:	**J=E-(F+G+H+I)**
Food (J)	All forms of a particular commodity available for human consumption, for example, wheat flour, vegetable oils, etc. (not included in H).

Chapter 2.2.3: Food loss & waste percentages

While providing the best available source for international comparison, FBS however, do not provide an accurate representation of FLW in terms of edible food at each stage of the food supply chain. For example, FBS have a tendency to overestimate the actual amount of food consumed at the consumption stage because of difficulties accounting for household or individual level waste (GEMS/Food, 2003). “Based on detailed national surveys, average food consumption estimates based on FBS data are about 15% higher than actual average food consumption in the worst cases, e.g. certain fruits and other highly perishable products” (GEMS/Food, 2003).

In order to best correct for the limitations of FBS data, the SIK studies included an extensive literature review regarding available estimates for FLW by commodity group and region. For each stage of the food supply chain, the following activities were considered in order to determine the FLW for animal and vegetal commodities respectively (tables 5 & 6) (Gustavsson et al, 2013):

For animal commodities:

Table 5: Activities considered for FLW at each stage of the food supply chain, animal commodities (Gustavsson et al, 2013).

Food production	For meat losses refer to animal death during breeding. For fish losses refer to discards during fishing. For milk losses refer to illness of dairy cows. Beyond the scope of this project for example, are the FLW due to over-production, where for example, farmers will produce more food than they harvest because of sole-supplier agreements which restrict their right to sell to any other supplier, particularly relevant in the milk industry.
Postharvest handling and storage	For meat losses refer to animal death during transport to the slaughterhouse and rejection upon arrival at the slaughterhouse. For fish losses refer to spoilage and degradation during icing, packing, transport and landing. For milk losses refer to spillage and degradation between farm and distribution.
Processing and packaging	For meat losses refer to trimming spillage during slaughtering and industrial processing (for example, sausage making). For fish losses refer to industrial processing (for example smoking, canning). For milk losses refer to processing into dairy products (for example cheese, yogurt).
Distribution	For all animal commodities this includes losses and wastes in the market system, for example wholesale, retail, wet markets and supermarkets.
Consumption	Include losses and wastes at the household level.

For vegetal commodities:

Table 6: Activities considered for FLW at each stage of the food supply chain, vegetal commodities (Gustavsson et al, 2013)

Food production	Losses from mechanical damage/spilling during harvest, and waste due to crop sorting postharvest, etc. Beyond the scope of this project for example, are the losses due to natural disasters such as sever drough or flooding. Also not included here are the FLW due to over-production, where for example, farmers will produce more food than they harvest either for aesthetic reasons or because of sole-supplier agreements which restrict their right to sell to any other supplier.
Postharvest handling and storage	Losses from spillage or degradation during handling, storage and transportation between the farm and distribution.

Processing and packaging	Losses from spillage and degradation during industrial or domestic processing (for example, making juice, canning or baking). Losses and waste may occur when crops are sorted out if not suitable to process or during washing, peeling, slicing and boiling or during process interruptions or accidental spillage. Beyond the scope of this project are the FLW occuring from residues during processing, for example the remaining fruit pulp during the juicing process.
Distribution	For all vegetal commodities this includes losses and wastes in the market system, for example wholesale, retail, wet markets and supermarkets.
Consumption	Include losses and wastes at the household level.

Chapter 2.2.4: Data Analysis

FBS data is provided in primary commodity or primary commodity equivalents, "[i]n some cases, values are given for semi-processed and processed commodities, particularly when the commodities are always processed before consumption" (GEMS/Food, 2003). Based on the FBS numbers, allocation factors and conversion factors were employed on a region and commodity specific basis, in order to determine the available and edible fractions of food.

Allocation factors:

Determines which proportion of the total food production is in fact available for human consumption rather than being used for other purposes. Estimating which proportion of loss and waste at the food production stage and post-harvest handling resulted in a decrease in food for human consumption. For example, if total production of cereals is equal to 100% and 65% of that is used for animal feed and biofuels, only 35% is meant for human consumption. That means that 35% of the losses at the food production stage result in losses of food available for human consumption, (not counting the losses in animal feed towards a decrease in animal commodities available for consumption). Certain commodity groups such as fruit & vegetables for example, were given allocation factors for the percentage used fresh, in order to determine which percentage of the total production moved to the processing stage of the food supply chain. One allocation factor was used per world region and commodity group (Gustavsson et al, 2013). The exact description of the

allocation factor used is provided for each regional analysis and commodity group respectively in chapter 3 and appendices A-F.

Conversion factors:

Determines from the food available for human consumption, what the mass is in edible equivalents. The number of conversion factors used depends on the commodity group, when multiple conversion factors are available, a mean value is employed. For example, in the case of cereals, if the total food available for human consumption of cereals is equal to 1, after milling only 0.78 of the original mass remains as edible food. For example, in the case of fruit & vegetables, the mean conversion factor between industrial peeling and hand peeling is 0.77 (Gustavsson et al, 2013).

Chapter 3: Regional Analysis Africa

Chapters 3.1-3.7 provide a detailed account of how the FBS data were converted into the five stage food supply chain shown in figure 1. Each sub-chapter represents one of the commodity groups presented in table 3 , begining with a summary table of the data from FBS from 2009 in the categoried provided by FBS (as presented in table 4), for the country group Africa (FAOSTAT, 2014). The next table shows the waste percentages considered for each stage of the FSC, and the last table shows how the FBS data is converted into the mass of FLW for each stage of the FSC. (Following the same basic concept, Chapter 3.8 includes more tables due to the complexity in analysis for the commodity group meat.)

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group Sub-Saharan Africa (Gustavsson et al, 2013).

Chapter 3.1: Cereal

Mean Conversion Factor= 0.78, (78% of total production is edible food).

Wheat + rye= 0.78

Maize+ Miller + sorghum= 0.79

Oats + barley + other= 0.78

Allocation Factors=0.75**,** (for loss during food production and postharvest handling and storage), 75% of total cereal production is allocated for food consumption, the remaining 25% is allocated for other uses.

Table 7: Cereal mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009 for Africa (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
146,217	55,987	1,163	-4,065	199,303
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
30,802	3,448	4,282	4,574	141,037
Milled (K) *	Feed (L) *			
Jx0.78=	J-K=			

110,009	31,028

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in Africa.

$$\frac{4{,}574(I)}{146{,}217(A) + 55987(B) + 1{,}163(C)} = 2\%$$

Table 8: Waste percentages for cereals in Africa, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	2%	3.5%(m), 3.5%(p)	2%	1%

Table 9: Calculation for losses and wastes (1000 tonnes) for cereal in Africa - taking into account waste percentages, conversion and allocation factors as above.

Food production	$\frac{0.06}{1-0.06} \times 146{,}217(A) = 9{,}333$ Allocation factor: $9{,}333 \times 0.75 = \mathbf{7{,}000}$
Postharvest handling & storage	$0.02 \times 146{,}217(A) = 2{,}924$ Allocation factor: $2{,}924 \times 0.75 = \mathbf{2{,}193}$
Processing & packaging	Milling: $0.035 \times 141{,}037(J) = 4{,}936$ Industrial Baking: $(110{,}009(K) + 141{,}037(J) - 4{,}936) \times 0.035 = 8{,}614$ Total Processing and Packaging: $4{,}936 + 8{,}614 = \mathbf{13{,}550}$
Distribution	$(110{,}009(K) + 4{,}282(H) - 4{,}936 - 8{,}614) \times 0.02 = \mathbf{2{,}015}$
Consumption	$(110{,}009(K) + 4{,}282(H) - 4{,}936 - 8{,}614 - 2{,}015) \times 0.01 = \mathbf{987}$

Food production & Postharvest handling & storage: In this stage of the FSC the total production volume (A) is used because FLW being considered at each of these stages occurs before the plant as a primary product or a primary product equivolent. The allocation factor of 75% is then used, because only 75% of the total production is being used for food, the remaining 25% is being used for other purposes such as biofuel production for example.

Therefore of the total loss and waste calculated for each of these stages, 25% of this represents a loss to another industry.

Processing & Packaging: In this stage of the FSC the FLW for the milling and industrial baking processes are considered. For the milling process, the food volume (J) is used to determine the FLW, where (J) represents the mass of food that actually undergoes the milling process (ie. it has been adjusted to consider exports, imports, feed, seed, etc. see table 4 for more details). For the industrial baking process, both the volumes milled (K) and food (J) are considered, minus the FLW that was calculated for the milling process. The sum of the two FLW volumes is the toal FLW for this stage of the FSC.

Distribution: In this stage fo the FSC the FLW is calculated using the milled volume (K) with the food manufarture volume (H), and subtracting the FLW calculated at the packaging & processing stage of the FSC.

Consumption: : In this stage fo the FSC the FLW is calculated using the milled volume (K) with the food manufarture volume (H), and subtracting the FLW calculated at the packaging & processing and the distribution stages of the FSC.

Note: FLW refers only to the portion of losses and wastes that occure to the mass of the commodity designated as food. It is for this reason that the allocation factor is applied. While in the case of cereals in Africa, the allocation factor is 75%, that means that only 75% of the total mass of losses and wastes are considered as food losses and wastes.

All other commodity groups show similar conversions between the FBS data and the FSC, calculated using their respective waste percentages as shown in the following chapters.

Mass flow summary for cereal: (1000 tonnes)

A total of 25,745 kilotonnes of cereal are lost or waste in the African food supply chain each year, representing 23% of the total mass at the food production stage. The largest FLW occurs at the packaging and processing stage of the FSC, accounting for slightly more than 50% of all cereal FLW and 12% of the total mass of cereal produced for food. *When considering the entire agricultural production volume (not only the food production), a total of 62,299 kilotonnes is lost from the supply chain, representing 43% of the total initial mass and increasing the FLW at the food production stage to: 43,544 kilotonnes.

Total cereal production: (100%)	146,217

Total cereal for other uses: (25%)	-36,554*
Total cereal production for food: (75%)	109,663
FLW at the Agricultural Production stage of the FSC:	-7,000
Remaining food that moves to the next stage of the FSC:	102,663
FLW at the postharvest handling & storage stage of the FSC:	-2,193
Remaining food that moves to the next stage of the FSC:	100,470
FLW at the packaging & process stage of the FSC:	-13,550
Remaining food that moves to the next stage of the FSC:	86,920
FLW at the distribution stage of the FSC:	-2,015
Remaining food that moves to the next stage of the FSC:	84,905
FLW at the consumption stage of the FSC:	-987
Remaining food that is available for consumption:	83,918
Total FLW for all stages of the FSC:	-25,745

Chapter 3.2: Roots & Tubers

Assumed proportion utilized fresh = 50%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 10: Roots& tubers mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009 for Africa. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
200,056	1,078	1,877	-517	202,495
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
44,522	3,728	1	13,675	115,262
Fresh (K) *	Processed (L) *			
Jx0.5= 57,631	J-K= 57,631			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of roots & tubers (1000 tonnes) in Africa.

$$\frac{13{,}675(I)}{200{,}056(A) + 1{,}078(B) + 1{,}877(C)} = 7\%$$

Table 11: Waste percentages used for roots & tubers in Africa, f=fresh, p=processed (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
14%	7%	15%	5%(f), 2%(p)	2%(f), 11%(p)

Table 12: Calculation for losses and wastes (1000 tonnes) for roots & tubers in Africa - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.14}{1-0.14} \times 200{,}056(A) = 32{,}567$ Conversion factor: $32{,}567 \times 0.82 = \mathbf{26{,}705}$
Postharvest handling & storage	$0.07 \times 200{,}056(A) = 14{,}004$ Conversion factor: $14{,}004 \times 0.82 = \mathbf{11{,}483}$
Processing & packaging	$0.15 \times (1(H) + 57{,}631(L)) = 8{,}645$ Conversion factor: $8{,}645 \times 0.9 = \mathbf{7{,}780}$
Distribution	Processed: $0.02 \times (1(H) + 57{,}631(L) - 8{,}645) = 980$ Conversion factor: $980 \times 0.9 = 882$ Fresh: $0.05 \times 57{,}631\ (K) = 2{,}882$ Conversion factor: $2{,}882 \times 0.74 = 2{,}132$ Total distribution: $882 + 2{,}132 = \mathbf{3{,}014}$
Consumption	Processed: $0.11 \times (1(H) + 57{,}631(L) - 8{,}645 - 980) = 5{,}281$ Conversion factor: $5{,}281 \times 0.9 = 4{,}753$ Fresh: $0.02 \times (57{,}631\ (K) - 2{,}882) = 1{,}095$ Conversion factor: $1{,}095 \times 0.74 = 810$ Total consumption: $4{,}753 + 810 = \mathbf{5563}$

Note: FLW refers only to the portion of losses and wastes that occure to the mass of the commodity designated as food. It is for this reason that the conversion factor is applied. While in the case of roots & tubers in Africa, the average conversion factor is 82%, that

means that only 82% of the total mass of losses and wastes are considered as food losses and wastes. Both specific conversion factors 90% and 74% are applied where possible. The remaining 18% (10%, 26%) represent the losses for parts of roots & tubers that are considered inedible and are therefore not considered further.

Mass flow summary for roots & tubers: (1000 tonnes)

A total of 54,545 kilotonnes of roots & tubers are lost or waste in the African food supply chain each year, representing 33% of the total mass produced for food at the food production stage. The largest FLW occurs at the food production stage of the FSC, accounting for 49% of all roots & tubers FLW and 16% of the total mass of roots & tubers produced for food. *When considering the entire agricultural production volume (not only food production), a total of 90,555 kilotonnes is lost from the supply chain, representing 45% of the total initial mass and increasing the FLW at the food production stage to: 62,715 kilotonnes.

Total roots & tubers production: (100%)	200,056
Proportion of roots & tubers removed by peeling: (18%)	-36,010*
Total roots & tubers production for food: (82%)	164,046
FLW at the Agricultural Production stage of the FSC:	-26,705
Remaining food that moves to the next stage of the FSC:	137,341
FLW at the postharvest handling & storage stage of the FSC:	-11,483
Remaining food that moves to the next stage of the FSC:	125,858
FLW at the packaging & process stage of the FSC:	-7,780
Remaining food that moves to the next stage of the FSC:	118,078
FLW at the distribution stage of the FSC:	-3,014
Remaining food that moves to the next stage of the FSC:	115,064
FLW at the consumption stage of the FSC:	-5,563
Remaining food that is available for consumption:	109,501
Total FLW for all stages of the FSC:	-54,545

Chapter 3.3: Oilcrops & Pulses

Allocation Factor=0.63 (for loss during agricultural production & postharvest handling and storage)

Table 13: Oilcrops & pulses mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009

OILCROPS & PULSES
Supply Elements

Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
36,352	3,344	356	-2,943	37,109
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
1,341	1,560	14,703	1,172	16,446

Table 14: Vegetable oils mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)
7,108	6,625	-240	-1,376	12,117
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
0	0	9	3,712	8,374

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in Africa.

$$\frac{1{,}172(I)}{36{,}352(A) + 3{,}344(B) + 356(C)} = 3\%$$

Table 15: Waste percentages used for oilcrops & pulses in Africa (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
12%	3%	8%	2%	1%

Table 16: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in Africa - taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.12}{1-0.12} \times 36{,}352(A) = 4{,}957$ Allocation factor: $4{,}957 \times 0.63 = \mathbf{3{,}123}$
Postharvest	Oil crops & pulses: $0.03 \times 36{,}352(A) = 1{,}091$

handling & storage	Allocation factor: $1{,}091 \times 0.63 = \mathbf{687}$
Processing & packaging	Vegetable Oil: $(0.08 \times 9(R)) + ((\frac{0.08}{1-0.08}) \times 8{,}374(T)) = \mathbf{729}$
Distribution	Vegetable Oil: $0.02 \times (16{,}446(J) + 8{,}374(T) + 9(R) - 729) = \mathbf{482}$
Consumption	Vegetable Oil: $0.01 \times (16{,}446(J) + 8{,}374(T) + 9(R) - 729 - 482) = \mathbf{236}$

Note: FLW refers only to the portion of losses and wastes that occure to the mass of the commodity designated as food. It is for this reason that the allocation factor is applied. While in the case of oilseeds & pulses in Africa, the allocation factor is 63%, that means that only 63% of the total mass of losses and wastes are considered as food losses and wastes, the remaining 37% is not considered.

Mass flow summary for oilseeds & pulses: (1000 tonnes)

A total of 5,257 kilotonnes of oilseeds & pulses are lost or waste in the African food supply chain each year, representing 19% of the total mass produced for food at the food production stage. The largest FLW occurs at the food production stage of the FSC, accounting for 59% of all oilseeds & pulses FLW and 11% of the total mass of oilseeds & pulses produced for food. *When considering the entire agricultural production volume (not only food production), a total of 21,337 kilotonnes is lost from the supply chain, representing 49% of the total initial mass and increasing the FLW at the food production stage to: 19,203 kilotonnes.

Total oilseeds & pulses production: (100%)	43,460
Total oilseeds & pulses for other uses: (37%)	-16,080*
Total oilseeds & pulses production for food: (63%)	27,380
FLW at the Agricultural Production stage of the FSC:	-3,123
Remaining food that moves to the next stage of the FSC:	24,257
FLW at the postharvest handling & storage stage of the FSC:	-687
Remaining food that moves to the next stage of the FSC:	23,570

FLW at the packaging & process stage of the FSC:	-729
Remaining food that moves to the next stage of the FSC:	22,841
FLW at the distribution stage of the FSC:	-482
Remaining food that moves to the next stage of the FSC:	22,359
FLW at the consumption stage of the FSC:	-236
Remaining food that is available for consumption:	22,123
Total FLW for all stages of the FSC:	-5,257

Chapter 3.4: Fruit & Vegetables

Assumed proportion utilized fresh = 99%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 17: Fruit & vegetable mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
143,914	4,941	181	-8,181	140,855
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,636	0	6,440	138	118,388
Fresh (K)*	Processed (L)*			
Jx0.99 =117,204	=J-K =1,184			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in Africa.

$$\frac{138(I)}{143{,}914(A) + 4{,}941(B) + 181(C)} = 0.1\%$$

Table 18: Waste percentages used for fruit & vegetables in Africa, f=fresh, p=processed (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption

10%	0.1%	25%	17%(f), 10%(p)	5%(f), 1%(p)

Table 19: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in Africa – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.1}{1-0.1} \times 143{,}914(A) = 15{,}990$ Allocation factor: $15{,}990 \times 0.77 = \mathbf{12{,}312}$
Postharvest handling & storage	$0.001 \times 143{,}914(A) = 144$ Allocation factor: $144 \times 0.77 = \mathbf{111}$
Processing & packaging	$0.25 \times (6{,}440(H) + 1{,}184(L)) = 1{,}906$ Conversion factor: $1{,}906 \times 0.75 = \mathbf{1{,}430}$
Distribution	Processed: $0.1 \times (26{,}440(H) + 1{,}184(L) - 1{,}906) = 2{,}572$ Conversion factor: $2{,}572 \times 0.75 = 1{,}929$ Fresh: $0.17 \times 117{,}204(K) = 19{,}925$ Conversion factor: $19{,}925 \times 0.8 = 15{,}940$ Total distribution: $1{,}929 + 15{,}940 = \mathbf{17{,}869}$
Consumption	Processed: $0.01 \times (26{,}440(H) + 1{,}184(L) - 1{,}906 - 2{,}572) = 231$ Conversion factor: $231 \times 0.75 = 173$ Fresh: $0.05 \times (117{,}204(K) - 19{,}925) = 4{,}864$ Conversion factor: $4{,}864 \times 0.8 = 3{,}891$ Total consumption: $173 + 3{,}891 = \mathbf{4{,}064}$

Note: FLW refers only to the portion of losses and wastes that occure to the mass of the commodity designated as food. It is for this reason that the conversion factor is applied. While in the case of fruit & vegetables in Africa, the average conversion factor is 77%, that means that only 77% of the total mass of losses and wastes are considered as food losses and wastes. Both specific conversion factors 80% and 75% are applied where possible. The remaining 23% (20%, 25%) represent the losses for parts of fruit & vegetable that are considered inedible and are therefore not considered further.

Mass flow summary for fruit & vegetables: (1000 tonnes)

A total of 35,786 kilotonnes of fruit & vegetables are lost or waste in the African food supply chain each year, representing 32% of the total mass produced for food at the food production stage. The largest FLW occurs at the distribution stage, followed by the food production stage of the FSC, their combined FLW acconts for 84% of all fruit & vegetables FLW and 27% of the total mass of fruit & vegetables produced for food. *When considering the entire agricultural production volume (not only food production), a total of 68,886 kilotonnes is lost from the supply chain, representing 48% of the total initial mass and increasing the FLW at the food production stage to: 45,412 kilotonnes.

Total fruit & vegetables production: (100%)	143,914
Proportion of fruit & vegetables removed by peeling: (23%)	-33,100*
Total fruit & vegetables production for food: (77%)	110,814
FLW at the Agricultural Production stage of the FSC:	-12,312
Remaining food that moves to the next stage of the FSC:	98,502
FLW at the postharvest handling & storage stage of the FSC:	-111
Remaining food that moves to the next stage of the FSC:	98,391
FLW at the packaging & process stage of the FSC:	-1,430
Remaining food that moves to the next stage of the FSC:	96,961
FLW at the distribution stage of the FSC:	-17,869
Remaining food that moves to the next stage of the FSC:	79,092
FLW at the consumption stage of the FSC:	-4,064
Remaining food that is available for consumption:	75,028
Total FLW for all stages of the FSC:	-35,786

Chapter 3.5: Fish & Seafood

Assumed proportion utilized fresh = 60%

Mean Conversion Factor= 0.5

Table 20: Fish & Seafood mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
7,987	4,275	127	-2,346	10,043
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing	Other Utilities	Food (J)

		(H)	(I)	
1,039	5	0	183	8,816
Fresh (K)*	Processed (L)*			
Jx0.6= 5,289	=J-K =3,527			

Table 21: Waste percentages used for fish & seafood in Africa, f=fresh, p=processed (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	6%	9%	15%(f), 10%(p)	2%(f), 1%(p)

Table 22: Calculation for losses and wastes (1000 tonnes) for fish & seafood in Africa – taking into account waste percentages, conversion and allocation factors. *note this number comes directly out of the SIK report (Gustavsson et al, 2013).

Food Production	230* Conversion factor: $230 \times 0.5 = \mathbf{115}$
Postharvest handling & storage	$0.06 \times 7{,}987(A) = 479$ Conversion factor: $479 \times 0.5 = \mathbf{240}$
Processing & packaging	$0.09 \times (0(H) + 3{,}527(L)) = 317$ Conversion factor: $317 \times 0.5 = \mathbf{159}$
Distribution	Processed: $0.1 \times (0(H) + 3{,}527(L) - 317) = 321$ Conversion factor: $321 \times 0.5 = 161$ Fresh: $0.15 \times 5{,}289(K) = 793$ Conversion factor: $793 \times 0.5 = 397$ Total distribution: $161 + 397 = \mathbf{558}$
Consumption	Processed: $0.01 \times (0(H) + 3{,}527(L) - 317 - 321) = 29$ Conversion factor: $29 \times 0.5 = 15$ Fresh: $0.02 \times (5{,}289(K) - 793) = 90$ Conversion factor: $90 \times 0.5 = 45$

	Total consumption: $15 + 45 = \mathbf{60}$

Note: FLW refers only to the portion of losses and wastes that occure to the mass of the commodity designated as food. It is for this reason that the conversion factor is applied. While in the case of fish & seafood in Africa, the conversion factor is 50%, that means that only 50% of the total mass of losses and wastes are considered as food losses and wastes. The high percentage for the conversion factor here is due to bycatch.

Mass flow summary for fish & seafood: (1000 tonnes)

A total of 1,132 kilotonnes of fish & sefood are lost or waste in the African food supply chain each year, representing 28% of the total mass produced for food at the food production stage. The largest FLW occurs at the distribution stage of the FSC, accounting for 49% of all fish & seafood FLW and 14% of the total mass of fish & seafood produced for food. *When considering the entire agricultural production volume (not only food production), a total of 5,126 kilotonnes is lost from the supply chain, representing 64% of the total initial mass and increasing the FLW at the food production stage to: 4,109 kilotonnes.

Total fish & seafood production: (100%)	7,987
Total fish & seafood considered inedible: (50%)	-3,994*
Total cereal production for food: (50%)	3,994
FLW at the Agricultural Production stage of the FSC:	-115
Remaining food that moves to the next stage of the FSC:	3,879
FLW at the postharvest handling & storage stage of the FSC:	-240
Remaining food that moves to the next stage of the FSC:	3,639
FLW at the packaging & process stage of the FSC:	-159
Remaining food that moves to the next stage of the FSC:	3,480
FLW at the distribution stage of the FSC:	-558
Remaining food that moves to the next stage of the FSC:	2,922
FLW at the consumption stage of the FSC:	-60
Remaining food that is available for consumption:	2,862
Total FLW for all stages of the FSC:	-1,132

Chapter 3.6: Milk

Table 23: Milk mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009.

Supply Elements

Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
38,752	7,202	-39	-552	45,363
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,493	0	40	210	40,909

Table 24: Waste percentages used for milk in Africa (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	11%	0.1%	10%	0.1%

Table 25: Calculation for losses and wastes (1000 tonnes) for milk in Africa.

Food Production	$\frac{0.06}{1-0.06} \times 38{,}752(A) = \mathbf{2{,}474}$
Postharvest handling & storage	$0.11 \times 38{,}752(A) = \mathbf{4{,}263}$
Processing & packaging	$0.001 \times (40(H) + 40{,}909(J)) = \mathbf{41}$
Distribution	$0.1 \times (40(H) + 40{,}909(J) - 141) = \mathbf{4{,}091}$
Consumption	$0.001 \times (40(H) + 40{,}909(J) - 41 - 4{,}091) = \mathbf{37}$

Mass flow summary for milk: (1000 tonnes)

A total of 10,906 kilotonnes of milk are lost or waste in the African food supply chain each year, representing 28% of the total mass produced for food at the food production stage. The largest FLW occurs at the postharvest handling & storage stage and the distribution stage of the FSC, their combined FLW accounting for 77% of all milk FLW and 22% of the total mass of milk produced.

Total milk production for food: (100%)	38,752

FLW at the food production stage of the FSC:	-2,474
Remaining food that moves to the next stage of the FSC:	36,278
FLW at the postharvest handling & storage stage of the FSC:	-4,263
Remaining food that moves to the next stage of the FSC:	32,015
FLW at the packaging & process stage of the FSC:	-41
Remaining food that moves to the next stage of the FSC:	31,974
FLW at the distribution stage of the FSC:	-4,091
Remaining food that moves to the next stage of the FSC:	27,883
FLW at the consumption stage of the FSC:	-37
Remaining food that is available for consumption:	27,856
Total FLW for all stages of the FSC:	-10,906

Chapter 3.7: Eggs

Table 26: Eggs mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
2,593	48	0	8	2,633
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
0	269	0	5	2,176

Table 27: Waste percentages used for eggs in Africa.

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
8%	n/a	0.1%	3%	1%

Table 28: Calculation for losses and wastes (1000 tonnes) for eggs in Africa.

Food Production	$\frac{0.08}{1-0.08} \times 2{,}593(A) = \mathbf{225}$
Postharvest handling & storage	n/a
Processing & packaging	$0.001 \times 2{,}176(J) = \mathbf{2}$

Distribution	$0.03 \times (2{,}176(J) - 2) = \mathbf{65}$
Consumption	$0.01 \times (2{,}176(J) - 2 - 65) = \mathbf{21}$

Mass flow summary for eggs: (1000 tonnes)

A total of 313 kilotonnes of eggs are lost or waste in the African food supply chain each year, representing 12% of the total mass produced for food at the food production stage. The largest FLW occurs at the food production stage of the FSC which accounts for 72% of all eggs FLW and 9% of the total mass of eggs produced.

Total eggs production for food: (100%)	2,593
FLW at the food production stage of the FSC:	-225
Remaining food that moves to the next stage of the FSC:	2,268
FLW at the postharvest handling & storage stage of the FSC:	n/a
Remaining food that moves to the next stage of the FSC:	2,368
FLW at the packaging & process stage of the FSC:	-2
Remaining food that moves to the next stage of the FSC:	2,366
FLW at the distribution stage of the FSC:	-65
Remaining food that moves to the next stage of the FSC:	2,301
FLW at the consumption stage of the FSC:	-21
Remaining food that is available for consumption:	2,280
Total FLW for all stages of the FSC:	-313

Chapter 3.8: Meat

Table 29: Total meat mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown below in tables 33-37 and summarized in table 38.

Supply Elements				
Rejection at SH (K)*	During transport to SH (L)*	During breeding (M)*		
102	43	3,910		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
15,222	1,303	9	-129	16,405
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing	Other Utilities	Food (J)

		(H)	(I)	
1	0	0	14	16,939

Table 30: Meat mass flow by type of livestock through the food supply chain in Africa (1000 tonnes), from FBS 2009. *All calculations for the commodity Other Meat were calculated using SIK report measurements for turkey.

	Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manufacture (H)	Other Uses (I)	Food (J)
Cattle meat	5658	341	4	60	5944	0	0	0	8	5936
Mutton & Goat	2608	37	0	14	2631	0	0	0	1	2630
Pig meat	1135	146	4	8	1276	0	0	0	1	1276
Poultry	4346	765	1	20	5092	0	0		1	5092
Other Meat* (turkey)	1475	14	0	27	1462	1	0	0	3	1459
Total meat	**15222**	**1303**	**9**	**129**	**16405**	**1**	**0**	**0**	**14**	**16393**

Table 31: Waste percentages used for meat by type of livestock in Africa (Gustavsson et al, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat (turkey)
Food Production	20%					
Losses during breeding		10%	33%	10%	25%	25%
Postharvest Handling & Storage	0.9%					
Transport to the slaughter-house		0.1%	0.1%	0.4%	0.5%	0.5%
Rejection at the slaughter-house		0.3%	0.3%	0.06%	1.3%	1.3%
Processing	5%					
Distribution	7%					
Consumption	2%					

Table 32: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in Africa. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson et al, 2013).

	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Cattle meat	5,658	23,477,178	241
Mutton & Goat	2,608	173,866,666	15
Pig meat	1,135	12,897,727	88
Poultry	4,346	2,897,333,333	1.5
Other Meat (turkey)	1,475	202,054,795	7.3
Total	**15,222**		

Table 33: Cattle losses during production and postharvest handling & storage (number of heads).

Cattle	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 23{,}477{,}178 = 70{,}643$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (23{,}477{,}178 + 70{,}643) = 23{,}571$
	During breeding:
	$\frac{0.1}{1-0.1} \times (23{,}477{,}178 + 70{,}643 + 23{,}571) = 2{,}619{,}044$

Table 34: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 173{,}866{,}666 = 523{,}170$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (173{,}866{,}666 + 523{,}170) = 174{,}564$
	During breeding:
	$\frac{0.33}{1-0.33} \times (173{,}866{,}666 + 523{,}170 + 174{,}564) = 85{,}979{,}481$

Table 35: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0006}{1-0.0006} \times 12{,}897{,}727 = 7{,}743$
	Transportation to slaughterhouse:
	$\frac{0.004}{1-0.004} \times (12{,}897{,}727 + 7{,}743) = 51{,}829$

	During breeding:
	$\frac{0.1}{1-0.1} \times (12{,}897{,}727 + 7{,}743 + 51{,}829) = 143{,}970$

Table 36: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 2{,}897{,}333{,}333 = 38{,}161{,}432$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (2{,}897{,}333{,}333 + 38{,}161{,}432) = 14{,}751{,}230$
	During breeding:
	$\frac{0.25}{1-0.25} \times (2{,}897{,}333{,}333 + 38{,}161{,}432 + 14{,}751{,}230) = 983{,}415{,}332$

Table 37: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other meat (turkey)	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 202{,}054{,}795 = 2{,}661{,}309$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (202{,}054{,}795 + 2{,}661{,}309) = 1{,}028{,}724$
	During breeding:
	$\frac{0.25}{1-0.25} \times (202{,}054{,}795 + 2{,}661{,}309 + 1{,}028{,}724) = 68{,}581{,}609$

Table 38: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		**Transport to Slaughterhouse**		**During Breeding**	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	70,643	17	23,571	5.7	2,619,044	631
Mutton & Goat	523,170	7.8	174,564	2.6	85,979,481	1,290
Pig meat	7,743	0.7	51,829	4.6	143,970	13
Poultry	38,161,432	57	14,751,230	22	983,415,332	1,475
Other Meat (turkey)	2,661,309	19	1,028,724	8	68,581,609	501

Total		**102**		**43**		**3,910**

Weighted waste percentage for production:

$$\frac{3{,}910}{15{,}222(A) + 3{,}910} = 20\%$$

Weighted waste percentage postharvest handling and storage:

$$\frac{102 + 43}{15{,}222(A) + 102 + 43} = 0.9\%$$

Table 39: Calculation for losses and wastes (1000 tonnes) for meat in Africa - taking into account waste percentages, conversion and allocation factors

Food Production	$\mathbf{3,910}$ (table 38)
Postharvest handling & storage	$102 + 43 = \mathbf{145}$ (table 38)
Processing & packaging	$0.05 \times \big(0(H) + 16{,}939(J)\big) = \mathbf{847}$
Distribution	$0.07 \times (0(H) + 16{,}939(J) - 847) = \mathbf{1,126}$
Consumption	$0.02 \times (0(H) + 16{,}939(J) - 847 - 1{,}126) = \mathbf{299}$

Mass flow summary for meat: (1000 tonnes)

A total of 6,327 kilotonnes of meat are lost or waste in the African food supply chain each year, representing 42% of the total mass produced for food at the food production stage. The largest FLW occurs at the food production stage of the FSC which accounts for 62% of all meat FLW and 26% of the total mass of meat produced.

Total meat production for food: (100%)	15,222
FLW at the food production stage of the FSC:	-3,910
Remaining food that moves to the next stage of the FSC:	11,312
FLW at the postharvest handling & storage stage of the FSC:	-145
Remaining food that moves to the next stage of the FSC:	11,167
FLW at the packaging & process stage of the FSC:	-847
Remaining food that moves to the next stage of the FSC:	10,320
FLW at the distribution stage of the FSC:	-1,126

Remaining food that moves to the next stage of the FSC:	9,194
FLW at the consumption stage of the FSC:	-299
Remaining food that is available for consumption:	8,895
Total FLW for all stages of the FSC:	-6,327

Chapter 3.9: Food mass flow summary for Africa & the World

The table below provides a summary of the results from all of the FLW calculations in chapters 3.1-3.8.

Table 40: Summary of FLW in Africa (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***30% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW ** **	**% of total FLW**
Cereals	43,554	7,000	2,193	13,550	2,015	987	**25,745**	**18%**
Roots & Tubers	62,715	26,705	11,483	7,780	3,014	5,563	**54,545**	**39%**
Oilseeds & Pulses	19,203	3,123	687	729	482	236	**5,257**	**4%**
Fruit & Vegetables	45,412	12,312	111	1,430	17,869	4,064	**35,786**	**26%**
Fish & Seafood	4,109	115	240	159	558	60	**1,132**	**1%**
Milk	2,474	2,474	4,263	41	4,091	37	**10,906**	**8%**
Eggs	225	225	n/a	2	65	21	**313**	**0%**
Meat	3,910	3,910	145	847	1,126	299	**6,327**	**5%**
Total FLW	**181,602**	**55,864**	**19,122**	**24,538**	**29,220**	**11,267**	**140,011**	
% of total FLW	**30%*** **	**40%**	**14%**	**18%**	**21%**	**8%**		

This table shows that for Africa, the commodity group with the largest proporation of FLW is roots & tubers, followed by fruit & vegetables and cereals, where these three commodity groups account for 83% of all FLW. While for the FSC, the FLW is overwhelmingly the highest at the food production stage when considering the total mass of initial production, where FLW makes up 30% of the total initial mass. Whereas, when considering food production only, still food prodution is the stage of the FSC with the largest proportion of FLW, accounting for 40% of all FLW in the FSC, 21% at the distribution stage and 18% at processing and packaging stage, the consumption stage accounts for only 8% of all FLW. A total of 140,011 kilotonnes is lost or wasted in the African FSC annually, this represents 30% of the total production of food.

The table below provides an aggregated summary of the results for all FLW in the food supply chain for all world regions. Detailed calculations for the six remaining world regions can be found in appendices A-F.

Table 41: Summary of FLW in the world (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***39% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW FOOD**
Cereals	1,089,853	47,843	50,307	131,636	18,584	111,820	**360,190**	**29%**
Roots & Tubers	235,018	105,908	41,138	23,188	18,375	24,686	**213,295**	**17%**
Oilseeds & Pulses	496,467	16,255	8,701	5,480	2,906	3,988	**37,330**	**3%**
Fruit & Vegetables	565,327	199,040	4,860	19,058	95,012	118,636	**436,606**	**25%**
Fish & Seafood	87,195	6,050	2,404	3,516	4,916	3,580	**20,466**	**3%**
Milk	27,561	27,561	24,012	8,086	27,549	31,298	**118,506**	**11%**
Eggs	4,275	4,275	n/a	299	1,960	3,199	**9,733**	**1%**
Meat	16,675	16,675	2,093	13,921	13,967	20,252	**66,908**	**4%**
Total FLW FOOD	**2,522,372**	**423,607**	**133,515**	**205,184**	**183,269**	**317,439**	1,263,034	
% of total FLW FOOD	**39%*** **	**34%**	**11%**	**16%**	**15%**	**25%**		

On a global scale, 1.26 billion tonnes of food is lost or wasted each annually, this represents 29% of the total food produced. Similar to findings in the African regional analysis on a commodity group basis, fruit & vegetables, cereals and roots & tubers are the three largest areas of FLW, accounting for 71% of all FLW. Notably, on a global scale, there are distinct differences in the FLW at each stage of the FSC. While again, overwhelmingly the highest FLW is at the agricultural production stage when considering the total mass of initial production, where FLW makes up 39% of the total initial mass. Food production remains the biggest source of FLW for food only agricultural production also, but only 9% above the global consumption stage which accounts for 25% of all FLW. Together the first and last stages in the FSC accout for more than half of the total FLW. The three middle stages; postharvest handling & storage, packaging & processing and distribution share rather similar proportions of the total FLW.

Chapter 4: Global food mass flow MFA

The five stage food supply chain outlined in Chapter 2.2.2: food supply chains, and used for the regional analyses of Chapter 3 and annexes A-F provides the basis for the global food mass flow. From a mass flow perspective, consumption at the household level is not the end of the chain and therefore further estimates are provided below, for the final food mass flows with outputs as feces, urine and the remaining stock as human body mass.

Chapter 4.1 Feces & Urine

The mass flow through the human body on a daily basis is described in Baccini and Brunner's Metabolism of the Anthroposphere as follows (Baccini and Brunner, 2012);

Inputs	**Mass (kg)**	**Output**	**Mass (kg)**
Oxygen	0.83	CO2	1
Food, dry	0.62	Respiration & perspiration water	2.28
Food, water	1.15	Urine	1.5
Drinking water	1.61	Feces	0.09
Food preparation water	0.79	Sweat solids	0.02
		Urine solids	0.06
		Feces solids	0.03
Total:	**5**	**Total:**	**4.98**

This represents the entire input-output flow including solid, liquid and gas for the human body. For the purposes of this project this analysis is too wide and must be narrowed only to the food related flows of feces and urine. It is for this reason that from the input side oxygen, food preparation water and drinking water will be removed, and from the output side CO2 and respiration and perspiration water will be removed;

Inputs	**Mass (kg)**	**Output**	**Mass (kg)**
Food, dry	0.62	Urine	1.5
Food, water	1.15	Feces	0.09
		Sweat solids	0.02
		Urine solids	0.06
		Feces solids	0.03
Total:	**1.77**	**Total:**	**1.7**

This updated analysis is consistent with the consumption found for MHIC regions of the world, but notably larger than the consumption trends in LIC regions, as summarized in the follwing table.

Table 42: MHIC per capita analysis for food production, waste and consumption. All values in 1000 tonnes, population derived from adding regional populations from FBS for 2009 in 1000 people (FAOSTAT, 2014).

	MHIC	LIC	Global Average
Population	2,673,694	3,955,893	6,629,587
Agricultural Production	3,678,693	2,804,308	6,483,001
Food Production	2,374,206	2,010,030	4,384,236
Food production per capita/year (kg)	888	508	661
FLW	701,570	561,464	1,263,034
FLW per capita/year (kg)	262	142	191
FLW %	30%	28%	29%
Consumption (Food Production-FLW)	1,672,636	1,448,566	3,121,202
Consumption per capita/year (kg)	626	366	471
Consumption per capita/day (kg)	**1.7**	**1**	**1.28**

This table shows that on average in MHIC regions food consumption is 1.7kg per person, per day, and for LIC regions it is 1kg.

A weighted average for global consumption shows that the average daily consumption per person is: 1.28kg. Using the same ratio as in Baccini and Brunner's analysis, the daily production of feces, urine and sweat would be: 1.23kg per person, and an annual production of 450kg. On a global scale this production of feces, urine and sweat combines to be 2,980,213 kilotonnes per year. The discrepancy between food consumption as an input and excreta as an output on an individual level, as well as the total system discrpancy can be explained by the process of human respiration. Humans eat in order to gain energy, as large part of that occurs through the oxidation of consumed carbon as CO2 off-gas through breathing. The exact calculation for respiration is beyond the scope of this project, but it is an important factor in the complete material flow balance, and therefore respiration represents the additional output at the consumption end of the system.

Chapter 4.4: Global food mass flow MFA

It is important to note the significant difference between the amount of food produced at the farmer level and the amount of food actually consumed. There is currently enough food produced in the world to feed the entire human population, but there remain 842 million hungry people around the world (Gustavsson et al, 2011).

While the global MFA is an aggregation of the whole food system, the results show similar loss and waste magnitudes for the three intermediary processes within the system, but larger magnitudes for the first and last processes. These results indicate that the current focus on food waste at the consumption stage represents only a part of the picture. In fact, shifting the global focus to to earlier stages in the food supply chain would result in less overall FLW and allow for a larger mass flow of edible food to move to the consumption stage.

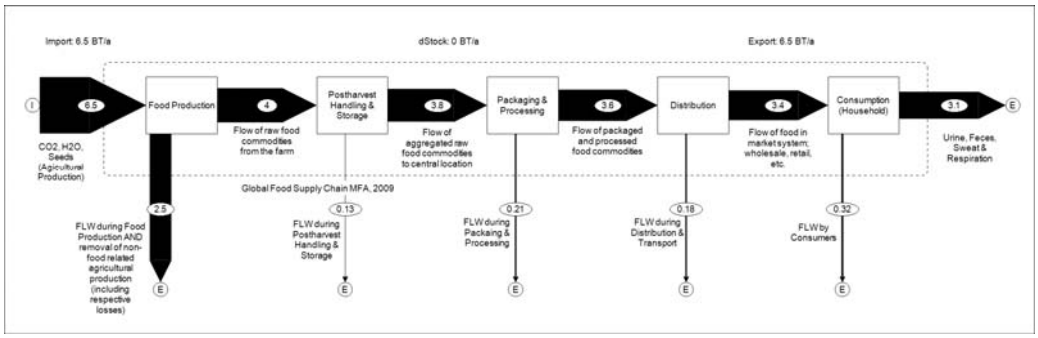

Figure 2: Global food mass flow MFA (2009). BT/a= billion tonnes per year. Numbers are rounded to two significant digits.

The input into the global food supply chain system is the total agricultural production that comes from CO2, H2O and seeds (both animal and vegetal). While “agricultural production” is the system input which represents the total mass of agricultural produce for all purposes, food production is the process during which the mass of food undergoes the largest FLW in the enitre system. Food production as a process entrails sepreating the proportion of agricultural produce designated as food consumption, as well as the edible proportion of this food. 39% of the total mass of agricultural production is removed from the food supply chain at this point. This mass is so large because it considers not only the removal of food related FLW but also the removal of the entire mass of non-food related agricultural production. The mass leaving the system at the food production stage is nearly as big as the mass leaving the system at the post-consumption as human excreta.

After the food production stage, the remaining balance of food travels further, to postharvest handling and storage, where it experiences the least FLW of the whole system. The remaining balance again moves to the next stage of the system at packaging and processing, where the largest FLW of the three intermediary processes occurs, then the balance moves on. At the distribution stage the second smallest FLW occurs before the remaining food balance moves to the consumption stage. The consumption stage represents the household level consumption. The FLW from the consumption stage accounts for 5% of the total agricultural production or 7% of the total food production. It is at this stage where the system experiences the second largest FLW. The last output, the largest output for the whole FSC is the results of successful consumption; urine, feces and sweat. Human excreta account for 45% of the total mass of agricultural production and 68% of the food production.

“Human digestion results in the following products: feces, urine, and off-gas mostly from breathing” (Baccini and Brunner, 2012). The stock present in the consumption stage represents a combination of things, first the added human body mass per year, secondly the parts of the human digestion that are beyond the socpe of this project; the concept of breath. Using the principal of mass-balance, conservation of mass (or simply input equals output) is not a new concept, it even dates back more than 300 years, when Dr. Santorio tried to perform an mass-balance analysis for the human metabolism (Brunner and Rechberger, 2004). While weighing all of the inputs (food and drink), and the outputs (feces and urine), Dr. Santorio discovered that more than half of the human excreta leaves the body in a form other than feces and urine (Brunner and Rechberger, 2004). While at the time he could not identify what this pathway is, later it became known that respiration is a major outflow of carbon and water from the human body (Baccini and Brunner, 2012).

Performing an analysis of the human metabolism is not the aim of this project, best estimations were used to analyse the urine, feces and sweat outputs from food related consumption and therefore, while recognizing their importance, the input of beverages and output of respiration are not considered further.

PART II: Average Global Diet Mass Flow

Chapter 5

In today's world, food availability is no longer regionally or seasonally dependant, for example, fresh tropical fruit is available in North America all year round. While access to food has overcome most technical barriers, the largest remaining barrier are the costs, ie. how much will the mango cost? The cost impacts of our food system are significant, wide-spread and while at the household level we see these costs as economic, they also span into environmental, political, and cultural costs as well. Unlike access issues, where and how food losses and wastes occur remains very much commodity and location dependant.

While PART I provided a complete food system mass flow overview, identifying which foods make up the "average global diet", and how their mass flows compare to the global total is the focus of PART II. The "average global diet" represents the ten most abundantly consumed foods on the planet. In a time where globalization, trade liberalization and industrial corporate farming are changing food consumption patterns around the world, it is critical to establish a current baseline for food consumption. Also, in reference to food loss and waste, how the consumption of these staples compares to the global food mass flow as a whole. The average global diet MFA will show where the most significant food loss and waste happens for the most important staple foods we eat today.

Chapter 5.1: Different dietary divisions

There are different methods used to define an average global diet, the most common of which is a regional diet based on energy or kilocalorie consumption. For the purposes of this paper using an energy-based analysis is not appropriate. The average global diet to be described here is the most abundantly consumed foods by mass. With the population and consumption data for the seven world regions, the commodity groups can be ranked in terms of most abundantly consumed. While a review of FBS production statistics will indicate the top ten most produced individual commodities per region, the agregation of these regions will show the world total.

Staple foods

"A food staple is a food that makes up the dominant part of a population's diet. Food staples are eaten regularly—even daily—and supply a major proportion of a

person's energy and nutritional needs" (National Geographic, 2014). Food staples vary across the globe, traditionally they are made up of native species, but in today's globalized world, diets are changing, including the staples. While the consumption of non-native staples is increasing in different regions, cereals and tubers remain the most common type of staple foods. For example, a traditional staple from the Andes Mountains in South America is quinoa, a grain whose consumption is now spreading rapidly across the globe (National Geographic, 2014). Rice, maize and wheat account for sixty percent of the world's energy intake, "other staples include millet and sorghum; tubers and potatoes, cassava, yams and taro; and animal products such as meat, fish and dairy" (National Geographic, 2014).

Most popular food survey:

Diets have changed and continue to be influenced by the abundant diversity in choices resulting from globalization. Oxfam International conducted a 17 country food related survey in 2011, with a sample size of over 16,000 people and countries representing all of the seven world regions with the exception of Eastern Asia. The results showed a clear trend towards the popularization of western dietary preferences worldwide (Mountford and Martin, 2011). Notably, the traditional preferences of low income countries in Africa for maize based foods remain (Mountford and Martin, 2011). The majority of respondents stated that they no longer eat some of the foods they did two years ago, particularly in South Africa, Mexico and Kenya, however the rationales provided were predominantly money or health related rather than preferences (Mountford and Martin, 2011). When asked to identify their favorite foods, the single most popular response was pasta, the cereal based staple, because of its price and versatility (Mountford and Martin, 2011).

GEMS/Food Cluster Diets:

In response to the accident at the Chernobyl nuclear site, the World Health Organization (WHO) created a food monitoring program under the Global Environment Monitoring System - Food Contamination Monitoring and Assessment Programme (GEMS/Food). GEMS/Food was originally established to predict the impacts of radiation on food and as such, developed the first regional diets in 1989. The regional diets were derived from FAO FBS for five regions; Middle East, Far East, Africa, Latin America and Europe, note that countries with similar diets to those in Europe such as Canada, the United States and Australia are also included in this group (GEMS/Food, 2003).

A few years later, GEMS/Food had a new task, predicting exposure of food to different kinds of chemicals and toxicities and the concept of cluster diets was developed. Cluster diets are grouped based on dietary similarity being more important than geographic proximity (GEMS/Food, 2003). While cluster diets are used to predict chemical exposure through food, the concept behind them, using FBS food supply data for a region of consumption is relevant for this paper.

What is the average global diet by region?

The litterature is full of examples of regional diets, such as; "[t]he main staple foods in the average African diet are (in terms of energy) cereals (46 percent), roots and tubers (20 percent) and animal products (7 percent)" (FAO, 1995), "[i]n Western Europe the main staple foods in the average diet are (in terms of energy) animal products (33 percent), cereals (26 percent) and roots and tubers (4 percent)" (FAO, 1995). Using the same regional divisions as in PART I, and similar to the GEMS/Food cluster diet approach, chapter 5.2 will go back to the mass related analysis of food production and consumption.

Chapter 5.2: Identifying the 'global diet'

A breakdown of the global and regional consumption trends are described in the following tables. Where consumption was derived by subtracting the total FLW from the initial food production volumes per commodity group.

Table 43: Global summary of food losses and waste, production and consumption by commodity group, add values in 1000 tonnes. All FLW, production and consumption figures can be found in Appendices A-F, Tables , based on data from FBS 2009 (FAOSTAT, 2014).

	Total Food Losses & Waste	Food Production	**Consumption**	Population (1000 ppl)
Cereals	360,190	1,208,012	**847,822**	
Roots & Tubers	213,295	588,170	**374,875**	
Oilseeds & Pulses	37,330	230,365	**193,035**	
Fruit & Vegetables	436,606	1,226,267	**789,661**	
Fish & Seafood	20,466	81,145	**60,679**	
Milk	118,506	698,596	**580,090**	
Eggs	9,733	67,763	**58,030**	
Meat	66,908	283,919	**217,011**	
Total	**1,263,034**	**4,384,236**	**3,121,202**	**6,629,587**
%	**29%**			
kg/capita	**191kg**	**661kg**	**471kg**	

This table shows that for the world, by mass, fruit & vegetables are the most produced and the second most consumed commodity group, following by cereal. Milk is the third most produced and consumed commodity group, followed by roots & tubers in fourth place, meat and oilseeds & pulses as a fifth and sixth. The smallest production and consumption takes place in the commodity groups fish & seafood and eggs. The average annual consumption per person is 471 kg/capita, and the average annual mass of FLW is 191 kg/capita.

World population by region for 2009 (FAOSTAT, 2014) (*population derived by adding two regional populations together; Central Asia and Western Asia, Central America and South America, North America and Oceania, Southern Asia and Southeastern Asia).

Table 44: Regional divisions of food consumption by largest to smallest consumers, including population and MHIC and LIC regional division. All consumption figures can be found in Appendices A-F, Tables , based on data from FBS 2009 (FAOSTAT, 2014). Cons=consumption, Pop'l=population.

Region	**Cons** (1000 t)	**Cons** % of total	**Pop'l** (1000 ppl)	**Pop'l** % of total	**MHIC – Cons** (1000 t) (%)	**MHIC – Pop'l** (1000 ppl) (%)	**LIC – Cons** (1000 t) (%)	**LIC – Pop'l** (1000 ppl) (%)
Eastern Asia	775,852	25%	1,567,046	24%	Ø	Ø		
South & Southeast Asia*	741,363	24%	2,230,671	34%			Ø	Ø
Europe	503,183	16%	736,591	11%	Ø	Ø		
North America & Oceania*	393,601	13%	370,057	6%	Ø	Ø		
Africa	332,452	11%	932,610	14%			Ø	Ø
Latin America*	257,670	8%	541,956	8%			Ø	Ø
Central & Western Asia*	117,082	4%	250,656	4%			Ø	Ø
Total	3,121,202	**1**	**6,629,587**	**1**	**1,672,636**	**2,673,694**	**1,448,566**	**3,955,893**
					54%	**40%**	**46%**	**60%**

This table shows that the Eastern Asian region is that largest consumer of food by mass, followed by South & Southeast Asia, Europe and North America. Medium and high income country (MHIC) regions make up 54% of the food consumption by mass and represent 40% of the population. Low income country (LIC) regions consume the remaining 46% of total food mass and represent 60% of the world population. Understanding who represents the global diet helps to better understand which commodities make up the global diet.

In order to determine the top ten most produced commodities in the world, the top fifteen commodities were selected for each region, then all of the same commoditeis which were producted by more than one region were added together to get the total world. Of the most produced commodities in the world, the top ten and their production volumes are summarized in the table below.

Table 45: World top ten produced commodities, based on FBS for 2009 (FAOSTAT, 2014). *Commodities were agregated under the group fruit & vegetables. **Commodities were agregated under the group roots & tubers.

#	Commodity	Production (1000 tonnes)
1	Maize and products	816,145
2	Vegetables, Other*	780,788
3	Wheat and products	680,101
4	Milk - Excluding Butter	647,647
5	Rice (Milled Equivalent)	444,280
6	Potatoes and products**	331,101
7	Cassava and products**	214,381
8	Soyabeans	190,227
9	Fruits, Other*	166,494
10	Tomatoes and products*	141,324
	Total	**4,412,488**
	Fruit & Vegetables	1,088,606
	Roots & Tubers	545,482

Chapter 5.3: Regional analysis Africa – global diet

Once again using the methodology for finding FLW by commodity groups of the SIK report, as in PART I, a regional based anlysis was conducted to dertermine the mass flow for the top ten most produced commodities.

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group Sub-Saharan Africa (Gustavsson et al, 2013). All of the data comes from FBS from 2009, for the country group Africa (FAOSTAT, 2014).

Chapter 5.3.1: Maize

Conversion Factor= 0.79: (edible food = 79%)

Allocation Factors=0.75: (produced for food consumption=75%)

Table 46: Maize mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009 for Africa (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
57,702	14,995	-3,498	-2,132	67,067
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
20,506	747	602	586	39,202
Milled (K) *	Feed (L) *			
Jx0.79= 30,970	J-K= 8,232			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total maize mass flows (1000 tonnes) in Africa.

$$\frac{586(I)}{57{,}702(A) + 14{,}995(B) - 3{,}498(C)} = 0.8\%$$

Table 47: Waste percentages for maize in Africa, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	0.8%	3.5%(m), 3.5%(p)	2%	1%

Table 48: Calculation for losses and wastes (1000 tonnes) for maize in Africa – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 57{,}702(A) = 3{,}683$ Allocation factor: $3{,}683 \times 0.75 = \mathbf{2{,}762}$
Postharvest handling & storage	$0.008 \times 57{,}702(A) = 462$ Allocation factor: $462 \times 0.75 = \mathbf{347}$
Processing & packaging	Milling: $0.035 \times 39{,}202(J) = 1{,}372$

	Industrial Baking: $(30{,}970(K) + 39{,}202(J) - 1{,}372) \times 0.035 = 2{,}408$ Total Processing and Packaging: $1{,}372 + 2{,}408 = \mathbf{3{,}780}$
Distribution	$(30{,}970(K) + 602(H) - 1{,}372 - 2{,}408) \times 0.02 = \mathbf{556}$
Consumption	$(30{,}970(K) + 602(H) - 1{,}372 - 2{,}408 - 556) \times 0.01 = \mathbf{272}$

Chapter 5.3.2: Wheat

Conversion Factor= 0.78: (edible food = 78%)

Allocation Factors=0.75: (produced for food consumption=75%)

Table 49: Wheat mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009 for Africa (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
26,074	30,288	-126	-897	55,339
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,668	947	1	2,068	46,311
Milled (K) *	Feed (L) *			
Jx0.78= 36,123	J-K= 10,188			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total wheat mass flows (1000 tonnes) in Africa.

$$\frac{2{,}068(I)}{26{,}074(A) + 30{,}288(B) - 126(C)} = 4\%$$

Table 50: Waste percentages for wheat in Africa, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	4%	3.5%(m), 3.5%(p)	2%	1%

Table 51: Calculation for losses and wastes (1000 tonnes) for wheat in Africa – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 26{,}074(A) = 1{,}664$ Allocation factor: $1{,}664 \times 0.75 = \mathbf{1{,}248}$
Postharvest handling & storage	$0.04 \times 26{,}074(A) = 1{,}043$ Allocation factor: $1{,}043 \times 0.75 = \mathbf{782}$
Processing & packaging	Milling: $0.035 \times 46{,}311(J) = 1{,}621$ Industrial Baking: $(36{,}123(K) + 46{,}311(J) - 1{,}621) \times 0.035 = 2{,}828$ Total Processing and Packaging: $1{,}621 + 2{,}828 = \mathbf{4{,}449}$
Distribution	$(36{,}123(K) + 1(H) - 1{,}621 - 2{,}828) \times 0.02 = \mathbf{634}$
Consumption	$(36{,}123(K) + 1(H) - 1{,}621 - 2{,}828 - 634) \times 0.01 = \mathbf{310}$

Chapter 5.3.3: Rice

Conversion Factor= 1: (edible food = 100%)

Allocation Factors=0.75: (produced for food consumption=75%)

Table 52: Rice mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009 for Africa (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
15,235	7,212	1,576	-904	23,119
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
812	456	133	442	19,646
Milled (K) *	Feed (L) *			
Jx1=	J-K=			

19,646	0

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total rice mass flows (1000 tonnes) in Africa.

$$\frac{442(I)}{15{,}235(A) + 7{,}212(B) + 1{,}576(C)} = 2\%$$

Table 53: Waste percentages for rice in Africa, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	2%	3.5%(m), 3.5%(p)	2%	1%

Table 54: Calculation for losses and wastes (1000 tonnes) for rice in Africa – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 15{,}235(A) = 972$ Allocation factor: $972 \times 0.75 = \mathbf{729}$
Postharvest handling & storage	$0.02 \times 15{,}235(A) = 305$ Allocation factor: $305 \times 0.75 = \mathbf{229}$
Processing & packaging	Milling: $0.035 \times 19{,}646(J) = \mathbf{688}$
Distribution	$(19{,}646(K) + 133(H) - 688) \times 0.02 = \mathbf{382}$
Consumption	$(19{,}646(K) + 133(H) - 688 - 382) \times 0.01 = \mathbf{187}$

Chapter 5.3.4: Roots & Tubers

The following analysis of roots & tubers consists of FBS data for the commodidies potatoes and produts and cassava and prodcuts only. It does not represent the FBS data for the entire FAOSTAT group roots & tubers.

Assumed proportion utilized fresh = 50%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 55: Roots & tubers mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009 for Africa. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
125,090	1,055	1,868	479	127,534
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
37,498	1,881	0	3,125	69,526
Fresh (K) *	Processed (L) *			
Jx0.5= 34,763	J-K= 34,763			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of roots & tubers (1000 tonnes) in Africa.

$$\frac{3{,}125(I)}{125{,}090(A) + 1{,}055(B) + 1{,}868(C)} = 2\%$$

Table 56: Waste percentages used for roots & tubers in Africa, f=fresh, p=processed (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
14%	2%	15%	5%(f), 2%(p)	2%(f), 11%(p)

Table 57: Calculation for losses and wastes (1000 tonnes) for roots & tubers in Africa – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.14}{1-0.14} \times 125{,}090(A) = 20{,}363$ Conversion factor: $20{,}363 \times 0.82 = \mathbf{16{,}698}$
Postharvest handling & storage	$0.02 \times 125{,}090(A) = 2{,}502$ Conversion factor: $2{,}502 \times 0.82 = \mathbf{2{,}051}$
Processing & packaging	$0.15 \times (0(H) + 34{,}763(L)) = 5{,}214$ Conversion factor: $5{,}214 \times 0.9 = \mathbf{4{,}693}$
Distribution	Processed: $0.02 \times (0(H) + 34{,}763(L) - 5{,}214) = 591$ Conversion factor: $591 \times 0.9 = 532$ Fresh: $0.05 \times 34{,}763\ (K) = 1{,}738$ Conversion factor: $1{,}738 \times 0.74 = 1{,}286$ Total distribution: $532 + 1{,}286 = \mathbf{1{,}818}$
Consumption	Processed: $0.11 \times (0(H) + 34{,}763(L) - 5{,}214 - 591) = 3{,}185$ Conversion factor: $3{,}185 \times 0.9 = 2{,}867$ Fresh: $0.02 \times (34{,}763(K) - 1{,}738) = 661$ Conversion factor: $661 \times 0.74 = 489$ Total consumption: $2{,}867 + 489 = \mathbf{3{,}356}$

Chapter 5.3.5: Fruit & Vegetables

The following analysis of fruit & vegetables consists of FBS data for the commodidies 'vegetables, other', 'tomatoes and products' and 'fruit, other'. It does not represent the FBS data for the entire FAOSTAT groups fruit and vegetables.

Assumed proportion utilized fresh = 99%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 58: Fruit & vegetable mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
72,024	3,168	152	-2,968	72,376
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
123	0	28	27	65,602
Fresh (K)*	Processed (L)*			
Jx0.99 =64,946	=J-K =656			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in Africa.

$$\frac{27(I)}{72{,}024(A) + 3{,}168(B) + 152(C)} = 0.04\%$$

Table 59: Waste percentages used for fruit & vegetables in Africa, f=fresh, p=processed (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
10%	0.04%	25%	17%(f), 10%(p)	5%(f), 1%(p)

Table 60: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in Africa – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.1}{1-0.1} \times 72{,}024(A) = 8{,}003$ Allocation factor: $8{,}003 \times 0.77 = \mathbf{6{,}162}$
Postharvest handling & storage	$0.0004 \times 72{,}024(A) = 29$ Allocation factor: $29 \times 0.77 = \mathbf{22}$
Processing & packaging	$0.25 \times (28(H) + 656(L)) = 171$

	Conversion factor: $171 \times 0.75 = \mathbf{128}$
Distribution	Processed: $0.1 \times (28(H) + 656(L) - 171) = 51$ Conversion factor: $51 \times 0.75 = 38$ Fresh: $0.17 \times 64{,}946(K) = 11{,}041$ Conversion factor: $11{,}041 \times 0.8 = 8{,}833$ Total distribution: $51 + 8{,}833 = \mathbf{8{,}884}$
Consumption	Processed: $0.01 \times (28(H) + 656(L) - 171 - 51) = 5$ Conversion factor: $5 \times 0.75 = 4$ Fresh: $0.05 \times (64{,}946(K) - 11{,}041) = 2{,}695$ Conversion factor: $2{,}695 \times 0.8 = 2{,}156$ Total consumption: $4 + 2{,}156 = \mathbf{2{,}160}$

Chapter 5.3.6: Milk

Table 61: Milk mass flow through the food supply chain in Africa (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
38,752	7,202	-39	-552	45,363
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,493	0	40	210	40,909

Table 62: Waste percentages used for milk in Africa (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	11%	0.1%	10%	0.1%

Table 63: Calculation for losses and wastes (1000 tonnes) for milk in Africa.

Food Production	$\frac{0.06}{1 - 0.06} \times 38{,}752(A) = \mathbf{2{,}474}$

Postharvest handling & storage	$0.11 \times 38{,}752(A) = \mathbf{4{,}263}$
Processing & packaging	$0.001 \times (40(H) + 40{,}909(J)) = \mathbf{41}$
Distribution	$0.1 \times (40(H) + 40{,}909(J) - 41) = \mathbf{4{,}091}$
Consumption	$0.001 \times (40(H) + 40{,}909(J) - 41 - 4{,}081) = \mathbf{37}$

Chapter 5.4: Average global diet mass flow summary for Africa & the World

The table below provides a summary of the results from all of the FLW calculations in chapters 5.3.1-5.3.6.

Table 64: Summary of FLW in global diet commodities in Africa (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***28% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	22,728	6,162	22	128	8,884	2,160	**17,356**	**23%**
Maize	17,188	2,762	347	3,780	556	272	**7,717**	**10%**
Wheat	7,767	1,248	782	4,449	634	310	**7,423**	**10%**
Milk	2,474	2,474	4,263	41	4,091	37	**10,906**	**15%**
Rice	4,538	729	229	688	382	187	**2,215**	**3%**
Roots & Tubers	39,214	16,698	2,051	4,693	1,818	3,356	**28,616**	**39%**
Soyabeans	-	-	-	-	-	-	-	-
Total FLW	**93,907**	**30,073**	**7,694**	**13,779**	**16,365**	**6,322**	**74,233**	
% of total FLW	**28%*** **	**41%**	**10%**	**19%**	**22%**	**9%**		

This table shows that for Africa, the commodity groups with the largest proporation of FLW is roots & tubers, followed by fruit & vegetables, where these groups, representing four commodities account for 62% of the total FLW. Should maize, wheat and rice be regarded together as the commodity group cereals, they would account for a similar mass of the FLW as that of fruit & vegetables. While for the FSC, 41% of all FLW takes place at the food stage, 22% at the distribution stage and 19% at processing and packaging stage, the consumption

stage accounts for only 8% of all FLW. These proportions are very similar with those of the total food mass flow for Africa, as presented in PART I.

Summaries for the six remaining world regions can be found in appendix G. The table below provides an aggregated summary of the results for all FLW in the food supply chain for the ten global diet commodities for all world regions.

Table 65: Summary of FLW in global diet commodities for the world (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***38% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	377,724	127,345	4,589	8,954	64,149	84,080	289,117	**33%**
Maize	402,551	14,228	25,490	14,092	5,033	45,512	104,355	**12%**
Wheat	345,654	13,448	6,381	63,389	6,549	38,018	127,785	**15%**
Milk	25,713	25,713	23,503	7,466	27,294	28,760	112,736	**13%**
Rice	174,679	14,360	15,678	8,269	6,594	29,294	74,195	**8%**
Roots & Tubers	175,566	77,379	25,392	18,571	14,197	19,025	154,564	**18%**
Soyabeans	165,581	2,931	34	8,189	1,787	3,101	16,042	**2%**
Total FLW	**1,667,468**	**275,404**	**101,067**	**128,930**	**125,603**	**247,790**	**878,794**	
% of total FLW	**38%*** **	**31%**	**12%**	**15%**	**14%**	**28%**		

Similar to findings in the African regional analysis on a commodity group basis, fruit & vegetables and roots & tubers are the largest areas of FLW, though their fraction of the total is less at 50% of all the FLW. Cereals account for a much larger percentage on the global scale at 35% of all the FLW. Notably, on a global scale, while the food production stage of the FSC represents the largest contribution of FLW at 31%, the consumption stage represents almost the same amount at 28%. Together the first and last stages in the FSC accout for more than half of the total FLW. The three middle stages; postharvest handling & storage, packaging & processing and distribution share rather similar proportions of the total FLW, postharvest handling & storage undoubtably accounts for the lowest amount of FLW.

Chapter 5.4: Average global diet MFA

Following the same principal for derving human excreta as in PART I, the following tables shows the average consumption of food from the global diet as follows;

Table 66: MHIC, LIC and global average per capita analysis for food production, waste and consumption for the average global diet. All values in 1000 tonnes, population derived from adding regional populations from FBS for 2009 in 1000 people (FAOSTAT, 2014).

	MHIC	LIC	Global Average
Population	2,673,694	3,955,893	6,629,587
Agricultural Production	2,565,490	1,846,998	4,412,488
Food Production	1,680,865	1,339,559	3,020,424
Production of FOOD per capita/year (kg)	629	339	456
FLW	507,780	371,014	878,794
FLW per capita/year (kg)	190	94	133
FLW %	30%	28%	29%
Consumption (Food Production-FLW)	1,173,085	968,545	2,141,630
Consumption per capita/year (kg)	439	245	323
Consumption per capita/day (kg)	**1.2**	**0.67**	**0.89**

This table shows that on average in MHIC regions food consumption of commodities in the average global diet is 1.2kg per person, per day, and for LIC regions it is 0.67kg.

A weighted average for global consumption shows that the average daily consumption per person is: 0.89kg. Using the same ratio as in Baccini and Brunner's analysis, the daily production of feces, urine and sweat would be: 0.85kg per person, and an annual production of 310kg for food coming from the commodities making up the average global diet. On a global scale this production of feces, urine and sweat combines to be 2,058,196 kilotonnes per year.

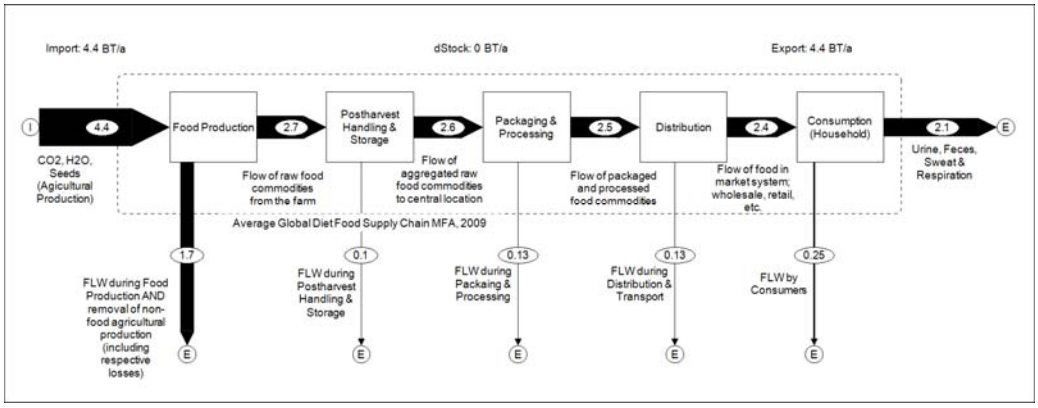

Figure 3: Average Global Diet MFA (2009). BT/a= billion tonnes per year. Numbers are rounded to two significant digits.

While the global MFA is an aggregation of the whole food system, the results show similar loss and waste magnitudes for the three intermediary processes packaging & processing and distribution within the system, but larger magnitudes for the first and last processes of the FSC.

The input into the global food supply chain system is the total agricultural production for the top ten most produced commodities globally, that comes from CO2, H2O and seeds (both animal and vegetal). While, like with the global food mass flow, “agricultural production” is the system input which represents the total mass of agricultural production for all purposes, food production is the process during which the mass of food undergoes the largest FLW in the enitre system. Where 38% of the total mass of agricultural production is removed from the food supply chain at this point. Again, this mass is so large because it considers not only the removal of food related FLW but also the removal of the entire mass of non-food related agricultural production. The mass leaving the system at the food production stage is 81% of that leaving the system at the post-consumption as human excreta.

After the food production stage, the remaining balance of food travels further, to postharvest handling and storage, where it experiences the least FLW of the whole system. The remaining balance again moves to the next stage of the system at packaging and processing, where the largest FLW of the three intermediary processes occurs, then the balance moves on. At the distribution stage the second smallest FLW occurs before the remaining food balance moves to the consumption stage. The consumption stage represents the household level consumption. The FLW from the consumption stage accounts for 6% of the total agricultural production or 8% of the total food production,

those are both 1% higher than that of the global food mass flow. It is at this stage where the system experiences the second largest FLW. The last output, the largest output for the whole FSC is the results of successful consumption; urine, feces and sweat. Human excreta account for 47% of the total mass of agricultural production and 68% of the food production.

PART III: Discussion & Conclusion

Chapter 6

The food sector is the most vital and the most resource intensive (Moomaw et al, 2010). It doesn't matter which corner of the earth or economic situation we find ourselves in, food means family, culture and survival (Moomaw et al, 2010). Food is a heavily politicized, billion dollar industry and with such significant political, economic and cultural implications, it is logical that the unsustainable aspects of this system stay in the shadows.

This paper aimed to narrow the current information gap regarding food loss and waste on the global scale, by providing an updated summary of the global food mass flow, as well as the mass flow for the global diet; illustrating the food supply chain from farm to feces. The following chapter will provide a quick overview of the results from PART I and PART II, followed by further analysis of the results in the wider context of global food losses and wastes.

Overview – PART I

PART I established the current trends in food losses and wastes across all commodities and the world. Based on the methodology used in the FAO's most current global food loss and waste report, the mass flow for FLW were calculated on a regional basis and then agregated to provide the world total with the most accurately representative results.

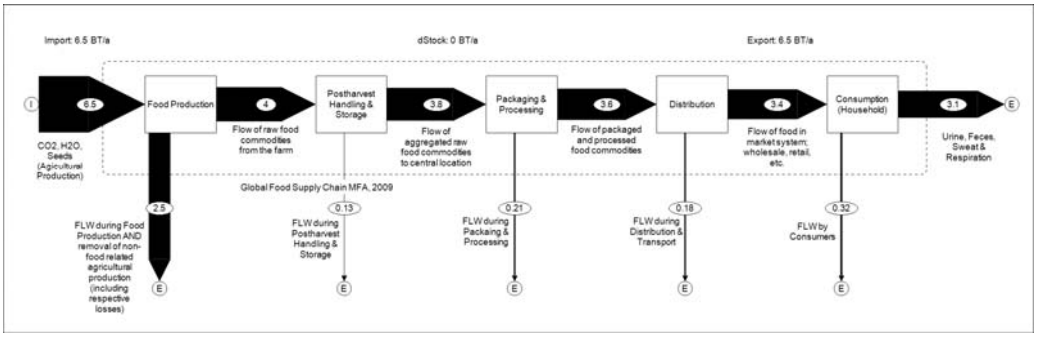

Figure 4: Global food mass flow MFA (2009). BT/a= billion tonnes per year. Numbers are rounded to two significant digits.

The MFA presented in Figure 2 shows that overwhelmingly, the largest system outputs are at the consumption stage human excreta and the food production stage. Where losses at the first stage of the FSC account for 39% of the total input.

When the food production, when condering only the mass of losses associated with food, then on average, 29% of all food is lost or wasted throughout the food chain, that equals the sum of 1.26 billion tonnes per year. The largest FLW occurs in the commodity groups cereal, fruit & vegetables and roots & tubers, accounting for 71% of the total FLW. In terms of total mass produced, these same commodity groups account for 28%, 28% and 13% respectively, and adding to 69% of the total food produced. A hypothesis regarding which commodity groups would experience the most FLW was not made, though the relatively high perishability and high production masses of the commodities within the group fruit & vegetables explains its high fraction of FLW.

The working hypothesis was that the FLW would be of the same magnitude for each stage of the aggregated global FSC, was not entirely correct. While the masses were in the millions of tonnes for each stage, the most FLW overwhelmingly occurs at the food production stage, followed by the consumption stage, packaging & processing, distribution, and finally postharvest handling & storage. The results of the global food mass flow MFA suggest that the need for policy development, action and funding should be increased at earlier stages of the FSC, particularly focusing on reducing the FLW at the agricultural end of the spectrum, the food production stage.

The following tables summarize the findings in terms of waste, prodcution and consumption globally, where consumption figures are generated by subtracting the total waste from total food production for each commodity group.

Table 67: PART I: Overview of global FLW along the food supply chain (2009). A.P.=agricultural production; includes the FLW for FP, F.P.=agricultural production for food only, P.H.H.&S.=postharvest handling & storage, P.&P.=processing and packaging, Dist.=Distribution, Cons.=Consumption. All figures in 1000 tonnes. *39% of the total mass of initial agricultural production inputs are lost.

	A.P. FLW	F.P. FLW	P.H.H.&S. FLW	P.&P. FLW	Dist. FLW	Cons. FLW	**Total FLW**	**% of total FLW**
Cereals	1,089,853	47,843	50,307	131,636	18,584	111,820	**360,190**	**29%**
Roots & Tubers	235,018	105,908	41,138	23,188	18,375	24,686	**213,295**	**17%**
Oilseeds & Pulses	496,467	16,255	8,701	5,480	2,906	3,988	**37,330**	**3%**
Fruit & Vegetables	565,327	199,040	4,860	19,058	95,012	118,636	**436,606**	**25%**
Fish & Seafood	87,195	6,050	2,404	3,516	4,916	3,580	**20,466**	**3%**
Milk	27,561	27,561	24,012	8,086	27,549	31,298	**118,506**	**11%**
Eggs	4,275	4,275	n/a	299	1,960	3,199	**9,733**	**1%**
Meat	16,675	16,675	2,093	13,921	13,967	20,252	**66,908**	**4%**
Total FLW	**2,522,372**	**423,607**	**133,515**	**205,184**	**183,269**	**317,439**	**1,263,034**	
% of total FLW	**39%***	34%	11%	16%	15%	25%		
Available food	-	**4,384,236**	**3,960,629**	**3,827,114**	**3,621,930**	**3,438,661**	**3,121,222**	

Table 68: PART I: Overview of waste, production and consumption trends in the global food supply chain (2009). Waste % of Prod.= % of FLW in terms of total food production, Food Prod.= food production, Cons.=Consumption. All figures in 1000 tonnes and population in 1000 people.

	Total FLW	**Waste % of Prod.**	**Food Prod.**	**Commodity % of total prod.**	**Cons.**	**Population**
Cereals	360,190	**30%**	1,208,012	**28%**	847,822	**6,629,587**
Roots & Tubers	213,295	**36%**	588,170	**13%**	374,875	**Waste/capita** (kg)= 191
Oilseeds & Pulses	37,330	**16%**	230,365	**5%**	193,035	**Prod./capita** (kg)= 661
Fruit & Vegetables	436,606	**36%**	1,226,267	**28%**	789,661	**Cons./capita** (kg)= 471
Fish & Seafood	20,466	**25%**	81,145	**2%**	60,679	**Total Waste**= 29%
Milk	118,506	**17%**	698,596	**16%**	580,090	
Eggs	9,733	**14%**	67,763	**2%**	58,030	
Meat	66,908	**24%**	283,919	**6%**	217,011	
Total FLW	**1,263,034**		**4,384,236**		**3,121,202**	

Overview – PART II

Having established the trends of the total food mass flow, what are the most important foods in the average global diet and how do the flows of FLW from these foods compare to

the global total. Part II established a global diet, by looking at the mass flow of the ten most produced commodities in the world, representing the most important staple foods in the "global diet". These staples were largely represented by commodities within the groups cereals and fruit & vegetables. Starting with the most produced commodity, the global diet consists of the following ten staples; maize, 'other vegetables', wheat, milk, rice, potatoes, cassava, soyabeans, 'other fruit' and tomoatoes.

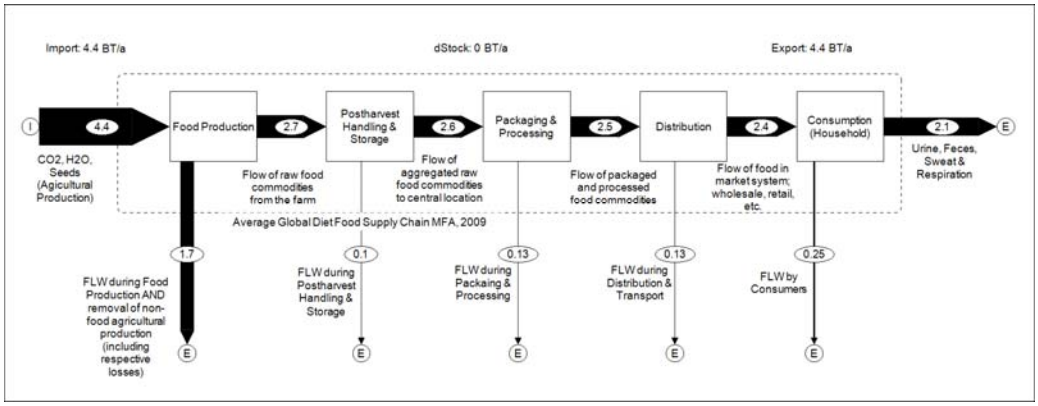

Figure 5: Average Global Diet MFA (2009). BT/a= billion tonnes per year. Numbers are rounded to two significant digits.

The MFA presented in Figure 3 shows that again, the largest system outputs are at the consumption stage human excreta and the agricultural production stage. Where losses at the first stage of the FSC account for 38% of the total input.

When considering only the agricultural prodcution for food, the percentage of total waste compared to production of food remained consistent with that of the entire global food mass flow at 29%. The waste percentages for each stage of the three intermediary stages of the food supply chain remained similar, varrying only within 1% except for the agricultural prodcution stage which showed 3% fewer losses and the consumption stage, which showed 3% more waste in the global diet, accounting for 28% of the total FLW.

The global diet accounts for 68% of the total mass of agricultural production annually, 69% of the total food related agricultural production and 70% of the total FLW. The most FLW occurs in the cereal commodities maize, wheat and rice and make up 35% of the total FLW. The commodities in the group fruit & vegetables account for the second largest proporation of FLW with 33%, followed by roots & tubers, milk and then soyabeans. In terms of production values, the cereals maize, wheat and rice make up the largest share of produciton followed by fruit & vegetatbles and the other commodities.

The following tables summarize the findings in terms of waste, prodcution and consumption globally, where consumption figures are substration of total waste from total production for each commodity group.

Table 69: PART II: Overview of global FLW in the food supply chain for the global diet (2009). A.P.=agricultural production, F.P.=agricultural production for FOOD, P.H.H.&S.=postharvest handling & storage, P.&P.=processing and packaging, Dist.=Distribution, Cons.=Consumption. All figures in 1000 tonnes. *38% of the initial total mass of agricultural production is lost.

	A.P. FLW	F.P. FLW	P.H.H.&S. FLW	P.&P. FLW	Dist. FLW	Cons. FLW	Total FLW	% of total FLW
Fruit & Vegetables	377,724	127,345	4,589	8,954	64,149	84,080	**289,117**	**33%**
Maize	402,551	14,228	25,490	14,092	5,033	45,512	**104,355**	**12%**
Wheat	345,654	13,448	6,381	63,389	6,549	38,018	**127,785**	**15%**
Milk	25,713	25,713	23,503	7,466	27,294	28,760	**112,736**	**13%**
Rice	174,679	14,360	15,678	8,269	6,594	29,294	**74,195**	**8%**
Roots & Tubers	175,566	77,379	25,392	18,571	14,197	19,025	**154,564**	**18%**
Soyabeans	165,581	2,931	34	8,189	1,787	3,101	**16,042**	**2%**
Total	**1,667,468**	**275,404**	**101,067**	**128,930**	**125,603**	**247,790**	**878,794**	
% of total FLW	**38%***	**31%**	**12%**	**15%**	**14%**	**28%**		
Available food	-	3,020,424	2,745,020	2,643,953	2,515,023	2,389,420	**2,141,630**	

Table 70: : PART II: Overview of waste, production and consumption trends in the average global diet food supply chain (2009). Waste % of prod.= % of FLW in terms of total food production, Prod. FOOD=food production, Cons.=Consumption. All figures in 1000 tonnes and population in 1000 people.

	Total FLW	Waste % of prod.	Prod. FOOD	Commodity % of total prod.	Cons.	Population
Fruit & Vegetables	289,117	34%	838,227	28%	549,110	**6,629,587**
Maize	104,355	24%	427,822	14%	323,467	**Waste/capita** (kg)= 133
Wheat	127,785	37%	347,895	12%	220,110	**Prod./capita** (kg)= 456
Milk	112,736	17%	647,647	21%	534,911	**Cons./capita** (kg)= 323
Rice	74,195	26%	283,961	9%	209,766	
Roots & Tubers	154,564	35%	447,295	15%	292,731	
Soyabeans	16,042	58%	27,577	1%	11,535	
Total FLW	**878,794**		**3,020,424**		**2,141,630**	

One of the major shortcomings of this project was the lack of specific commodity related allocation and conversion factors available. With the exception of the cereals commodity

group, with specific conversion factors for maize, wheat and rice, all other commodity FLW was calculated using the same percentages as with the global diet commodity groups. This represents a shortcoming in the results and limits the deviation between the two mass flows. The need for regularly updated and available data is recognized in this field (Parfitt et al, 2010). The global community is starting to recognize and address these issues, not only through international bodies like the FAO, but also through inidvidual government initiatives as well.

Implications of FLW trends

One of the goals of this project as a whole is to identify areas in need of policy and technology measures to better address food losses and waste. The results from PART I and PART II show what is mirrored in the litterature, that in fact the global food system is on an unsustainable trajectory.

It is the food production and consumption stages of the food supply chain that endure the largest proportions of FLW. The problem with solely focusing on only one end of the FSC is that the consumption trends largely dictate the shape of production trends (Moomaw et al, 2010). Therefore there are clear priorities along to address the issue along the food supply chain. First, address the issue at the agicultural end so that a larger portion of food is able to make it futher along the FSC. Seond, address the issue at the consumption end; by addressing the issue directly with consumers and ensuring an efficient supply chain through the intermediary stages to help prolong the value of food at the end.

Food losses and wastes are caused for a variety of different reasons and require a variety of different policy and technical solutions to address them. “Food losses are indicative of poorly functioning and inefficient value chains and food systems, and as such they represent a loss of economic value” (Njie, 2012). At the agricultural end, the food production stage endures the largest losses, predominantly because of the non-food related removal of agricultural production, one of the first issues to address is, that such a large proporation of potential food is being removed from the food system entirely. Of the production designated for food, the largest losses still occure at the food production stage, inidcating a need for better agricultural practices worldwide. In general, some of the factors influencing FLW are the choices, patterns and technologies available for production and processing, the system’s internal infrastructure and capacity, and consumer purchasing and food use practices (Njie, 2012).

The food supply chains of the rural populations in LIC tend to be short (Parfitt et al, 2010), therefore indicating limited postharvest involvement and therefore limiting the FLW that takes place in these stages of the chain. The majority of FLW in LIC, "result from wide-ranging managerial and technical limitations in harvesting teuchniques, storage, transportation, processing, cooling facilities (in difficult climatic conditions), infrastructure, packaging and marketing systems" (Njie, 2012). While the FSC of the urban populations are increasingly complex and more similar to those of MHIC (Parfitt et al, 2010).

The overly complex FSC in the developed MHIC is often championed for the FLW reduction by central processing, while trends in consumer wastage may outweigh the benefits of efficiency (Parfitt et al, 2010). This is particularly true when considering the effort and energy invested to move through the entire food supply chain, each progressive stage of the FSC represents more FLW of higher value and therefore more significant impact (the analysis of which is beyond the scope of this project). The main causes of FLW in MHIC "mainly relate to consumer behaviours as well as to policies and regulations put in place to address other sectoral priorities" (Njie, 2012). At the production end of the spectrum, agricultural subsities are associated with trends in overproduction (Njie, 2012), and the market power of retailers demanding overprodution in case of increased demands on short notice (Parfitt et al, 2010).

The most obviously visible FLW in the system remains at the consumption end of the FSC. Dietary transition is becoming a global driver influencing FLW. Trends in consumption have led to this being the first time in human history, where the number of people who are overweight exceeds the number which are underweight (FAO, 2012). Obesity rates are rising in both LIC and MHIC regions (FAO, 2012). This can be associated with increasing urbanisation and the shifting dietary patterns that follow. "Studies across the developing world show that, as urbanisations occurs and incomes rise, a converdence rowards diets high in resource-intensive saturated fats, sugar and refined foods – often termed the "western diet" occurs –" (Moomaw, 2010). This transition conforms to Bennett's Law (Bennett 1941), where the food share of starchy staples declines as income increases" (Parfitt et al, 2010), and diets diversify to include more fruit and vegetables, meat, fish and dairy.

While there is no significant difference between the trends of FLW in the whole global food mass flow and the food mass flow of the average global diet, the fact that the top ten most

produced commodities account for 70% of the total mass of food losses and wastes globally, better addressing the FSC inefficiencies of these 10 commodities would make a significant difference in the entire food supply chain.

From a nutrient point of view, the largest output from the system are the products of successful consumption; urine, feces and sweat. The mass of human excreta is the largest and in terms of nurtrient recovery, the most important to address. However, the loss of nutrients at the food production stage, is of the same order of magnitde. In terms of nutrient recovery, because a large portion of the losses represented here are non-food related agriculture, recovery here would be less relevant than at post-consumption output. Better addressing and combining the waste treatment of all outputs from the FSC would provide the best opportunity for nutrient recovery and improved system efficency.

The greatest potential for address FLW lies in address the sustainability of the FSC as a whole (Parfitt et al, 2010). Our food system is a global one, and must be treated as such, it cannot be looked at in national or regional isolation. Although it is possible to find contrasts between MHIC and LIC regions, looking at the world food system as a whole allows us to avoid the over-simplification of prodcution and consumption trends. Trends in the food system have significant implications across the board, from health to economics and the environmental (Moomaw et al, 2010).

Looking at the food system as a whole, it is a strategic mix of interventions in at the production and consumption end of the supply chain, from both the public and private spheres with support from NGOs (Moomaw et al, 2010). For LIC this means technology transfer and spread of best practices at the prodcution end, while for MHIC, this could mean the illimination of agricultural subsidies that encourage unsustainable production and consumption choices. Governments can play a role in both LIC and MHIC regions promoting awarness campaigns and adjusting policy measures (Moomaw et al, 2010). Attempting to change consumption behaviour may result in a decrease of food waste, but it is “changes in legislation and business behaviour towards more sustainable food production and consumption” (Parfitt et al, 2010) which are truly necessary for change in FWL. Closing the loop of food supply chains, aiming towards a sustainable approach, where as much of the FLW is repurposed at each stage. Overall there is a need for new strategies and innovative approaches to reduce FLW (Njie, 2012). If the world food system has 1.28 billion tonnes of

waste in a year, 20% of the total food produced, perhaps the economic valuation of food wrong.

While on the one hand we have 1.26 billion tonnes of food losses and waste, on the other hand we have 842 million hungry people and FAO estimating that in order to address food secuirty needs in 2050, 70% more food will be required (Moomaw et al, 2010). While increasing food production is certainly an important area of focus we must take serious steps towards reducing food waste. Increase the mass of the system input and you will increase the mass of all the ouputs as well. If the global food system were a bucket full of water, and the food losses and wastes along the food chain were holes in that bucket, adding more water could only ever be a temporary solution because the water would spray rather than drip out of the holes. In order to fill the bucket, first we have to fix the holes.

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Appendices

Appendix A – Regional Analysis Central & Western Asia

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group North Africa, Central & Western Asia (Gustavsson et al, 2013). All of the data comes from FBS from 2009, for the country groups Central Asia and Western Asia (FAOSTAT, 2014).

A.1: Cereal

Mean Conversion Factor= 0.78

Wheat + rye= 0.78

Maize+ Miller + sorghum= 0.79

Oats + barley + other= 0.78

Allocation Factor=0.6

Table 71: Cereal mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009 for Central Asia and Western Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
78,645	41,760	-7,591	-11,787	101,027
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
35,982	6,438	1,007	3,569	47,674
Milled (K) *	Feed (L) *			
Jx0.78= 37,186	J-K= 10,488			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in Central & Western Asia.

$$\frac{3{,}569(I)}{78{,}645(A) + 41{,}760(B) - 7{,}591(C)} = 3\%$$

Table 72: Waste percentages for cereals in Central & Western Asia, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption

6%	3%	2%(m), 7%(p)	4%	12%

Table 73: Calculation for losses and wastes (1000 tonnes) for cereal in Central & Western Asia - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 78{,}645(A) = 5{,}020$ Allocation factor: $5{,}020 \times 0.6 = \mathbf{3{,}012}$
Postharvest handling & storage	$0.03 \times 78{,}645(A) = 2{,}359$ Allocation factor: $2{,}924 \times 0.6 = \mathbf{1{,}415}$
Processing & packaging	Milling: $0.02 \times 47{,}674(J) = 953$ Industrial Baking: $(37{,}186(K) + 47{,}674(J) - 953) \times 0.07 = 5{,}873$ Total Processing and Packaging: $953 + 5{,}873 = \mathbf{6{,}826}$
Distribution	$(37{,}186(K) + 1{,}007(H) - 953 - 5{,}873) \times 0.04 = \mathbf{1{,}255}$
Consumption	$(37{,}186(K) + 1{,}007(H) - 953 - 5{,}873 - 1{,}255) \times 0.12 = \mathbf{3{,}613}$

A.2: Roots & Tubers

Assumed proportion utilized fresh = 81%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 74: Roots & tubers mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009 for Central Asia and Western Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
15,757	1,187	20	-805	16,160
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
1,759	1,599	75	654	10,859
Fresh (K) *	Processed (L) *			
Jx0.81= 8,796	J-K= 2,063			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total roots & tubers mass flows (1000 tonnes) in Central & Western Asia.

$$\frac{654(I)}{15{,}757(A) + 1{,}187(B) + 20(C)} = 4\%$$

Table 75: Waste percentages for roots & tubers in Central & Western Asia, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	4%	12%	4%(f), 2%(p)	6%(f), 3%(p)

Table 76: Calculation for losses and wastes (1000 tonnes) for roots & tubers in Central & Western Asia - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 15{,}757(A) = 1{,}006$ Conversion factor: $1{,}006 \times 0.82 = \mathbf{825}$
Postharvest handling & storage	$0.04 \times 15{,}757(A) = 630$ Conversion factor: $630 \times 0.82 = \mathbf{517}$
Processing & packaging	$0.12 \times (75(H) + 2{,}063(L)) = 257$ Conversion factor: $257 \times 0.9 = \mathbf{231}$
Distribution	Processed: $0.02 \times (75(H) + 2{,}063(L) - 257) = 38$ Conversion factor: $38 \times 0.9 = 34$ Fresh: $0.04 \times 8{,}796\ (K) = 352$ Conversion factor: $352 \times 0.74 = 260$ Total distribution: $34 + 260 = \mathbf{294}$
Consumption	Processed: $0.03 \times (75(H) + 2{,}063(L) - 257 - 38) = 55$ Conversion factor: $55 \times 0.9 = 50$ Fresh: $0.06 \times (8{,}796\ (K) - 352) = 507$ Conversion factor: $507 \times 0.74 = 375$ Total consumption: $50 + 375 = \mathbf{425}$

A.3: Oilseeds & Pulses

Allocation Factor=0.12

Table 77: Oilcrops & pulses mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009.

OILCROPS & PULSES				
Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)

12,135	6,310	-117	-1,344	16,983
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
1,385	383	9,729	773	4,314

Table 78: Vegetable oils mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009.

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)
2,409	3,605	-86	-817	5,112
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
0	0	20	1,430	5,112

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in Central & Western Asia.

$$\frac{773(I)}{12{,}135(A) + 6{,}310(B) - 117(C)} = 4\%$$

Table 79: Waste percentages used for oilcrops & pulses in Central & Western Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
15%	4%	8%	2%	2%

Table 80: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in Central & Western Asia – taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.15}{1-0.15} \times 12{,}135(A) = 2{,}141$ Allocation factor: $2{,}141 \times 0.12 = \mathbf{257}$
Postharvest handling & storage	Oil crops & pulses: $0.04 \times 12{,}135(A) = 485$ Allocation factor: $485 \times 0.12 = \mathbf{58}$
Processing & packaging	Vegetable Oil: $(0.08 \times 20(R)) + ((\frac{0.08}{1-0.08}) \times 5{,}112(T)) = \mathbf{446}$
Distribution	Vegetable Oil: $0.02 \times (4{,}314(J) + 5{,}112(T) + 20(R) - 446) = \mathbf{180}$
Consumption	Vegetable Oil:

	$0.02 \times (4{,}314(J) + 5{,}112(T) + 20(R) - 446 - 180) = \mathbf{176}$

A.4: Fruit & Vegetables

Assumed proportion utilized fresh = 50%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 81: Fruit & vegetable mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
82,874	8,672	152	-12,731	78,967
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
5,309	21	1,164	932	63,008
Fresh (K)	Processed (L)			
Jx0.5= 31,504	=J-K =31,504			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in Central & Western Asia.

$$\frac{932(I)}{82{,}874(A) + 8{,}672(B) + 152(C)} = 0.1\%$$

Table 82: Waste percentages used for fruit & vegetables in Central & Western Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
17%	0.1%	20%	15%(f), 3%(p)	12%(f), 1%(p)

Table 83: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in Central & Western Asia – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.17}{1 - 0.17} \times 82{,}874(A) = 16{,}974$ Allocation factor: $16{,}974 \times 0.77 = \mathbf{13{,}070}$
Postharvest handling &	$0.001 \times 82{,}874(A) = 83$

storage	Allocation factor: $83 \times 0.77 = \mathbf{64}$
Processing & packaging	$0.2 \times \left(1{,}164(H) + 31{,}504(L)\right) = 6{,}534$ Conversion factor: $6{,}534 \times 0.75 = \mathbf{4{,}901}$
Distribution	Processed: $0.03 \times (1{,}164(H) + 31{,}504(L) - 6{,}534) = 784$ Conversion factor: $784 \times 0.75 = 588$ Fresh: $0.15 \times 31{,}504(K) = 4{,}726$ Conversion factor: $4{,}726 \times 0.8 = 3{,}781$ Total distribution: $588 + 3{,}781 = \mathbf{4{,}369}$
Consumption	Processed: $0.01 \times (1{,}164(H) + 31{,}504(L) - 6{,}534 - 784) = 254$ Conversion factor: $254 \times 0.75 = 191$ Fresh: $0.12 \times (31{,}504(K) - 4{,}726) = 3{,}213$ Conversion factor: $3{,}213 \times 0.8 = 2{,}570$ Total consumption: $191 + 2{,}570 = \mathbf{2{,}761}$

A.5: Fish & Seafood

Assumed proportion utilized fresh = 60%

Mean Conversion Factor= 0.5

Table 84: Fish & Seafood mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
1,281	1,375	3	-306	2,353
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
635	4	0	86	1,628
Fresh (K)	Processed (L)			
Jx0.6 =977	=J-K =651			

Table 85: Waste percentages used for fish & seafood in Central & Western Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
7%	5%	9%	10%(f), 5%(p)	4%(f), 2%(p)

Table 86: Calculation for losses and wastes (1000 tonnes) for fish & seafood in Central & Western Asia – taking into account waste percentages, conversion and allocation factors. *note this number comes directly out of the SIK report (Gustavsson et al, 2013).

Food Production	240* Conversion factor: $240 \times 0.5 = \mathbf{120}$
Postharvest handling & storage	$0.05 \times 1{,}281(A) = 64$ Conversion factor: $64 \times 0.5 = \mathbf{32}$
Processing & packaging	$0.09 \times (0(H) + 651(L)) = 59$ Conversion factor: $59 \times 0.5 = \mathbf{30}$
Distribution	Processed: $0.05 \times (0(H) + 651(L) - 59) = 30$ Conversion factor: $30 \times 0.5 = 15$ Fresh: $0.1 \times 977(K) = 98$ Conversion factor: $98 \times 0.5 = 49$ Total distribution: $15 + 49 = \mathbf{64}$
Consumption	Processed: $0.02 \times (0(H) + 651(L) - 59 - 30) = 11$ Conversion factor: $11 \times 0.5 = 6$ Fresh: $0.04 \times (977(K) - 98) = 35$ Conversion factor: $35 \times 0.5 = 18$ Total consumption: $6 + 18 = \mathbf{24}$

A.6: Milk

Table 87: Milk mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
37,353	61,71	166	-2,307	41,384
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
7,551	0	7	884	32,019

Table 88: Waste percentages used for milk in Central & Western Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
3.5%	6%	2%	8%	2%

Table 89: Calculation for losses and wastes (1000 tonnes) for milk in Central & Western Asia.

Food Production	$\frac{0.035}{1 - 0.035} \times 37{,}353(A) = \mathbf{1{,}355}$

Postharvest handling & storage	$0.06 \times 37{,}353(A) = \mathbf{2{,}241}$
Processing & packaging	$0.02 \times (7(H) + 32{,}019(J)) = \mathbf{641}$
Distribution	$0.08 \times (7(H) + 32{,}019(J) - 641) = \mathbf{2{,}511}$
Consumption	$0.02 \times (7(H) + 32{,}019(J) - 641 - 2{,}511) = \mathbf{577}$

A.7: Eggs

Table 90: Eggs mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
2,123	91	0	-142	2,072
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
48	193	0	54	1,671

Table 91: Waste percentages used for eggs in Central & Western Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
8%	n/a	0.2%	3%	2%

Table 92: Calculation for losses and wastes (1000 tonnes) for eggs in Central & Western Asia.

Food Production	$\frac{0.08}{1 - 0.08} \times 2{,}123(A) = \mathbf{185}$
Postharvest handling & storage	n/a
Processing & packaging	$0.002 \times 1{,}671(J) = \mathbf{3}$
Distribution	$0.03 \times (1{,}671(J) - 3) = \mathbf{50}$
Consumption	$0.02 \times (1{,}671(J) - 3 - 50) = \mathbf{32}$

A.8: Meat

Table 93: Total meat mass flow through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown in tables below.

Supply Elements				
Animals arrived at SH (K)	Animals transported to SH (L)	Animals at farm (M)		
60	23	1,920		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
7,451	2,317	9	-280	9,498
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
7	0	1	211	9,238

Table 94: Meat mass flow by type of livestock through the food supply chain in Central & Western Asia (1000 tonnes), from FBS 2009.

	Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manufacture (H)	Other Uses (I)	Food (J)
Cattle meat	2,209	433	1	44	2,599	7	0	0	83	2,489
Mutton & Goat	1,322	131	0	10	1,443	0	0	0	6	1,418
Pig meat	341	144	0	13	471	0	0	0	24	448
Poultry	3,397	1,594	10	209	4,793	0	0	1	85	4,703
Other Meat	182	15	-2	4	192	0	0	0	13	180
Total meat	**7,451**	**2,317**	**9**	**280**	**9,498**	**7**	**0**	**1**	**211**	**9,238**

Table 95: Waste percentages used for meat by type of livestock in Central & Western Asia (Gustavsson, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat (turkey)
Food Production	20%					
Losses during breeding		10%	15%	8%	8%	8%
Postharvest Handling & Storage	1%					
Transport to the slaughter-house		0.1%	0.1%	0.4%	0.5%	0.5%
Rejection at the slaughter-house		0.3%	0.3%	0.06%	1.3%	1.3%
Processing	5%					
Distribution	5%					
Consumption	8%					

Table 96: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in Central & Western Asia. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson, 2013). CW=carcass weight.

	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Cattle meat	2,209	9,165,975	241
Mutton & Goat	1,322	88,133,333	15
Pig meat	341	3,875,000	88
Poultry	3,397	2,264,666,667	1.5
Other Meat (turkey)	182	24,931,507	7.3
Total	7,451		

Table 97: Cattle losses during production and postharvest handling & storage (number of heads).

Cattle	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 9{,}165{,}975 = 27{,}581$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (9{,}165{,}975 + 27{,}581) = 9{,}203$
	During breeding:
	$\frac{0.1}{1-0.1} \times (9{,}165{,}975 + 27{,}581 + 9{,}203) = 1{,}022{,}529$

Table 98: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 88{,}133{,}333 = 250{,}150$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (88{,}133{,}333 + 250{,}150) = 83{,}467$
	During breeding:
	$\frac{0.15}{1-0.15} \times (88{,}133{,}333 + 250{,}150 + 83{,}467) = 88{,}466{,}950$

Table 99: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0006}{1-0.0006} \times 3{,}875{,}000 = 2{,}326$
	Transportation to slaughterhouse:
	$\frac{0.004}{1-0.004} \times (3{,}875{,}000 + 2{,}326) = 15{,}572$
	During breeding:
	$\frac{0.08}{1-0.08} \times (3{,}875{,}000 + 2{,}326 + 15{,}572) = 338{,}513$

Table 100: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 2{,}264{,}666{,}667 = 29{,}828{,}436$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (2{,}264{,}666{,}667 + 29{,}828{,}436) = 11{,}530{,}126$
	During breeding:

	$\frac{0.08}{1-0.08} \times (2{,}264{,}666{,}667 + 29{,}828{,}436 + 11{,}530{,}126) = 200{,}523{,}933$

Table 101: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other meat (turkey)	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 24{,}931{,}507 = 328{,}379$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (24{,}931{,}507 + 328{,}379) = 126{,}934$
	During breeding:
	$\frac{0.08}{1-0.08} \times (24{,}931{,}507 + 328{,}379 + 126{,}934) = 2{,}207{,}550$

Table 102: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		Transport to Slaughterhouse		During Breeding	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	27,581	6.6	9,203	2.2	1,022,529	246
Mutton & Goat	250,150	3.7	83,467	1.2	88,466,950	1,327
Pig meat	2,326	0.2	15,572	1.3	338,513	30
Poultry	29,828,436	45	11,530,126	17	200,523,933	301
Other Meat (turkey)	328,379	2.4	126,934	0.9	2,207,550	16
Total		60		23		1,920

Weighted waste percentage for production:

$$\frac{1{,}920}{7{,}451(A) + 1{,}920} = 20\%$$

Weighted waste percentage for postharvest handling and storage:

$$\frac{60 + 23}{7{,}451(A) + 60 + 23} = 1\%$$

Table 103: Calculation for losses and wastes (1000 tonnes) for meat in Central & Western Asia – taking into account waste percentages, conversion and allocation factors.

Food Production	$\mathbf{1{,}920}$ (see table 104).
Postharvest handling & storage	$60 + 23 = \mathbf{83}$ (see table 104).
Processing & packaging	$0.05 \times \big(1(H) + 9{,}238(J)\big) = \mathbf{462}$
Distribution	$0.05 \times (1(H) + 9{,}238(J) - 462) = \mathbf{459}$
Consumption	$0.08 \times (1(H) + 9{,}238(J) - 462 - 459) = \mathbf{668}$

Summary of FLW in Central & Western Asia

Table 104: Summary of FLW for Central & Western Asia (2009). *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***36% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Cereals	34,470	3,012	1,415	6,826	1,255	3,613	**16,121**	**29%**
Roots & Tubers	3,661	825	517	231	294	425	**2,292**	**4%**
Oilseeds & Pulses	13,056	257	58	446	180	176	**1,117**	**2%**
Fruit & Vegetables	32,131	13,070	64	4,901	4,369	2,761	**25,165**	**45%**
Fish & Seafood	761	120	32	30	64	24	**270**	**0%**
Milk	1,355	1,355	2,241	641	2,511	577	**7,325**	**13%**
Eggs	185	185	n/a	3	50	32	**270**	**0%**
Meat	1,920	1,920	83	462	459	668	**3,592**	**6%**
Total FLW	**87,539**	**20,744**	**4,410**	**13,540**	**9,182**	**8,276**	**56,152**	
% of total FLW	**36%*** **	**37%**	**8%**	**24%**	**16%**	**15%**		

This table shows that for Central & Western Asia, the commodity group with the largest proporation of FLW is fruit & vegetables, followed by cereal and milk, where these three commodity groups account for 87% of all FLW. While for the FSC, 37% of all FLW takes place at the agricultural stage, 24% at the packaging and processing stage and 16% at distribution stage, the consumption stage accounts for 15% of all FLW. A total of 56,152 kilotonnes is lost or wasted in the Central & Western Asian FSC annually, this represents 32% of the total production of food.

Appendix B: Latin America

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group Latin America (Gustavsson et al, 2013). All of the data

comes from FBS from 2009, for the country groups Central America and South America (FAOSTAT, 2014).

B.1: Cereal

Mean Conversion Factor= 0.78

Wheat + rye= 0.78

Maize+ Miller + sorghum= 0.79

Oats + barley + other= 0.78

Allocation Factor=0.4

Table 105: Cereal mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009 for Central America and Southern America (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
153,470	46,028	6,726	-36,660	169,565
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
73,522	2,521	6,767	4,194	69,249
Milled (K) *	Feed (L) *			
54,014	15,235			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in Latin America.

$$\frac{4{,}194(I)}{153{,}470(A) + 46{,}028(B) + 6{,}726(C)} = 2\%$$

Table 106: Waste percentages for cereals in Latin America, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	2%	2%(m), 7%(p)	4%	10%

Table 107: Calculation for losses and wastes (1000 tonnes) for cereal in Latin America - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 153{,}470(A) = 9{,}796$ Allocation factor: $9{,}796 \times 0.4 = \mathbf{3{,}918}$
Postharvest	$0.02 \times 153{,}470(A) = 3{,}069$

handling & storage	Allocation factor: $3{,}069 \times 0.4 = \mathbf{1{,}228}$
Processing & packaging	Milling: $0.02 \times 69{,}249(J) = 1{,}385$ Industrial Baking: $(54{,}014(K) + 69{,}249(J) - 1{,}385) \times 0.07 = 8{,}531$ Total Processing and Packaging: $1{,}385 + 8{,}531 = \mathbf{9{,}916}$
Distribution	$(54{,}014(K) + 6{,}767(H) - 1{,}385 - 8{,}531) \times 0.04 = \mathbf{2{,}035}$
Consumption	$(54{,}014(K) + 6{,}767(H) - 1{,}385 - 8{,}531 - 2{,}035) \times 0.1 = \mathbf{4{,}883}$

B.2: Roots & Tubers

Assumed proportion utilized fresh = 20%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 108: Roots & tubers mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009 for Central America and Southern America (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
51,130	1,637	-67	-975	51,725
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
14,689	1,504	93	2,597	27,454
Fresh (K) *	Processed (L) *			
5,491	21,963			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total roots & tubers mass flows (1000 tonnes) in Latin America.

$$\frac{2{,}597(I)}{51{,}130(A) + 1{,}637(B) - 67(C)} = 5\%$$

Table 109: : Waste percentages for roots & tubers in Latin America, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
14%	5%	12%	3%(f), 3%(p)	4%(f), 2%(p)

Table 110: Calculation for losses and wastes (1000 tonnes) for roots & tubers in Latin America - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.14}{1-0.14} \times 51{,}130(A) = 8{,}323$ Conversion factor: $8{,}323 \times 0.82 = \mathbf{6{,}825}$
Postharvest handling & storage	$0.05 \times 51{,}130(A) = 2{,}557$ Conversion factor: $2{,}557 \times 0.82 = \mathbf{2{,}097}$
Processing & packaging	$0.12 \times (93(H) + 21{,}963(L)) = 2{,}647$ Conversion factor: $2{,}647 \times 0.9 = \mathbf{2{,}382}$
Distribution	Processed: $0.03 \times (93(H) + 21{,}963(L) - 2{,}647) = 582$ Conversion factor: $582 \times 0.9 = 524$ Fresh: $0.03 \times 5{,}491\ (K) = 165$ Conversion factor: $165 \times 0.74 = 122$ Total distribution: $524 + 122 = \mathbf{646}$
Consumption	Processed: $0.02 \times (93(H) + 21{,}963(L) - 2{,}647 - 582) = 377$ Conversion factor: $377 \times 0.9 = 339$ Fresh: $0.04 \times (5{,}491(K) - 165) = 213$ Conversion factor: $213 \times 0.74 = 158$ Total consumption: $339 + 158 = \mathbf{497}$

B.3: Oilseeds & Pulses

Allocation Factor= 0.12

Table 111: Oilcrops & pulses mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009.

OILCROPS & PULSES				
Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
115,236	8,967	13,208	-38,881	98,530
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,225	2,625	82,179	1,112	10,897

Table 112: Vegetable oils mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009.

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)

18,485	3,243	-1,090	-9,303	11,335
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
0	0	40	4,248	7,241

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in Latin America.

$$\frac{1{,}112(I)}{115{,}236(A) + 8{,}967(B) + 13{,}208(C)} = 0.8\%$$

Table 113: Waste percentages used for oilcrops & pulses in Latin America (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	0.8%	8%	2%	2%

Table 114: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in Central & Western Asia – taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.06}{1-0.06} \times 115{,}236(A) = 7{,}355$ Allocation factor: $7{,}355 \times 0.12 = \mathbf{883}$
Postharvest handling & storage	Oil crops & pulses: $0.008 \times 115{,}236(A) = 922$ Allocation factor: $922 \times 0.12 = \mathbf{111}$
Processing & packaging	Vegetable Oil: $(0.08 \times 40(R)) + ((\frac{0.08}{1-0.08}) \times 7{,}241(T)) = \mathbf{633}$
Distribution	Vegetable Oil: $0.02 \times (10{,}897(J) + 7{,}241(T) + 40(R) - 633) = \mathbf{351}$
Consumption	Vegetable Oil: $0.02 \times (10{,}897(J) + 7{,}241(T) + 40(R) - 633 - 351) = \mathbf{344}$

B.4: Fruit & Vegetables

Assumed proportion utilized fresh = 50%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 115: Fruit & vegetable mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
141,619	6,238	-279	-43,766	103,812
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
841	34	4,069	51	84,161
Fresh (K) *	Processed (L) *			
Jx0.5= 42,081	J-K= 42,081			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in Latin America.

$$\frac{51(I)}{141{,}619(A) + 6{,}238(B) - 279(C)} = 0.03\%$$

Table 116: Waste percentages used for fruit & vegetables in Latin America, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
20%	0.03%	20%	12%(f), 2%(p)	10%(f), 1%(p)

Table 117: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in Latin America – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.2}{1-0.2} \times 141{,}619(A) = 35{,}405$ Allocation factor: $35{,}405 \times 0.77 = \mathbf{27{,}262}$
Postharvest handling & storage	$0.0003 \times 141{,}619(A) = 42$ Allocation factor: $42 \times 0.77 = \mathbf{32}$
Processing & packaging	$0.2 \times \left(4{,}069(H) + 42{,}081(L)\right) = 9{,}230$ Conversion factor: $9{,}230 \times 0.75 = \mathbf{6{,}923}$
Distribution	Processed: $0.02 \times (4{,}069(H) + 42{,}081(L) - 9{,}230) = 738$ Conversion factor: $738 \times 0.75 = 554$ Fresh: $0.12 \times 42{,}081(K) = 5{,}050$ Conversion factor: $5{,}050 \times 0.8 = 4{,}040$ Total distribution: $554 + 4{,}040 = \mathbf{4{,}594}$
Consumption	Processed: $0.01 \times (4{,}069(H) + 42{,}081(L) - 9{,}230 - 738) = 362$ Conversion factor: $362 \times 0.75 = 272$

	Fresh: $0.1 \times (42{,}081(K) - 5{,}050) = 3{,}703$ Conversion factor: $3{,}703 \times 0.8 = 2{,}962$ Total consumption: $272 + 2{,}962 = \mathbf{3{,}234}$

B.5: Fish & Seafood

Assumed proportion utilized fresh = 60%

Mean Conversion Factor= 0.5

Table 118: Fish & Seafood mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
17,736	1,907	89	-11,769	7,961
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,327	0	0	344	5,290
Fresh (K)*	Processed (L)*			
Jx0.6= 3,174	J-K= 2,116			

Table 119: Waste percentages used for fish & seafood in Latin America, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
5.7%	5%	9%	10%(f), 5%(p)	4%(f), 2%(p)

Table 120: Calculation for losses and wastes (1000 tonnes) for fish & seafood in Latin America – taking into account waste percentages, conversion and allocation factors. *note this number comes directly out of the SIK report (Gustavsson et al, 2013).

Food Production	920* Conversion factor: $920 \times 0.5 = \mathbf{460}$
Postharvest handling & storage	$0.05 \times 17{,}736(A) = 887$ Conversion factor: $887 \times 0.5 = \mathbf{443}$
Processing & packaging	$0.09 \times (0(H) + 2{,}116(L)) = 190$ Conversion factor: $190 \times 0.5 = \mathbf{95}$
Distribution	Processed: $0.05 \times (0(H) + 2{,}116(L) - 190) = 96$ Conversion factor: $96 \times 0.5 = 48$ Fresh: $0.1 \times 3{,}174(K) = 317$ Conversion factor: $317 \times 0.5 = 159$

	Total distribution: $48 + 159 = \mathbf{207}$
Consumption	Processed: $0.02 \times (0(H) + 2{,}116(L) - 190 - 96) = 37$ Conversion factor: $37 \times 0.5 = 18$ Fresh: $0.04 \times (3{,}174(K) - 317) = 114$ Conversion factor: $114 \times 0.5 = 57$ Total consumption: $18 + 57 = \mathbf{75}$

B.6: Milk

Table 121: Milk mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
75,624	7,135	22	-4,674	78,105
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
7,563	0	40	629	66,877

Table 122: Waste percentages used for milk in Latin America (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
3.5%	6%	2%	8%	4%

Table 123: Calculation for losses and wastes (1000 tonnes) for milk in Latin America.

Food Production	$\frac{0.035}{1 - 0.035} \times 75{,}624(A) = \mathbf{2{,}743}$
Postharvest handling & storage	$0.06 \times 75{,}624(A) = \mathbf{4{,}537}$
Processing & packaging	$0.02 \times (40(H) + 66{,}877(J)) = \mathbf{1{,}338}$
Distribution	$0.08 \times (40(H) + 66{,}877(J) - 1{,}338) = \mathbf{5{,}246}$
Consumption	$0.04 \times (40(H) + 66{,}877(J) - 1{,}338 - 5{,}246) = \mathbf{2{,}413}$

B.7: Eggs

Table 124: Eggs mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009.

Supply Elements

Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
6,825	39	0	-68	6,796
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
0	737	0	0	5,607

Table 125: Waste percentages used for eggs in Latin America (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	n/a	0.5%	4%	4%

Table 126: Calculation for losses and wastes (1000 tonnes) for eggs in Latin America.

Food Production	$\frac{0.06}{1-0.06} \times 6{,}825(A) = \mathbf{436}$
Postharvest handling & storage	n/a
Processing & packaging	$0.005 \times 5{,}607(J) = \mathbf{28}$
Distribution	$0.04 \times (5{,}607(J) - 28) = \mathbf{223}$
Consumption	$0.04 \times (5{,}607(J) - 28 - 223) = \mathbf{214}$

B.8: Meat

Table 127: Total meat mass flow through the food supply chain in Latin America (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown in tables below.

Supply Elements				
Animals arrived at SH (K)	Animals transported to SH (L)	Animals at farm (M)		
374	131	2,669		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
44,089	2,777	12	-8,503	38,441
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
5	0	4	675	37,075

Table 128: Meat mass flow by type of livestock through the food supply chain in Latin America (1000 tonnes), from FBS 2009.

	Prod-uction (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manu-facture (H)	Other Uses (I)	Food (J)
Cattle Meat	17,511	766	11	3,239	15,116	0	0	0	0	14,482
Mutton & Goat	419	28	0	38	409	0	0	0	0	396
Pig meat	6,189	855	0	1,138	5,906	0	0	0	0	5,880
Poultry	19,431	1,113	1	4,010	16,535	0	0	4	675	15,836
Other Meat	539	15	0	78	475	5	0	0	0	481
Total Meat	**44,089**	**2,777**	**12**	**8,503**	**38,441**	**5**	**0**	**4**	**675**	**37,075**

Table 129: Waste percentages used for meat by type of livestock in Latin America (Gustavsson, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat
Food Production	6%					
Losses during breeding		5%	10%	6%	6%	6%
Postharvest Handling & Storage	1%					
Transport to the slaughter-house		0.02%	0.1%	0.4%	0.5%	0.5%
Rejection at the slaughter-house		0.6%	0.3%	0.06%	1.3%	1.3%
Processing	5%					
Distribution	5%					
Consumption	6%					

Table 130: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in Latin America. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson, 2013). CW=carcass weight.

	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Cattle meat	17,511	72,659,751	241
Mutton & Goat	419	27,933,333	15
Pig meat	6,189	70,329,545	88
Poultry	19,431	12,954,000,000	1.5
Other Meat (turkey)	539	73,835,616	7.3
Total	44,089		

Table 131: Cattle losses during production and postharvest handling & storage (number of heads).

C a	*Rejection at slaughterhouse:*

	$\frac{0.006}{1-0.006} \times 72{,}659{,}751 = 438{,}590$
	Transportation to slaughterhouse:
	$\frac{0.0002}{1-0.0002} \times (72{,}659{,}751 + 438{,}590) = 14{,}623$
	During breeding:
	$\frac{0.05}{1-0.05} \times (72{,}659{,}751 + 438{,}590 + 14{,}623) = 3{,}848{,}051$

Table 132: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 27{,}933{,}333 = 84{,}052$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (27{,}933{,}333 + 84{,}052) = 28{,}045$
	During breeding:
	$\frac{0.1}{1-0.1} \times (27{,}933{,}333 + 84{,}052 + 28{,}045) = 3{,}116{,}159$

Table 133: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0006}{1-0.0006} \times 70{,}329{,}545 = 42{,}223$
	Transportation to slaughterhouse:
	$\frac{0.004}{1-0.004} \times (70{,}329{,}545 + 42{,}223) = 282{,}618$
	During breeding:
	$\frac{0.06}{1-0.06} \times (70{,}329{,}545 + 42{,}223 + 282{,}618) = 4{,}509{,}854$

Table 134: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 12{,}954{,}000{,}000 = 170{,}620{,}061$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (12{,}954{,}000{,}000 + 170{,}620{,}061) = 65{,}952{,}865$
	During breeding:
	$\frac{0.06}{1-0.06} \times (12{,}954{,}000{,}000 + 170{,}620{,}061 + 65{,}952{,}865) = 841{,}951{,}463$

Table 135: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other meat (turkey)	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 73{,}835{,}616 = 972{,}506$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (73{,}835{,}616 + 972{,}506) = 375{,}920$
	During breeding:
	$\frac{0.06}{1-0.06} \times (73{,}835{,}616 + 972{,}506 + 375{,}920) = 4{,}798{,}981$

Table 136: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		Transport to Slaughterhouse		During Breeding	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	438,590	106	14,623	3.5	3,848,051	927
Mutton & Goat	84,052	1.2	28,045	0.4	3,116,159	47
Pig meat	42,223	3.7	282,618	25	4,509,854	397
Poultry	170,620,061	256	65,952,865	99	841,951,463	1,263
Other Meat (turkey)	972,506	7	375,920	2.7	4,798,981	35
Total		374		131		2,669

Weighted waste % for production:

$$\frac{2{,}669}{44{,}089(A) + 2{,}669} = 6\%$$

Weighted waste % postharvest handling and storage:

$$\frac{374 + 131}{44{,}089(A) + 374 + 131} = 1\%$$

Table 137: Calculation for losses and wastes (1000 tonnes) for meat in Latin America – taking into account waste percentages, conversion and allocation factors.

Food Production	$\mathbf{2,669}$ (see table 137).
Postharvest handling & storage	$374 + 131 = \mathbf{505}$ (see table 137).
Processing & packaging	$0.05 \times \big(4(H) + 37{,}075(J)\big) = \mathbf{1,854}$
Distribution	$0.05 \times (4(H) + 37{,}075(J) - 1{,}854) = \mathbf{1,761}$
Consumption	$0.06 \times (4(H) + 37{,}075(J) - 1{,}854 - 1{,}761) = \mathbf{2,008}$

Summary of FLW in Latin America

Table 138: Summary of FLW for Latin America (2009). *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***49% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Agricultural Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW**	**% of total FLW**
Cereals	96,000	3,918	1,228	9,916	2,035	4,883	**21,980**	**21%**

Roots & Tubers	16,028	6,825	2,097	2,382	646	497	**12,447**	**12%**
Oilseeds & Pulses	118,557	883	111	633	351	344	**2,322**	**2%**
Fruit & Vegetables	59,834	27,262	32	6,923	4,594	3,234	**42,045**	**40%**
Fish & Seafood	9,328	460	443	190	207	75	**1,375**	**1%**
Milk	2,743	2,743	4,537	1,338	5,246	2,413	**16,277**	**15%**
Eggs	436	436	n/a	28	223	214	**901**	**1%**
Meat	2,669	2,669	505	1,854	1,761	2,008	**8,797**	**8%**
Total FLW	**305,596**	**45,196**	**8,953**	**23,264**	**15,063**	**13,668**	**106,144**	
% of total FLW	**49%*** **	**43%**	**8%**	**22%**	**14%**	**13%**		

This table shows that for Latin America, the commodity group with the largest proporation of FLW is fruit & vegetables, followed by cereal and milk, where these three commodity groups account for 76% of all FLW. While for the FSC, 43% of all FLW takes place at the agricultural stage, 22% at the packaging and processing stage and 14% at distribution stage, the consumption stage accounts for 13% of all FLW. A total of 106,144 kilotonnes is lost or wasted in the Central & Western Asian FSC annually, this represents 29% of the total production of food.

Appendix C: South & Southeast Asia

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group Southern & Southeast Asia (Gustavsson et al, 2013). All of the data comes from FBS from 2009, for the country groups Southern Asia and Southeast Asia (FAOSTAT, 2014).

C.1: Cereal

Mean Conversion Factor=0.84

Wheat + rye: 0.78

Maize+ Miller + sorghum: 0.79

Oats + barley + other: 0.78

Rice: 1

Allocation Factor= 0.67

Table 139: Cereal mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009 for Southern Asia and Southeast Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
471,373	40,764	-17,701	-26,650	467,786
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
49,192	12,801	2,361	31,121	346,605
Milled (K) *	Feed (L) *			
Jx0.84= 291,148	J-K= 55,457			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in South & Southeast Asia.

$$\frac{31{,}121(I)}{471{,}373(A) + 40{,}764(B) - 17{,}701(C)} = 6\%$$

Table 140: Waste percentages for cereals in South & Southeast Asia, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	3%	3.5%(m), 3.5%(p)	4%	12%

Table 141: Calculation for losses and wastes (1000 tonnes) for cereal South & Southeast Asia - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1-0.06} \times 471{,}373(A) = 30{,}088$ Allocation factor: $30{,}088 \times 0.67 = \mathbf{20{,}159}$
Postharvest handling & storage	$0.06 \times 471{,}373(A) = 28{,}282$ Allocation factor: $28{,}282 \times 0.67 = \mathbf{18{,}949}$
Processing & packaging	Milling: $0.035 \times 346{,}605(J) = 12{,}131$ Industrial Baking: $(291{,}148(K) + 346{,}605(J) - 12{,}131) \times 0.035 = 21{,}897$ Total Processing and Packaging: $12{,}131 + 21{,}897 = \mathbf{34{,}028}$
Distribution	$(291{,}148(K) + 2{,}361(H) - 12{,}131 - 21{,}897) \times 0.02 = \mathbf{5{,}190}$
Consumption	$(291{,}148(K) + 2{,}361(H) - 12{,}131 - 21{,}897 - 5{,}190) \times 0.03 = \mathbf{7{,}629}$

C.2: Roots & Tubers

Assumed proportion utilized fresh = 90%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 142: Roots & tubers mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009 for Southern Asia and Southeast Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
136,034	4,590	-54	-22,177	118,394
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
9,170	4,243	15	20,593	70,756
Fresh (K) *	Processed (L) *			
Jx0.9= 63,680	J-K= 7,076			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total roots & tubers mass flows (1000 tonnes) in Central & Western Asia.

$$\frac{20{,}593(I)}{136{,}034(A) + 4{,}590(B) - 54(C)} = 15\%$$

Table 143: Waste percentages for roots & tubers in South & Southeast Asia, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	15%	10%	11%(f), 8%(p)	3%(f), 5%(p)

Table 144: Calculation for losses and wastes (1000 tonnes) for roots & tubers in South & Southeast Asia - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.06}{1 - 0.06} \times 136{,}034(A) = 8{,}683$ Conversion factor: $8{,}683 \times 0.82 = \mathbf{7{,}120}$
Postharvest handling &	$0.15 \times 136{,}034(A) = 20{,}405$

storage	Conversion factor: $20{,}405 \times 0.82 = \mathbf{16{,}732}$
Processing & packaging	$0.1 \times (15(H) + 7{,}076(L)) = 709$ Conversion factor: $709 \times 0.9 = \mathbf{638}$
Distribution	Processed: $0.08 \times (15(H) + 7{,}076(L) - 709) = 511$ Conversion factor: $511 \times 0.9 = 460$ Fresh: $0.11 \times 63{,}680\ (K) = 7{,}005$ Conversion factor: $7{,}005 \times 0.74 = 5{,}184$ Total distribution: $460 + 5{,}184 = \mathbf{5{,}644}$
Consumption	Processed: $0.05 \times (15(H) + 7{,}076(L) - 709 - 511) = 294$ Conversion factor: $294 \times 0.9 = 265$ Fresh: $0.03 \times (63{,}680(K) - 7{,}005) = 1{,}700$ Conversion factor: $1{,}700 \times 0.74 = 1{,}258$ Total consumption: $265 + 1{,}258 = \mathbf{1{,}523}$

C.3: Oilseeds & Pulses

Allocation Factor=0.63

Table 145: Oilcrops & pulses mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009.

OILCROPS & PULSES				
Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
133,937	13,778	-40	-6,365	141,309
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
6,898	2,738	69,317	13,036	44,228

Table 146: Vegetable oils mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009.

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)
57,424	16,466	-1,447	-41,022	31,421
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
0	0	6	12,481	18,876

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in South & Southeast Asia.

$$\frac{13{,}036(I)}{133{,}937(A) + 13{,}778(B) - 40(C)} = 9\%$$

Table 147: Waste percentages used for oilcrops & pulses in South & Southeast Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
7%	9%	8%	2%	1%

Table 148: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in South & Southeast Asia – taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.07}{1-0.07} \times 133{,}937(A) = 10{,}081$ Allocation factor: $10{,}081 \times 0.63 = \mathbf{6{,}351}$
Postharvest handling & storage	Oil crops & pulses: $0.09 \times 133{,}937(A) = 12{,}054$ Allocation factor: $12{,}054 \times 0.63 = \mathbf{7{,}594}$
Processing & packaging	Vegetable Oil: $(0.08 \times 6(R)) + ((\frac{0.08}{1-0.08}) \times 18{,}876(T)) = \mathbf{1{,}642}$
Distribution	Vegetable Oil: $0.02 \times (44{,}228(J) + 18{,}876(T) + 6(R) - 1{,}642) = \mathbf{1{,}229}$
Consumption	Vegetable Oil: $0.01 \times (44{,}228(J) + 18{,}876(T) + 6(R) - 1{,}642 - 1{,}229) = \mathbf{602}$

C.4: Fruit & Vegetables

Assumed proportion utilized fresh = 95%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 149: Fruit & vegetable mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)

303,870	8,376	161	-13,748	298,660
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
906	9	682	465	270,230
Fresh (K)	Processed (L)			
Jx0.9= 256,719	=J-K =13,511			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in South & Southeast Asia.

$$\frac{465(I)}{303{,}870(A) + 8{,}376(B) + 161(C)} = 0.1\%$$

Table 150: Waste percentages used for fruit & vegetables in South & Southeast Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
15%	0.1%	25%	10%(f), 10%(p)	7%(f), 1%(p)

Table 151: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in South & Southeast Asia – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.15}{1-0.15} \times 303{,}870(A) = 53{,}624$ Allocation factor: $53{,}624 \times 0.77 = \mathbf{41{,}290}$
Postharvest handling & storage	$0.001 \times 303{,}870(A) = 304$ Allocation factor: $304 \times 0.77 = \mathbf{234}$
Processing & packaging	$0.25 \times \big(682(H) + 13{,}511(L)\big) = 3{,}548$ Conversion factor: $3{,}548 \times 0.75 = \mathbf{2{,}661}$
Distribution	Processed: $0.1 \times (682(H) + 13{,}511(L) - 3{,}548) = 1{,}065$ Conversion factor: $1{,}065 \times 0.75 = 799$ Fresh: $0.1 \times 256{,}719(K) = 25{,}672$ Conversion factor: $25{,}672 \times 0.8 = 20{,}538$ Total distribution: $799 + 20{,}538 = \mathbf{21{,}337}$
Consumption	Processed: $0.01 \times (682(H) + 13{,}511(L) - 3{,}548 - 1{,}065) = 96$ Conversion factor: $96 \times 0.75 = 72$ Fresh: $0.07 \times (256{,}719(K) - 25{,}672) = 16{,}173$ Conversion factor: $16{,}173 \times 0.8 = 12{,}938$ Total consumption: $72 + 12{,}938 = \mathbf{13{,}010}$

C.5: Fish & Seafood

Assumed proportion utilized fresh = 60%

Mean Conversion Factor= 0.5

Table 152: Fish & Seafood mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
41,225	4,169	18	-7,701	37,712
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,881	0	0	5,481	29,349
Fresh (K)	Processed (L)			
Jx0.6 =17,609	=J-K =11,740			

Table 153: Waste percentages used for fish & seafood in South & Southeast Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
8.2%	6%	9%	15%(f), 10%(p)	2%(f), 1%(p)

Table 154: Calculation for losses and wastes (1000 tonnes) for fish & seafood in South & Southeast Asia – taking into account waste percentages, conversion and allocation factors. *note this number comes directly out of the SIK report (Gustavsson et al, 2013).

Food Production	$1{,}890^*$ Conversion factor: $1{,}890 \times 0.5 = \mathbf{945}$
Postharvest handling & storage	$0.06 \times 41{,}225(A) = 2{,}474$ Conversion factor: $2{,}474 \times 0.5 = \mathbf{1{,}237}$
Processing & packaging	$0.09 \times (0(H) + 11{,}740(L)) = 1{,}057$ Conversion factor: $1{,}057 \times 0.5 = \mathbf{529}$
Distribution	Processed: $0.1 \times (0(H) + 11{,}740(L) - 1{,}057) = 1{,}068$ Conversion factor: $1{,}068 \times 0.5 = 534$ Fresh: $0.15 \times 17{,}609(K) = 2{,}641$ Conversion factor: $2{,}641 \times 0.5 = 1{,}321$ Total distribution: $534 + 1{,}321 = \mathbf{1{,}855}$
Consumption	Processed: $0.01 \times (0(H) + 11{,}740(L) - 1{,}057 - 1{,}068) = 96$ Conversion factor: $96 \times 0.5 = 48$

	Fresh: $0.02 \times (17{,}609(K) - 2{,}641) = 299$ Conversion factor: $299 \times 0.5 = 150$ Total consumption: $48 + 150 = \mathbf{198}$

C.6: Milk

Table 155: Milk mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
162,063	7,702	162	-1,553	168,375
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
23,193	0	8	144	136,628

Table 156: Waste percentages used for milk in South & Southeast Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
3.5%	6%	2%	10%	1%

Table 157: Calculation for losses and wastes (1000 tonnes) for milk in South & Southeast Asia.

Food Production	$\frac{0.035}{1 - 0.035} \times 162{,}063(A) = \mathbf{5{,}878}$
Postharvest handling & storage	$0.06 \times 162{,}063(A) = \mathbf{9{,}724}$
Processing & packaging	$0.02 \times (8(H) + 136{,}628(J)) = \mathbf{2{,}733}$
Distribution	$0.1 \times (8(H) + 136{,}628(J) - 2{,}733) = \mathbf{13{,}390}$
Consumption	$0.01 \times (8(H) + 136{,}628(J) - 2{,}733 - 13{,}390) = \mathbf{1{,}205}$

C.7: Eggs

Table 158: Eggs mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
8,786	18	-10	-244	8,550

Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
0	776	0	0	7,120

Table 159: Waste percentages used for eggs in South & Southeast Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
8%	n/a	0.1%	3%	2%

Table 160: Calculation for losses and wastes (1000 tonnes) for eggs in South & Southeast Asia.

Food Production	$\frac{0.08}{1-0.08} \times 8{,}786(A) = \mathbf{764}$
Postharvest handling & storage	n/a
Processing & packaging	$0.001 \times 7{,}120(J) = \mathbf{7}$
Distribution	$0.03 \times (7{,}120(J) - 7) = \mathbf{213}$
Consumption	$0.02 \times (7{,}120(J) - 7 - 213) = \mathbf{138}$

C.8: Meat

Table 161: Total meat mass flow through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown in tables below.

Supply Elements				
Animals arrived at SH (K)	Animals transported to SH (L)	Animals at farm (M)		
177	94	2,423		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
27,153	972	15	-1,178	26,962
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
0	0	24	70	26,877

Table 162: Meat mass flow by type of livestock through the food supply chain in South & Southeast Asia (1000 tonnes), from FBS 2009.

	Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manufacture (H)	Other Uses (I)	Food (J)

Cattle meat	6,427	464	0	606	6,285	0	0	0	0	6,294
Mutton & Goat	2,227	24	0	60	2,190	0	0	0	0	2,190
Pig meat	7,330	81	15	46	7,380	0	0	16	0	7,366
Poultry	10,879	387	0	453	10,814	0	0	0	70	10,731
Other Meat	290	16	0	13	293	0	0	8	0	296
Total meat	27,153	972	15	1,178	26,962	0	0	24	70	26,877

Table 163: Waste percentages used for meat by type of livestock in South & Southeast Asia (Gustavsson, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat (turkey)
Food Production	8%					
Losses during breeding		10%	10%	6%	8%	8%
Postharvest Handling & Storage	1%					
Transport to the slaughter-house		0.1%	0.1%	0.4%	0.5%	0.5%
Rejection at the slaughter-house		0.3%	0.3%	0.06%	1.3%	1.3%
Processing	5%					
Distribution	7%					
Consumption	4%					

Table 164: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in South & Southeast Asia. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson, 2013). CW=carcass weight.

	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Cattle meat	6,427	26,668,050	241
Mutton & Goat	2,227	148,466,667	15
Pig meat	7,330	83,295,455	88
Poultry	10,879	7,252,666,667	1.5
Other Meat (turkey)	290	39,726,027	7.3
Total	27,153		

Table 165: Cattle losses during production and postharvest handling & storage (number of heads).

Cattle	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 26{,}668{,}050 = 80{,}245$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (26{,}668{,}050 + 80{,}245) = 26{,}775$
	During breeding:
	$\frac{0.1}{1-0.1} \times (26{,}668{,}050 + 27{,}581 + 26{,}775) = 2{,}969{,}156$

Table 166: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.003}{1-0.003} \times 148{,}466{,}667 = 446{,}740$
	Transportation to slaughterhouse:
	$\frac{0.001}{1-0.001} \times (148{,}466{,}667 + 446{,}740) = 149{,}062$
	During breeding:
	$\frac{0.1}{1-0.1} \times (148{,}466{,}667 + 446{,}740 + 149{,}062) = 16{,}562{,}497$

Table 167: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0006}{1-0.0006} \times 83{,}295{,}455 = 50{,}007$
	Transportation to slaughterhouse:
	$\frac{0.004}{1-0.004} \times (83{,}295{,}455 + 50{,}007) = 334{,}721$
	During breeding:
	$\frac{0.06}{1-0.06} \times (83{,}295{,}455 + 50{,}007 + 334{,}721) = 5{,}341{,}288$

Table 168: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 7{,}252{,}666{,}667 = 95{,}526{,}511$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (7{,}252{,}666{,}667 + 95{,}526{,}511) = 36{,}925{,}594$
	During breeding:
	$\frac{0.08}{1-0.08} \times (7{,}252{,}666{,}667 + 95{,}526{,}511 + 36{,}925{,}594) = 642{,}184{,}241$

Table 169: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other meat (turkey)	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 39{,}726{,}027 = 523{,}240$
	Transportation to slaughterhouse:
	$\frac{0.005}{1-0.005} \times (39{,}726{,}027 + 523{,}240) = 202{,}258$
	During breeding:
	$\frac{0.08}{1-0.08} \times (39{,}726{,}027 + 523{,}240 + 202{,}258) = 3{,}517{,}524$

Table 170: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		**Transport to Slaughterhouse**		**During Breeding**	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	80,245	19	26,775	6	2,969,156	716
Mutton & Goat	446,740	6.7	149,062	2.2	16,562,497	248

Pig meat	50,007	4.4	334,721	29	5,341,288	470
Poultry	95,526,511	143	36,925,594	55	642,184,241	963
Other Meat (turkey)	523,240	3.8	202,258	1.4	3,517,524	26
Total		177		94		2,423

Weighted waste % for production:

$$\frac{2{,}423}{27{,}153(A) + 2{,}423} = 8\%$$

Weighted waste % postharvest handling and storage:

$$\frac{177 + 94}{27{,}153(A) + 177 + 94} = 1\%$$

Table 171: Calculation for losses and wastes (1000 tonnes) for meat in South & Southeast Asia – taking into account waste percentages, conversion and allocation factors.

Food Production	$\mathbf{2{,}423}$ **(**see table 170).
Postharvest handling & storage	$177 + 94 = \mathbf{271}$ (see table 170).
Processing & packaging	$0.05 \times \big(24(H) + 26{,}877(J)\big) = \mathbf{1{,}345}$
Distribution	$0.07 \times (24(H) + 26{,}877(J) - 1{,}345) = \mathbf{1{,}789}$
Consumption	$0.04 \times (24(H) + 26{,}877(J) - 1{,}345 - 1{,}789) = \mathbf{951}$

Summary of FLW in South & Southeast Asia

Table 172: Summary of FLW in South & Southeast Asia (2009). *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***32% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Agricultural Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW**	**% of total FLW**
Cereals	175,712	20,159	18,949	34,028	5,190	7,629	**85,955**	**33%**
Roots & Tubers	31,606	7,120	16,732	638	5,644	1,523	**31,657**	**12%**
Oilseeds & Pulses	77,155	6,351	7,594	1,642	1,229	602	**17,418**	**7%**
Fruit & Vegetables	111,180	41,290	234	2,661	21,337	13,010	**78,532**	**30%**
Fish & Seafood	21,558	945	1,237	529	1,855	198	**4,764**	**2%**
Milk	5,878	5,878	9,724	2,733	13,390	1,205	**32,930**	**13%**
Eggs	764	764	n/a	7	213	138	**1,122**	**0%**

Meat	2,423	2,423	271	1,345	1,789	951	**6,779**	**3%**
Total FLW	**426,275**	**84,930**	**54,741**	**43,583**	**50,647**	**25,256**	**259,157**	
% of total FLW	**32%*** **	**33%**	**21%**	**17%**	**20%**	**10%**		

This table shows that for South & Southeast Asia, the commodity group with the largest proporation of FLW is cereal, followed by fruit & vegetables, both milk and roots & tubers have similar FLW, where these four commodity groups account for 88% of all FLW. While for the FSC, 33% of all FLW takes place at the agricultural stage, 21% at the postharvest handling and storage stage and 20% at distribution stage, the consumption stage accounts for 10% of all FLW. A total of 259,157 kilotonnes is lost or wasted in the South & Southeast Asian FSC annually, this represents 26% of the total production of food.

Appendix D: Eastern Asia

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group Industrialized Asia (Gustavsson et al, 2013). All of the data comes from FBS from 2009, for the country group Eastern Asia (FAOSTAT, 2014).

D.1: Cereal

Mean Conversion Factor= 0.81

Wheat + rye= 0.78

Maize+ Miller + sorghum= 0.69

Oats + barley + other= 0.78

Rice= 1

Allocation Factors=0.6

Table 173: Cereal mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009 for Eastern Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
434,723	49,136	-20,392	-3,279	460,188
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing	Other Utilities	Food (J)

		(H)	(I)	
152,820	10,720	12,129	32,145	232,082
Milled (K) *	Feed (L) *			
Jx0.81= 187,986	J-K= 44,096			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in Eastern Asia.

$$\frac{32{,}145(I)}{434{,}723(A) + 49{,}136(B) - 20{,}392(C)} = 7\%$$

Table 174: Waste percentages for cereals in Eastern Asia, m=milling, p=processing (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
2%	7%	0.5%(m), 10%(p)	2%	20%

Table 175: Calculation for losses and wastes (1000 tonnes) for cereal in Eastern Asia – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.02}{1-0.02} \times 434{,}723(A) = 8{,}872$ Allocation factor: $8{,}872 \times 0.6 = \mathbf{5{,}323}$
Postharvest handling & storage	$0.07 \times 434{,}723(A) = 30{,}431$ Allocation factor: $30{,}431 \times 0.6 = \mathbf{18{,}259}$
Processing & packaging	Milling: $0.005 \times 232{,}082(J) = 1{,}160$ Industrial Baking: $(187{,}986(K) + 232{,}082(J) - 1{,}160) \times 0.1 = 41{,}891$ Total Processing and Packaging: $1{,}160 + 41{,}891 = \mathbf{43{,}051}$
Distribution	$(187{,}986(K) + 12{,}129(H) - 1{,}160 - 41{,}891) \times 0.02 = \mathbf{3{,}141}$
Consumption	$(187{,}986(K) + 12{,}129(H) - 1{,}160 - 41{,}891 - 3{,}141) \times 0.2 = \mathbf{30{,}785}$

D.2: Roots & Tubers

Assumed proportion utilized fresh = 85%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 176: Roots & tubers mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009 for Eastern Asia. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
163,210	28,459	22	-950	190,741
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
66,519	3,144	10,625	6,837	95,391
Fresh (K) *	Processed (L) *			
Jx0.85= 81,082	J-K= 14,309			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of roots & tubers (1000 tonnes) in Eastern Asia.

$$\frac{6{,}837(I)}{163{,}210(A) + 28{,}459(B) + 22(C)} = 4\%$$

Table 177: Waste percentages used for roots & tubers in Eastern Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
20%	4%	15%	9%(f), 3%(p)	10%(f), 12%(p)

Table 178: Calculation for losses and wastes (1000 tonnes) for roots & tubers in Eastern Asia – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.2}{1-0.2} \times 163{,}210(A) = 40{,}803$ Conversion factor: $40{,}803 \times 0.82 = \mathbf{33{,}458}$
Postharvest handling & storage	$0.04 \times 163{,}210(A) = 6{,}528$ Conversion factor: $6{,}528 \times 0.82 = \mathbf{5{,}353}$
Processing & packaging	$0.15 \times (10{,}625(H) + 14{,}309(L)) = 3{,}740$ Conversion factor: $3{,}740 \times 0.9 = \mathbf{3{,}366}$
Distribution	Processed: $0.03 \times (10{,}625(H) + 14{,}309(L) - 3{,}740) = 636$ Conversion factor: $636 \times 0.9 = 572$ Fresh: $0.09 \times 81{,}082\ (K) = 7{,}297$ Conversion factor: $7{,}297 \times 0.74 = 5{,}400$ Total distribution: $572 + 5{,}400 = \mathbf{5{,}972}$
Consumption	Processed: $0.12 \times (10{,}625(H) + 14{,}309(L) - 3{,}740 - 636) = 2{,}467$ Conversion factor: $2{,}467 \times 0.9 = 2{,}220$ Fresh: $0.1 \times (81{,}082(K) - 7{,}297) = 7{,}379$

	Conversion factor: $7{,}379 \times 0.74 = 5{,}460$ Total consumption: $2{,}220 + 5{,}460 = \mathbf{7{,}680}$

D.3: Oilseeds & Pulses

Allocation Factor=0.24

Table 179: Oilcrops & pulses mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009.

OILCROPS & PULSES				
Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
66,463	57,706	-1,180	-2,639	120,351
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
7,063	2,464	84,387	695	16,670

Table 180: Vegetable oils mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009.

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)
20,781	13,068	71	-353	33,567
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
0	0	0	18,366	15,062

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in Eastern Asia.

$$\frac{695(I)}{66{,}463(A) + 57{,}706(B) - 1{,}180(C)} = 0.6\%$$

Table 181: Waste percentages used for oilcrops & pulses in Eastern Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	0.6%	5%	1%	4%

Table 182: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in Eastern Asia – taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.06}{1-0.06} \times 66{,}463(A) = 4{,}242$ Allocation factor: $4{,}242 \times 0.24 = \mathbf{1{,}018}$
Postharvest handling & storage	Oil crops & pulses: $0.006 \times 66{,}463(A) = 399$ Allocation factor: $399 \times 0.24 = \mathbf{96}$
Processing & packaging	Vegetable Oil: $\left(0.05 \times 0(R)\right) + \left(\left(\frac{0.05}{1-0.05}\right) \times 15{,}062(T)\right) = \mathbf{793}$
Distribution	Vegetable Oil: $0.01 \times (16{,}670(J) + 15{,}062(T) + 0(R) - 793) = \mathbf{309}$
Consumption	Vegetable Oil: $0.04 \times (16{,}670(J) + 15{,}062(T) + 0(R) - 793 - 309) = \mathbf{1{,}225}$

D.4: Fruit & Vegetables

Assumed proportion utilized fresh = 96%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 183: Fruit & vegetable mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
673,689	14,955	2	-18,112	670,535
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
29,613	0	6,902	5,557	576,477
Fresh (K)	Processed (L)			
Jx0.96= 553,418	J-K= 23,059			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in Eastern Asia.

$$\frac{5{,}557(I)}{673{,}689(A) + 14{,}955(B) + 2(C)} = 0.8\%$$

Table 184: Waste percentages used for fruit & vegetables in Eastern Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
10%	0.8%	2%	8%(f), 2%(p)	15%(f), 8%(p)

Table 185: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in Eastern Asia – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.1}{1-0.1} \times 673{,}689(A) = 74{,}854$ Allocation factor: $74{,}854 \times 0.77 = \mathbf{57{,}638}$
Postharvest handling & storage	$0.008 \times 673{,}689(A) = 5{,}390$ Allocation factor: $5{,}390 \times 0.77 = \mathbf{4{,}150}$
Processing & packaging	$0.02 \times \big(6{,}902(H) + 23{,}059(L)\big) = 599$ Conversion factor: $599 \times 0.75 = \mathbf{449}$
Distribution	Processed: $0.02 \times (6{,}902(H) + 23{,}059(L) - 599) = 587$ Conversion factor: $587 \times 0.75 = 440$ Fresh: $0.08 \times 553{,}418(K) = 44{,}273$ Conversion factor: $44{,}273 \times 0.8 = 35{,}418$ Total distribution: $440 + 35{,}418 = \mathbf{35{,}858}$
Consumption	Processed: $0.08 \times (6{,}902(H) + 23{,}059(L) - 599 - 587) = 2{,}302$ Conversion factor: $2{,}302 \times 0.75 = 1{,}727$ Fresh: $0.15 \times (553{,}418(K) - 44{,}273) = 76{,}372$ Conversion factor: $76{,}372 \times 0.8 = 61{,}098$ Total consumption: $1{,}727 + 61{,}098 = \mathbf{62{,}825}$

D.5: Fish & Seafood

Assumed proportion utilized fresh = 4%

Mean Conversion Factor= 0.5

Table 186: Fish & Seafood mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
71,281	18,685	109	-8,854	81,221
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing	Other Utilities	Food (J)

		(H)	(I)	
10,978	0	0	4,870	65,374
Fresh (K)	Processed (L)			
Jx0.04= 2,615	J-K= 62,759			

Table 187: Waste percentages used for fish & seafood in Eastern Asia, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
15%	1%	6%	11%(f), 5%(p)	8%(f), 7%(p)

Table 188: Calculation for losses and wastes (1000 tonnes) for fish & seafood in Eastern Asia – taking into account waste percentages, conversion and allocation factors. *note this number comes directly from the SIK report (Gustavsson, 2013).

Food Production	$6{,}940$* Conversion factor: $6{,}940 \times 0.5 = \mathbf{3{,}470}$
Postharvest handling & storage	$0.01 \times 71{,}281(A) = 713$ Conversion factor: $713 \times 0.5 = \mathbf{357}$
Processing & packaging	$0.06 \times (0(H) + 62{,}759(L)) = 3{,}766$ Conversion factor: $3{,}766 \times 0.5 = \mathbf{1{,}883}$
Distribution	Processed: $0.05 \times (0(H) + 62{,}759(L) - 3{,}766) = 2{,}950$ Conversion factor: $2{,}950 \times 0.5 = 1{,}475$ Fresh: $0.11 \times 2{,}615(K) = 288$ Conversion factor: $288 \times 0.5 = 144$ Total distribution: $1{,}475 + 144 = \mathbf{1{,}619}$
Consumption	Processed: $0.07 \times (0(H) + 62{,}759(L) - 3{,}766 - 2{,}950) = 3{,}923$ Conversion factor: $3{,}923 \times 0.5 = 1{,}962$ Fresh: $0.08 \times (2{,}615(K) - 288) = 186$ Conversion factor: $186 \times 0.5 = 93$ Total consumption: $1{,}962 + 93 = \mathbf{2{,}055}$

D.6: Milk

Table 189: Milk mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
50,949	5,779	4	-247	56,485
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing	Other Utilities	Food (J)

		(H)	(I)	
3,044	0	1	308	51,633

Table 190: Waste percentages used for milk in Eastern Asia (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
3.5%	1%	1.2%	0.5%	5%

Table 191: Calculation for losses and wastes (1000 tonnes) for milk in Eastern Asia.

Food Production	$\frac{0.035}{1-0.035} \times 50{,}949(A) = \mathbf{1{,}848}$
Postharvest handling & storage	$0.01 \times 50{,}949(A) = \mathbf{509}$
Processing & packaging	$0.012 \times \big(1(H) + 51{,}633(J)\big) = \mathbf{620}$
Distribution	$0.005 \times (1(H) + 51{,}633(J) - 620) = \mathbf{255}$
Consumption	$0.05 \times (1(H) + 51{,}633(J) - 620 - 255) = \mathbf{2{,}538}$

D.7: Eggs

Table 192: Eggs mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
31,030	141	0	-149	31,022
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
0	775	0	468	28,280

Table 193: Waste percentages used for eggs in Eastern Asia.

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
6%	n/a	0.5%	4%	5%

Table 194: Calculation for losses and wastes (1000 tonnes) for eggs in Eastern Asia.

Food Production	$\frac{0.06}{1-0.06} \times 31{,}030(A) = \mathbf{1{,}981}$

Postharvest handling & storage	n/a
Processing & packaging	$0.005 \times 28{,}280(J) = \mathbf{141}$
Distribution	$0.04 \times (28{,}280(J) - 141) = \mathbf{1{,}126}$
Consumption	$0.05 \times (28{,}280(J) - 141 - 1{,}126) = \mathbf{1{,}351}$

D.8: Meat

Table 195: Total meat mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown in the tables below.

Supply Elements				
Animals arrived at SH (K)	Animals transported to SH (L)	Animals at farm (M)		
397	172	3,021		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
83,759	6,527	-40	-1,574	88,671
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
1	0	17	129	88,414

Table 196: Meat mass flow by type of livestock through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009.

	Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manufacture (H)	Other Uses (I)	Food (J)
Cattle meat	7,250	1,262	-5	163	8,344	0	0	0	4	8,316
Mutton & Goat	4,083	131	-35	15	4,165	0	0	0	0	4,164
Pig meat	52,295	2,546	0	460	54,380	0	0	14	109	54,210
Poultry	18,406	2,562	0	905	20,062	0	0	2	16	20,011
Other Meat	1,725	26	0	31	1720	1	0	1	0	1,713
Total meat	83,759	6,527	-40	1,574	88,671	1	0	17	129	88,414

Table 197: Waste percentages used for meat by type of livestock in Eastern Asia (Gustavsson, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat (turkey)
Food Production	3%					
Losses during		3.2%	10%	2.5%	4%	10%

breeding						
Postharvest Handling & Storage	0.7%					
Transport to the slaughter-house		0.013%	1%	0.11%	0.35%	0.38%
Rejection at the slaughter-house		0.6%	0.6%	0.12%	1.3%	1.5%
Processing	5%					
Distribution	6%					
Consumption	8%					

Table 198: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in Eastern Asia. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson, 2013). CW=carcass weight.

	Production (1000 tonnes CW)	**Slaughtered (head)**	**CW/head (kg)**
Cattle meat	7,250	30,082,988	241
Mutton & Goat	4,083	272,200,000	15
Pig meat	52,295	594,261,367	88
Poultry	18,406	12,270,666,667	1.5
Other Meat (turkey)	1,725	236,301,370	7.3
Total	83,759		

Table 199: Cattle losses during production and postharvest handling & storage (number of heads).

Cattle	*Rejection at slaughterhouse:*
	$\frac{0.006}{1-0.006} \times 30{,}082{,}988 = 181{,}587$
	Transportation to slaughterhouse:
	$\frac{0.00013}{1-0.00013} \times (30{,}082{,}988 + 181{,}587) = 3{,}935$
	During breeding:
	$\frac{0.032}{1-0.032} \times (30{,}082{,}988 + 181{,}587 + 3{,}935) = 1{,}000{,}612$

Table 200: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.006}{1-0.006} \times 272{,}200{,}000 = 1{,}643{,}058$
	Transportation to slaughterhouse:
	$\frac{0.01}{1-0.01} \times (272{,}200{,}000 + 1{,}643{,}058) = 2{,}766{,}091$
	During breeding:
	$\frac{0.10}{1-0.10} \times (272{,}200{,}000 + 1{,}643{,}058 + 2{,}766{,}091) = 30{,}734{,}350$

Table 201: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0012}{1-0.0012} \times 594{,}261{,}367 = 713{,}970$
	Transportation to slaughterhouse:

	$\frac{0.0011}{1-0.0011} \times (594{,}261{,}367 + 713{,}970) = 655{,}194$
	During breeding:
	$\frac{0.025}{1-0.025} \times (594{,}261{,}367 + 713{,}970 + 655{,}194) = 15{,}272{,}578$

Table 202: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 12{,}270{,}666{,}667 = 161{,}619{,}723$
	Transportation to slaughterhouse:
	$\frac{0.0035}{1-0.0035} \times (12{,}270{,}666{,}667 + 161{,}619{,}723) = 43{,}665{,}833$
	During breeding:
	$\frac{0.04}{1-0.04} \times (12{,}270{,}666{,}667 + 161{,}619{,}723 + 43{,}665{,}833) = 519{,}831{,}343$

Table 203: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other meat (turkey)	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 236{,}301{,}370 = 3{,}112{,}379$
	Transportation to slaughterhouse:
	$\frac{0.0038}{1-0.0038} \times (236{,}301{,}370 + 3{,}112{,}379) = 913{,}243$
	During breeding:
	$\frac{0.1}{1-0.1} \times (236{,}301{,}370 + 3{,}112{,}379 + 913{,}243) = 26{,}702{,}999$

Table 204: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		Transport to Slaughterhouse		During Breeding	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	181,587	44	3,935	0.9	1,000,612	241
Mutton & Goat	1,643,058	25	2,766,091	41	30,734,350	461
Pig meat	713,970	63	655,194	58	15,272,578	1,344
Poultry	161,619,723	242	43,665,833	65	519,831,343	780
Other Meat (turkey)	3,112,379	23	913,243	7	26,702,999	195
Total		397		172		3,021

Weighted waste percentage for production:

$$\frac{3{,}021}{83{,}759(A) + 3{,}021} = 3\%$$

Weighted waste percentage for postharvest handling and storage:

$$\frac{397 + 172}{83{,}759(A) + 397 + 172} = 0.7\%$$

Table 205: Calculation for losses and wastes (1000 tonnes) for meat in Eastern Asia – taking into account waste percentages, conversion and allocation factors.

Food Production	$\mathbf{3,021}$ (see table 203).
Postharvest handling & storage	$397 + 172 = \mathbf{569}$ (see table 203).
Processing & packaging	$0.05 \times \big(17(H) + 88{,}414(J)\big) = \mathbf{4,422}$
Distribution	$0.06 \times (17(H) + 88{,}414(J) - 4{,}422) = \mathbf{5,041}$
Consumption	$0.08 \times (17(H) + 88{,}414(J) - 4{,}422 - 5{,}041) = \mathbf{6,317}$

Summary of FLW in Eastern Asia

Table 206: Summary of FLW in Eastern Asia (2009). *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***36% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Agricultural Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW**	**% of total FLW**
Cereals	179,212	5,323	18,259	43,051	3,141	30,785	**100,559**	**28%**
Roots & Tubers	62,836	33,458	5,353	3,366	5,972	7,680	**55,829**	**16%**
Oilseeds & Pulses	67,323	1,018	96	793	309	1,225	**3,441**	**1%**
Fruit & Vegetables	212,586	57,638	4,150	449	35,858	62,825	**160,920**	**45%**
Fish & Seafood	39,111	3,470	357	1,883	1,619	2,055	**9,384**	**3%**
Milk	1,848	1,848	509	620	255	2,538	**5,770**	**2%**
Eggs	1,981	1,981	n/a	141	1,126	1,351	**4,599**	**1%**
Meat	3,021	3,021	569	4,422	5,041	6,317	**19,370**	**5%**
Total FLW	**567,918**	**107,757**	**29,293**	**54,725**	**53,321**	**114,756**	**359,872**	
% of total FLW	**36%*** **	30%	8%	15%	15%	32%		

This table shows that for Eastern Asia, the commodity group with the largest proporation of FLW is fruit & vegetables, followed by cereal and roots & tubers, where these three commodity groups account for 89% of all FLW. While for the FSC, 32% of all FLW takes place at the consumption stage, 30% at the agricultural stage and both the packaging & processing and distribution stages make up 15% each. A total of 359,872 kilotonnes is lost

or wasted in the Eastern Asian FSC annually, this represents 32% of the total production of food.

Appendix E: Europe

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK study for the regional groups Europe (Gustavsson, 2013). All of the data comes from FBS from 2009, for the country group Europe (FAOSTAT, 2014).

E.1: Cereal

Mean Conversion Factor= 0.73

Wheat + rye: 0.78

Maize: 0.69

Miller + sorghum: 0.69

Oats + barley + other: 0.78

Allocation Factors=0.35

Table 207: Cereal mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009 for Europe (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
464,509	86,204	453	-152,280	398,886
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
229,587	24,308	25,693	11,458	96,704
Milled (K) *	Feed (L) *			
Jx0.73= 70,594	J-K= 26,110			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in Europe.

$$\frac{11{,}458(I)}{464{,}509(A) + 86{,}204(B) + 453(C)} = 2\%$$

Table 208: Waste percentages for cereals in Europe, m=milling, p=processing (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
2%	2%	0.5%(m), 10%(p)	2%	25%

Table 209: Calculation for losses and wastes (1000 tonnes) for cereal in Europe – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.02}{1-0.02} \times 464{,}509(A) = 9{,}480$ Allocation factor: $9{,}480 \times 0.35 = \mathbf{3{,}318}$
Postharvest handling & storage	$0.02 \times 464{,}509(A) = 9{,}290$ Allocation factor: $9{,}290 \times 0.35 = \mathbf{3{,}252}$
Processing & packaging	Milling: $0.005 \times 96{,}704(J) = 484$ Industrial Baking: $(70{,}594(K) + 96{,}704(J) - 484) \times 0.1 = 16{,}681$ Total Processing and Packaging: $484 + 16{,}681 = \mathbf{17{,}165}$
Distribution	$(70{,}594(K) + 25{,}693(H) - 484 - 16{,}681) \times 0.02 = \mathbf{1{,}582}$
Consumption	$(70{,}594(K) + 25{,}693(H) - 484 - 16{,}681 - 1{,}582) \times 0.25 = \mathbf{19{,}385}$

E.2: Roots & Tubers

Assumed proportion utilized fresh = 27%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 210: Roots & tubers mass flow through the food supply chain in Eastern Asia (1000 tonnes), from FBS 2009 for Eastern Asia. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
123,870	15,677	544	-17,867	122,224
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
26,308	18,273	3,148	5,706	63,096
Fresh (K) *	Processed (L) *			
Jx0.27= 17,036	J-K= 46,060			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of roots & tubers (1000 tonnes) in Europe.

$$\frac{5{,}706(I)}{123{,}870(A) + 15{,}677(B) + 544(C)} = 4\%$$

Table 211: Waste percentages used for roots & tubers in Europe, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
20%	4%	15%	7%(f), 3%(p)	17%(f), 12%(p)

Table 212: Calculation for losses and wastes (1000 tonnes) for roots & tubers in Europe – taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.2}{1-0.2} \times 123{,}870(A) = 30{,}968$ Conversion factor: $30{,}968 \times 0.82 = \mathbf{25{,}394}$
Postharvest handling & storage	$0.04 \times 123{,}870(A) = 4{,}955$ Conversion factor: $4{,}955 \times 0.82 = \mathbf{4{,}063}$
Processing & packaging	$0.15 \times (3{,}148(H) + 46{,}060(L)) = 7{,}381$ Conversion factor: $7{,}381 \times 0.9 = \mathbf{6{,}643}$
Distribution	Processed: $0.03 \times (3{,}148(H) + 46{,}060(L) - 7{,}381) = 1{,}255$ Conversion factor: $1{,}255 \times 0.9 = 1{,}130$ Fresh: $0.07 \times 17{,}036\ (K) = 1{,}193$ Conversion factor: $1{,}193 \times 0.74 = 883$ Total distribution: $1{,}130 + 883 = \mathbf{2{,}013}$
Consumption	Processed: $0.12 \times (3{,}148(H) + 46{,}060(L) - 7{,}381 - 1{,}255) = 4{,}869$ Conversion factor: $4{,}869 \times 0.9 = 4{,}382$ Fresh: $0.17 \times (17{,}036\ (K) - 1{,}193) = 2{,}693$ Conversion factor: $2{,}693 \times 0.74 = 1{,}993$ Total consumption: $4{,}382 + 1{,}993 = \mathbf{6{,}375}$

E.3: Oilseeds & Pulses

Allocation Factor=0.2

Table 213: Oilcrops & pulses mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009.

OILCROPS & PULSES
Supply Elements

Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
71,230	37,395	2,246	-19,116	91,754
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
9,525	1,624	69,855	280	7,922

Table 214: Vegetable oils mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009.

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)
23,936	23,872	-169	-17,297	30,342
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
808	0	276	16,242	13,207

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in Europe.

$$\frac{280(I)}{71{,}230(A) + 37{,}395(B) + 2{,}246(C)} = 0.3\%$$

Table 215: Waste percentages used for oilcrops & pulses in Europe (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
10%	0.3%	5%	1%	4%

Table 216: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in Europe – taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.1}{1-0.1} \times 71{,}230(A) = 7{,}914$ Allocation factor: $7{,}914 \times 0.2 = \mathbf{1{,}583}$
Postharvest handling & storage	Oil crops & pulses: $0.003 \times 71{,}230(A) = 214$ Allocation factor: $214 \times 0.2 = \mathbf{43}$
Processing & packaging	Vegetable Oil: $(0.05 \times 276(R)) + ((\frac{0.05}{1-0.05}) \times 13{,}207(T)) = \mathbf{709}$
Distribution	Vegetable Oil: $0.01 \times (7{,}922(J) + 13{,}207(T) + 276(R) - 709) = \mathbf{207}$
Consumption	Vegetable Oil:

	$0.04 \times (7{,}922(J) + 13{,}207(T) + 276(R) - 709 - 207) = \mathbf{820}$

E.4: Fruit & Vegetables

Assumed proportion utilized fresh = 40%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 217: Fruit & vegetable mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
171,045	95,616	1,182	-63,312	204,532
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
5,933	24	27,614	619	157,653
Fresh (K)	Processed (L)			
Jx0.4= 63,061	J-K= 94,592			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in Europe.

$$\frac{619(I)}{171{,}045(A) + 95{,}616(B) + 1{,}182(C)} = 0.2\%$$

Table 218: Waste percentages used for fruit & vegetables in Europe, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
20%	0.2%	2%	10%(f), 2%(p)	19%(f), 15%(p)

Table 219: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in Europe – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.2}{1 - 0.2} \times 171{,}045(A) = 42{,}761$ Allocation factor: $42{,}761 \times 0.77 = \mathbf{32{,}926}$
Postharvest handling &	$0.002 \times 171{,}045(A) = 342$

storage	Allocation factor: $342 \times 0.77 = \mathbf{263}$
Processing & packaging	$0.02 \times (27{,}614(H) + 94{,}592(L)) = 2{,}444$ Conversion factor: $2{,}444 \times 0.75 = \mathbf{1{,}833}$
Distribution	Processed: $0.02 \times (27{,}614(H) + 94{,}592(L) - 2{,}444) = 2{,}395$ Conversion factor: $2{,}395 \times 0.75 = 1{,}796$ Fresh: $0.1 \times 63{,}061(K) = 6{,}306$ Conversion factor: $6{,}306 \times 0.8 = 5{,}045$ Total distribution: $1{,}796 + 5{,}045 = \mathbf{6{,}841}$
Consumption	Processed: $0.15 \times (27{,}614(H) + 94{,}592(L) - 2{,}444 - 2{,}395) = 17{,}605$ Conversion factor: $17{,}605 \times 0.75 = 13{,}204$ Fresh: $0.19 \times (63{,}061(K) - 6{,}306) = 10{,}783$ Conversion factor: $10{,}783 \times 0.8 = 8{,}626$ Total consumption: $13{,}204 + 8{,}626 = \mathbf{21{,}830}$

E.5: Fish & Seafood

Assumed proportion utilized fresh = 4%

Mean Conversion Factor= 0.5

Table 220: Fish & Seafood mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
15,242	22,638	90	-16,137	21,833
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
5,229	66	0	288	16,220
Fresh (K)	Processed (L)			
Jx0.04= 649	J-K= 15,571			

Table 221: Waste percentages used for fish & seafood in Europe, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
9%	1%	6%	9%(f), 5%(p)	11%(f), 10%(p)

Table 222: Calculation for losses and wastes (1000 tonnes) for fish & seafood in Europe – taking into account waste percentages, conversion and allocation factors. *Note this number was taken directly from the SIK report (Gustavsson, 2013).

Food Production	1110^* Conversion factor: $1{,}110 \times 0.5 = \mathbf{555}$
Postharvest handling & storage	$0.01 \times 15{,}242(A) = 152$ Conversion factor: $152 \times 0.5 = \mathbf{76}$
Processing & packaging	$0.06 \times (0(H) + 15{,}571(L)) = 934$ Conversion factor: $934 \times 0.5 = \mathbf{467}$
Distribution	Processed: $0.05 \times (0(H) + 15{,}571(L) - 934) = 732$ Conversion factor: $732 \times 0.5 = 366$ Fresh: $0.09 \times 649(K) = 58$ Conversion factor: $58 \times 0.5 = 29$ Total distribution: $366 + 29 = \mathbf{395}$
Consumption	Processed: $0.1 \times (0(H) + 15{,}571(L) - 934 - 732) = 1{,}391$ Conversion factor: $1{,}391 \times 0.5 = 696$ Fresh: $0.11 \times (649(K) - 58) = 65$ Conversion factor: $65 \times 0.5 = 33$ Total consumption: $696 + 33 = \mathbf{729}$

E.6: Milk

Table 223: Milk mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
213,822	51,247	-253	-65,034	199,783
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
29,499	0	738	6,903	161,661

Table 224: Waste percentages used for milk in Europe (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
4%	1%	1%	1%	7%

Table 225: Calculation for losses and wastes (1000 tonnes) for milk in Europe.

Food Production	$\frac{0.04}{1 - 0.04} \times 213{,}822(A) = \mathbf{8{,}909}$

Postharvest handling & storage	$0.01 \times 213{,}822(A) = \mathbf{2{,}138}$
Processing & packaging	$0.01 \times (738(H) + 161{,}661(J)) = \mathbf{1{,}624}$
Distribution	$0.01 \times (738(H) + 161{,}661(J) - 1{,}624) = \mathbf{1{,}608}$
Consumption	$0.07 \times (738(H) + 161{,}661(J) - 1{,}624 - 1{,}608) = \mathbf{11{,}142}$

E.7: Eggs

Table 226: Eggs mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
10,406	1,471	4	1,522	10,358
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
18	729	0	188	9,334

Table 227: Waste percentages used for eggs in Europe (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
4%	n/a	1%	2%	8%

Table 228: Calculation for losses and wastes (1000 tonnes) for eggs in Europe.

Food Production	$\frac{0.04}{1 - 0.04} \times 10{,}406(A) = \mathbf{434}$
Postharvest handling & storage	n/a
Processing & packaging	$0.01 \times 9{,}334(J) = \mathbf{93}$
Distribution	$0.02 \times (9{,}334(J) - 93) = \mathbf{185}$
Consumption	$0.08 \times (9{,}334(J) - 93 - 185) = \mathbf{725}$

E.8: Meat

Table 229: Total meat mass flow through the food supply chain in Europe (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown in the tables below.

Supply Elements				
Animals arrived at SH (K)	Animals transported to SH (L)	Animals at farm (M)		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
54,768	18,883	-70	-16,631	56,951
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2	0	359	201	56,294

Table 230: Meat mass flow by type of livestock through the food supply chain in Europe (1000 tonnes), from FBS 2009.

	Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manufacture (H)	Other Uses (I)	Food (J)
Cattle meat	10,864	4,104	108	3,150	11,926	0	0	22	35	11,845
Mutton & Goat	1,271	430	0	224	1,478	0	0	0	8	1,464
Pig meat	25,887	8,448	-87	8,816	25,432	0	0	67	139	25,170
Poultry	15,620	4,873	-96	3,987	16,410	0	0	266	19	16,110
Other Meat	1,126	1,028	5	454	1,705	2	0	4	0	1,705
Total meat	54,768	18,883	-70	16,631	56,951	2	0	359	201	56,294

Table 231: Waste percentages used for meat by type of livestock in Europe (Gustavsson, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat (turkey)
Food Production	3.2%					
Losses during breeding		2.25%	10%	2.5%	4%	10%
Postharvest Handling & Storage	0.7%					
Transport to the slaughter-house		0.013%	0.018%	0.11%	0.35%	0.38%
Rejection at the slaughter-house		0.6%	0.6%	0.12%	1.3%	1.5%
Processing	5%					
Distribution	4%					
Consumption	11%					

Table 232: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in Europe. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson, 2013). CW=carcass weight.

	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Cattle meat	10,864	45,078,838	241
Mutton & Goat	1,271	84,733,333	15
Pig meat	25,887	294,170,455	88
Poultry	15,620	10,413,333,330	1.5
Other Meat (turkey)	1,126	154,246,575	7.3
Total	54,768		

Table 233: Cattle losses during production and postharvest handling & storage (number of heads).

Cattle	*Rejection at slaughterhouse:*
	$\frac{0.006}{1-0.006} \times 45{,}078{,}838 = 272{,}106$
	Transportation to slaughterhouse:
	$\frac{0.00013}{1-0.00013} \times (45{,}078{,}838 + 272{,}106) = 5{,}896$
	During breeding:
	$\frac{0.0225}{1-0.0225} \times (45{,}078{,}838 + 272{,}106 + 5{,}896) = 1{,}044{,}019$

Table 234: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.006}{1-0.006} \times 84{,}733{,}333 = 511{,}469$
	Transportation to slaughterhouse:
	$\frac{0.00018}{1-0.00018} \times (84{,}733{,}333 + 511{,}469) = 15{,}347$
	During breeding:
	$\frac{0.1}{1-0.1} \times (84{,}733{,}333 + 511{,}469 + 15{,}347) = 9{,}473{,}345$

Table 235: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0012}{1-0.0012} \times 294{,}170{,}455 = 353{,}429$
	Transportation to slaughterhouse:
	$\frac{0.0011}{1-0.0011} \times (294{,}170{,}455 + 353{,}429) = 324{,}333$
	During breeding:
	$\frac{0.025}{1-0.025} \times (294{,}170{,}455 + 353{,}429 + 324{,}333) = 7{,}560{,}211$

Table 236: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 10{,}413{,}333{,}330 = 137{,}156{,}366$
	Transportation to slaughterhouse:
	$\frac{0.00035}{1-0.00035} \times (10{,}413{,}333{,}330 + 137{,}156{,}366) = 3{,}693{,}964$
	During breeding:

	$\frac{0.04}{1-0.04} \times (10{,}413{,}333{,}330 + 137{,}156{,}366 + 3{,}693{,}964) = 439{,}757{,}653$

Table 237: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other meat (turkey)	*Rejection at slaughterhouse:*
	$\frac{0.015}{1-0.015} \times 154{,}246{,}575 = 2{,}348{,}933$
	Transportation to slaughterhouse:
	$\frac{0.00038}{1-0.00038} \times (154{,}246{,}575 + 2{,}348{,}933) = 59{,}529$
	During breeding:
	$\frac{0.1}{1-0.1} \times (154{,}246{,}575 + 2{,}348{,}933 + 59{,}529) = 17{,}406{,}115$

Table 238: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		Transport to Slaughterhouse		During Breeding	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	272,106	66	5,896	1.4	1,044,019	252
Mutton & Goat	511,469	8	15,347	0.2	9,473,345	142
Pig meat	353,429	31	324,333	29	7,560,211	665
Poultry	137,156,366	206	3,693,964	5.5	439,757,653	660
Other Meat (turkey)	2,348,933	17	59,529	0.4	17,406,115	127
Total		328		37		1,846

Weighted waste percentage for production:

$$\frac{1{,}846}{54{,}768(A) + 1{,}846} = 3.2\%$$

Weighted waste percentage for postharvest handling and storage:

$$\frac{37 + 328}{54{,}768(A) + 37 + 328} = 0.7\%$$

Table 239: Calculation for losses and wastes (1000 tonnes) for meat in Europe – taking into account waste percentages, conversion and allocation factors.

Food Production	$\mathbf{1{,}846}$ (see table 236).
Postharvest handling & storage	$37 + 328 = \mathbf{365}$ (see table 236).
Processing & packaging	$0.05 \times (359(H) + 56{,}294(J)) = \mathbf{2{,}833}$
Distribution	$0.04 \times (359(H) + 56{,}294(J) - 2{,}883) = \mathbf{2{,}151}$
Consumption	$0.11 \times (359(H) + 56{,}294(J) - 2{,}883 - 2{,}151) = \mathbf{5{,}678}$

Summary of FLW in Europe

Table 240: Summary of FLW in Europe (2009). *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***45% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Agricultural Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW**	**% of total FLW**
Cereals	305,249	3,318	3,252	17,165	1,582	19,385	**44,702**	**23%**
Roots & Tubers	47,691	25,394	4,063	6,643	2,138	6,375	**44,613**	**22%**
Oilseeds & Pulses	77,716	1,583	43	709	207	820	**3,362**	**2%**
Fruit & Vegetables	72,266	32,926	263	1,833	6,841	21,830	**63,693**	**32%**
Fish & Seafood	8,176	555	76	467	395	729	**2,222**	**1%**
Milk	8,909	8,909	2,138	1,624	1,608	11,142	**25,421**	**13%**
Eggs	434	434	n/a	93	185	725	**1,437**	**1%**
Meat	1,846	1,846	365	2,833	2,151	5,678	**12,873**	**6%**
Total FLW	**522,287**	**74,965**	**10,200**	**31,367**	**15,107**	**66,684**	**198,323**	
% of total FLW	**45%*** **	38%	5%	16%	8%	34%		

This table shows that for Europe, the commodity group with the largest proporation of FLW is fruit & vegetables, followed by cereal and roots & tubers, where these three commodity groups account for 77% of all FLW. While for the FSC, 38% of all FLW takes place at the at the agricultural stage, 34% at the consumption stage and 16% at the packaging & processing stage. A total of 198,323 kilotonnes is lost or wasted in the European FSC annually, this represents 28% of the total production of food.

Appendix F – Regional Analysis North America & Oceania

All of the following calculations for conversion factors, allocation factors and waste percentages which are not directly calculated below are based on the numbers provided in the SIK report for the regional group North America & Oceania (Gustavsson et al, 2013). All

of the data comes from FBS from 2009, for the country groups North America and Oceania (FAOSTAT, 2014).

F.1: Cereal

Mean Conversion Factor= 0.73

Wheat + rye: 0.78

Maize: 0.69

Miller + sorghum: 0.69

Oats + barley + other: 0.78

Allocation Factor=0.5

Table 241: Cereal mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009 for Central Asia and Western Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
501,085	13,762	-10,832	-127,630	376,385
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
172,074	5,118	146,222	10,438	40,002
Milled (K) *	Feed (L) *			
Jx0.78= 29,201	J-K= 10,801			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total cereal mass flows (1000 tonnes) in North America & Oceania.

$$\frac{10{,}438(I)}{501{,}085(A) + 13{,}762(B) - 10{,}832(C)} = 2\%$$

Table 242: Waste percentages for cereals in North America & Oceania, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
2%	2%	0.5%(m), 10%(p)	2%	27%

Table 243: Calculation for losses and wastes (1000 tonnes) for cereal in North America & Oceania - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.02}{1-0.02} \times 501{,}085(A) = 10{,}226$

	Allocation factor: $10{,}226 \times 0.5 = \mathbf{5{,}113}$
Postharvest handling & storage	$0.02 \times 501{,}085(A) = 10{,}022$ Allocation factor: $10{,}022 \times 0.5 = \mathbf{5{,}011}$
Processing & packaging	Milling: $0.005 \times 40{,}002(J) = 200$ Industrial Baking: $(29{,}201(K) + 40{,}002(J) - 200) \times 0.1 = 6{,}900$ Total Processing and Packaging: $200 + 6{,}900 = \mathbf{7{,}100}$
Distribution	$(29{,}201(K) + 146{,}222(H) - 200 - 6{,}900) \times 0.02 = \mathbf{3{,}366}$
Consumption	$(29{,}201(K) + 146{,}222(H) - 200 - 6{,}900 - 3{,}366) \times 0.27 = \mathbf{44{,}538}$

F.2: Roots & Tubers

Assumed proportion utilized fresh = 27%

Mean Conversion Factor= 0.82

Peeling by hand= 0.74

Industrial peeling= 0.9

Table 244: Roots & tubers mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009 for Central Asia and Western Asia (*calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
27,223	4,505	-20	-5,051	26,657
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
432	1,489	141	1,270	21,607
Fresh (K) *	Processed (L) *			
Jx0.27= 5,834	J-K= 15,773			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total roots & tubers mass flows (1000 tonnes) in North America & Oceania.

$$\frac{1{,}270(I)}{27{,}223(A) + 4{,}505(B) - 20(C)} = 4\%$$

Table 245: Waste percentages for roots & tubers in North America & Oceania, m=milling, p=processing (Gustavsson et al, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
20%	4%	15%	7%(f), 3%(p)	30%(f), 12%(p)

Table 246: Calculation for losses and wastes (1000 tonnes) for roots & tubers in North America & Oceania - taking into account waste percentages, conversion and allocation factors as above.

Food Production	$\frac{0.2}{1-0.2} \times 27{,}223(A) = 6{,}806$ Conversion factor: $6{,}806 \times 0.82 = \mathbf{5{,}581}$
Postharvest handling & storage	$0.04 \times 27{,}223(A) = 1{,}089$ Conversion factor: $1{,}089 \times 0.82 = \mathbf{893}$
Processing & packaging	$0.15 \times (141(H) + 15{,}773(L)) = 2{,}387$ Conversion factor: $2{,}387 \times 0.9 = \mathbf{2{,}148}$
Distribution	Processed: $0.03 \times (141(H) + 15{,}773(L) - 2{,}387) = 406$ Conversion factor: $406 \times 0.9 = 365$ Fresh: $0.07 \times 5{,}834\ (K) = 408$ Conversion factor: $408 \times 0.74 = 302$ Total distribution: $365 + 302 = \mathbf{667}$
Consumption	Processed: $0.12 \times (141(H) + 15{,}773(L) - 2{,}378 - 406) = 1{,}576$ Conversion factor: $1{,}576 \times 0.9 = 1{,}418$ Fresh: $0.3 \times (5{,}834\ (K) - 408) = 1{,}628$ Conversion factor: $1{,}628 \times 0.74 = 1{,}205$ Total consumption: $1{,}418 + 1{,}205 = \mathbf{2{,}623}$

F.3: Oilseeds & Pulses

Allocation Factor=0.12

Table 247: Oilcrops & pulses mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009.

OILCROPS & PULSES				
Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
131,149	4,122	2,727	-63,225	74,774
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)

8,302	3,582	57,548	692	5,273

Table 248: Vegetable oils mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009.

VEGETABLE OILS				
Supply Elements				
Production (K)	Import (L)	Stock Variation (M)	Export (N)	Total Supply Quantity (O)
13,932	4,593	389	-4,921	13,991
Utilization Elements				
Feed (P)	Seed (Q)	Food Manufacturing (R)	Other Utilities (S)	Food (T)
0	0	16	4,010	10,018

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of oilcrops & pulses (1000 tonnes) in North America & Oceania.

$$\frac{692(I)}{131{,}149(A) + 4{,}122(B) + 2{,}727(C)} = 0.5\%$$

Table 249: Waste percentages used for oilcrops & pulses in North America & Oceania (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
12%	0.5%	5%	1%	4%

Table 250: Calculation for losses and wastes (1000 tonnes) for oilcrops & pulses in North America & Oceania – taking into account waste percentages and allocation factors as above.

Food Production	Oil crops & pulses: $\frac{0.12}{1-0.12} \times 131{,}149(A) = 17{,}884$ Allocation factor: $17{,}884 \times 0.17 = \mathbf{3{,}040}$
Postharvest handling & storage	Oil crops & pulses: $0.005 \times 131{,}149(A) = 656$ Allocation factor: $656 \times 0.17 = \mathbf{112}$
Processing & packaging	Vegetable Oil: $(0.05 \times 16(R)) + ((\frac{0.05}{1-0.05}) \times 10{,}018(T)) = \mathbf{528}$
Distribution	Vegetable Oil: $0.01 \times (5{,}273(J) + 10{,}018(T) + 16(R) - 528) = \mathbf{148}$
Consumption	Vegetable Oil: $0.04 \times (5{,}273(J) + 10{,}018(T) + 16(R) - 528 - 148) = \mathbf{585}$

F.4: Fruit & Vegetables

Assumed proportion utilized fresh = 40%

Mean Conversion Factor= 0.77

Peeling by hand= 0.8

Industrial peeling= 0.75

Table 251: Fruit & vegetable mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
75,543	35,427	21	-14,713	96,277
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
199	16	5,834	14	85,946
Fresh (K)	Processed (L)			
Jx0.4= 34,378	=J-K =51,568			

The waste percentage for postharvest handling & storage was assumed to be I/(A+B+C) for the total mass flows of fruits & vegetables (1000 tonnes) in North America & Oceania.

$$\frac{14(I)}{75{,}543(A) + 35{,}427(B) + 21(C)} = 0.01\%$$

Table 252: Waste percentages used for fruit & vegetables in North America & Oceania, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
20%	0.01%	2%	12%(f), 2%(p)	28%(f), 10%(p)

Table 253: Calculation for losses and wastes (1000 tonnes) for fruit & vegetables in North America & Oceania – taking into account waste percentages, conversion and allocation factors.

Food Production	$\frac{0.2}{1-0.2} \times 75{,}543(A) = 18{,}886$ Allocation factor: $18{,}886 \times 0.77 = \mathbf{14{,}542}$
Postharvest handling & storage	$0.0001 \times 75{,}543(A) = 8$ Allocation factor: $8 \times 0.77 = \mathbf{6}$
Processing &	$0.02 \times \left(5{,}834(H) + 51{,}568(L)\right) = 1{,}148$

packaging	Conversion factor: $1{,}148 \times 0.75 = \mathbf{861}$
Distribution	Processed: $0.02 \times (5{,}834(H) + 51{,}568(L) - 1{,}148) = 1{,}125$ Conversion factor: $1{,}125 \times 0.75 = 844$ Fresh: $0.12 \times 34{,}378(K) = 4{,}125$ Conversion factor: $4{,}125 \times 0.8 = 3{,}300$ Total distribution: $844 + 3{,}300 = \mathbf{4{,}144}$
Consumption	Processed: $0.1 \times (5{,}834(H) + 51{,}568(L) - 1{,}148 - 1{,}125) = 5{,}513$ Conversion factor: $5{,}513 \times 0.75 = 4{,}135$ Fresh: $0.28 \times (34{,}378(K) - 4{,}125) = 8{,}471$ Conversion factor: $8{,}471 \times 0.8 = 6{,}777$ Total consumption: $4{,}135 + 6{,}777 = \mathbf{10{,}912}$

F.5: Fish & Seafood

Assumed proportion utilized fresh = 4%

Mean Conversion Factor= 0.5

Table 254: Fish & Seafood mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009. (*numbers calculated using conversion factor provided above).

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
7,538	6,431	61	-3,941	10,089
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
837	195	0	93	8,964
Fresh (K)	Processed (L)			
Jx0.04 =359	=J-K =8,605			

Table 255: Waste percentages used for fish & seafood in North America & Oceania, f=fresh, p=processed (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
12%	0.5%	6%	9%(f), 5%(p)	33%(f), 10%(p)

Table 256: Calculation for losses and wastes (1000 tonnes) for fish & seafood in North America & Oceania – taking into account waste percentages, conversion and allocation factors. *note this number comes directly out of the SIK report (Gustavsson et al, 2013).

Food Production	770*

	Conversion factor: $770 \times 0.5 = \mathbf{385}$
Postharvest handling & storage	$0.005 \times 7{,}538(A) = 38$ Conversion factor: $38 \times 0.5 = \mathbf{19}$
Processing & packaging	$0.06 \times (0(H) + 8{,}605(L)) = 516$ Conversion factor: $516 \times 0.5 = \mathbf{258}$
Distribution	Processed: $0.05 \times (0(H) + 8{,}605(L) - 516) = 404$ Conversion factor: $404 \times 0.5 = 202$ Fresh: $0.09 \times 359(K) = 32$ Conversion factor: $32 \times 0.5 = 16$ Total distribution: $202 + 16 = \mathbf{218}$
Consumption	Processed: $0.1 \times (0(H) + 8{,}605(L) - 516 - 404) = 769$ Conversion factor: $769 \times 0.5 = 385$ Fresh: $0.33 \times (359(K) - 32) = 108$ Conversion factor: $108 \times 0.5 = 54$ Total consumption: $385 + 54 = \mathbf{439}$

F.6: Milk

Table 257: Milk mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
120,033	4,921	696	-23,877	101,773
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
2,466	0	264	7,656	90,511

Table 258: Waste percentages used for milk in North America & Oceania (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
3.5%	0.5%	1.2%	0.5%	15%

Table 259: Calculation for losses and wastes (1000 tonnes) for milk in North America & Oceania.

Food Production	$\frac{0.035}{1 - 0.035} \times 120{,}033(A) = \mathbf{4{,}354}$
Postharvest handling & storage	$0.005 \times 120{,}033(A) = \mathbf{600}$

Processing & packaging	$0.012 \times (264(H) + 90{,}511(J)) = \mathbf{1{,}089}$
Distribution	$0.005 \times (264(H) + 90{,}511(J) - 1{,}089) = \mathbf{448}$
Consumption	$0.15 \times (264(H) + 90{,}511(J) - 1{,}089 - 448) = \mathbf{13{,}386}$

F.7: Eggs

Table 260: Eggs mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009.

Supply Elements				
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
6,000	50	0	-182	5,867
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
0	834	0	1	4,912

Table 261: Waste percentages used for eggs in North America & Oceania (Gustavsson, 2013).

Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption
4%	n/a	0.5%	2%	15%

Table 262: Calculation for losses and wastes (1000 tonnes) for eggs in North America & Oceania.

Food Production	$\frac{0.04}{1 - 0.04} \times 6{,}000(A) = \mathbf{250}$
Postharvest handling & storage	n/a
Processing & packaging	$0.005 \times 4{,}912(J) = \mathbf{25}$
Distribution	$0.02 \times (4{,}912(J) - 25) = \mathbf{98}$
Consumption	$0.15 \times (4{,}912(J) - 25 - 98) = \mathbf{718}$

F.8: Meat

Table 263: Total meat mass flow through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009. (*numbers calculated using allocation factors given). SH=Slaughterhouse. K,L,M calculations for each type of livestock are shown in tables below.

Supply Elements

Animals arrived at SH (K)	Animals transported to SH (L)	Animals at farm (M)		
125	30	886		
Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total Supply Quantity (E)
51,477	2,841	1	-10,770	43,550
Utilization Elements				
Feed (F)	Seed (G)	Food Manufacturing (H)	Other Utilities (I)	Food (J)
49	0	0	241	43,169

Table 264: Meat mass flow by type of livestock through the food supply chain in North America & Oceania (1000 tonnes), from FBS 2009.

	Production (A)	Import (B)	Stock Variation (C)	Export (D)	Total (E)	Feed (F)	Seed (G)	Food Manufacture (H)	Other Uses (I)	Food (J)
Cattle meat	15,920	1,550	0	3,164	14,306	0	0	0	32	14,274
Mutton & Goat	1,233	121	0	716	638	13	0	0	87	544
Pig meat	12,771	831	0	2,747	10,855	0	0	0	38	10,712
Poultry	21,190	328	0	4,089	17,429	0	0	0	84	17,344
Other Meat	363	11	1	54	322	36	0	0	0	295
Total meat	**51,477**	**2,841**	**1**	**10,770**	**43,550**	**49**	**0**	**0**	**241**	**43,169**

Table 265: Waste percentages used for meat by type of livestock in North America & Oceania (Gustavsson, 2013).

	Average for Meat	Cattle meat	Mutton & Goat	Pig meat	Poultry	Other Meat (turkey)
Food Production	2%					
Losses during breeding		2.3%	10%	2.5%	4%	10%
Postharvest Handling & Storage	0.3%					
Transport to the slaughter-house		0.013%	1%	0.11%	0.35%	0.38%
Rejection at the slaughter-house		0.6%	0.6%	0.12%	1.3%	1.5%
Processing	5%					
Distribution	4%					
Consumption	11%					

Table 266: Production volumes (tonnes carcass weight) and slaughtered animals (heads) for main livestock flows in North America & Oceania. Number of animals calculated from collected production volume and average carcass weight/head (kg) estimation based of SIK study (Gustavsson, 2013). CW=carcass weight.

	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Cattle meat	15,920	66,058,091	241
Mutton & Goat	1,233	82,200,000	15

Pig meat	12,771	145,125,000	88
Poultry	21,190	14,126,667	1.5
Other Meat (turkey)	363	49,726,027	7.3
Total	51,477		

Table 267: Cattle losses during production and postharvest handling & storage (number of heads).

Cattle	*Rejection at slaughterhouse:*
	$\frac{0.006}{1-0.006} \times 66{,}058{,}091 = 398{,}741$
	Transportation to slaughterhouse:
	$\frac{0.00013}{1-0.00013} \times (66{,}058{,}091 + 398{,}741) = 8{,}641$
	During breeding:
	$\frac{0.023}{1-0.023} \times (66{,}058{,}091 + 398{,}741 + 8{,}641) = 1{,}564{,}694$

Table 268: Mutton & goat losses during production and postharvest handling & storage (number of heads).

Mutton & Goat	*Rejection at slaughterhouse:*
	$\frac{0.006}{1-0.006} \times 82{,}200{,}000 = 496{,}177$
	Transportation to slaughterhouse:
	$\frac{0.01}{1-0.01} \times (82{,}200{,}000 + 496{,}177) = 835{,}315$
	During breeding:
	$\frac{0.1}{1-0.1} \times (82{,}200{,}000 + 496{,}177 + 835{,}315) = 9{,}281{,}277$

Table 269: Pig losses during production and postharvest handling & storage (number of heads).

Pig meat	*Rejection at slaughterhouse:*
	$\frac{0.0012}{1-0.0012} \times 145{,}125{,}000 = 174{,}359$
	Transportation to slaughterhouse:
	$\frac{0.0011}{1-0.0011} \times (145{,}125{,}000 + 174{,}359) = 160{,}005$
	During breeding:
	$\frac{0.025}{1-0.025} \times (145{,}125{,}000 + 174{,}359 + 160{,}005) = 3{,}729{,}727$

Table 270: Poultry losses during production and postharvest handling & storage (number of heads).

Poultry	*Rejection at slaughterhouse:*
	$\frac{0.013}{1-0.013} \times 14{,}126{,}667 = 186{,}066$
	Transportation to slaughterhouse:
	$\frac{0.0035}{1-0.0035} \times (14{,}126{,}667 + 186{,}066) = 50{,}271$
	During breeding:
	$\frac{0.04}{1-0.04} \times (14{,}126{,}667 + 186{,}066 + 50{,}271) = 598{,}485$

Table 271: Other meat (turkey) losses for production and postharvest handling & storage (number of heads).

Other	*Rejection at slaughterhouse:*
	$\frac{0.015}{1-0.015} \times 49{,}726{,}027 = 757{,}249$

	Transportation to slaughterhouse:
	$\frac{0.0038}{1-0.0038} \times (49{,}726{,}027 + 757{,}249) = 192{,}568$
	During breeding:
	$\frac{0.1}{1-0.1} \times (49{,}726{,}027 + 757{,}249 + 192{,}568) = 5{,}630{,}649$

Table 272: Summary of losses by type of livestock (carcass weight 1000 tonnes).

	Rejection at Slaughterhouse		Transport to Slaughterhouse		During Breeding	
	Heads	**Carcass weight**	**Heads**	**Carcass weight**	**Heads**	**Carcass weight**
Cattle meat	398,741	96	8,641	2	1,564,694	377
Mutton & Goat	496,177	7	835,315	13	9,281,277	139
Pig meat	174,359	15	160,005	14	3,729,727	328
Poultry	186,066	0.3	50,271	0.08	598,485	0.9
Other Meat (turkey)	757,249	6	192,568	1.4	5,630,649	41
Total		125		30		886

Weighted waste % for production:

$$\frac{886}{51{,}477(A) + 886} = 2\%$$

Weighted waste % postharvest handling and storage:

$$\frac{125 + 30}{51{,}477(A) + 125 + 30} = 0.3\%$$

Table 273: Calculation for losses and wastes (1000 tonnes) for meat in North America & Oceania – taking into account waste percentages, conversion and allocation factors.

Food Production	$\mathbf{886}$ (see table 269).
Postharvest handling & storage	$125 + 30 = \mathbf{155}$ (see table 269).
Processing & packaging	$0.05 \times \big(0(H) + 43{,}169(J)\big) = \mathbf{2{,}158}$
Distribution	$0.04 \times (0(H) + 43{,}169(J) - 2{,}158) = \mathbf{1{,}640}$
Consumption	$0.11 \times (0(H) + 43{,}169(J) - 2{,}158 - 1{,}640) = \mathbf{4{,}331}$

Summary of FLW in North America & Oceania

Table 274: Summary of FLW in North America & Oceania (2009). *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***46% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW**	**% of total FLW**
Cereals	255,656	5,113	5,011	7,100	3,366	44,538	**65,128**	**45%**
Roots & Tubers	10,481	5,581	893	2,148	667	2,623	**11,912**	**8%**
Oilseeds & Pulses	123,457	3,040	112	528	148	585	**4,413**	**3%**
Fruit & Vegetables	31,917	14,542	6	861	4,144	10,912	**30,465**	**21%**
Fish & Seafood	4,154	385	19	258	218	439	**1,319**	**1%**
Milk	4,354	4,354	600	1,089	448	13,386	**19,877**	**14%**
Eggs	250	250	n/a	25	98	718	**1,091**	**1%**
Meat	886	886	155	2,158	1,640	4,331	**9,170**	**6%**
Total FLW	**431,155**	**34,151**	**6,796**	**14,167**	**10,729**	**77,532**	**143,375**	
% of total FLW	**46%*** **	**24%**	**5%**	**10%**	**7%**	**54%**		

This table shows that for North America & Oceania, the commodity group with the largest proporation of FLW is cereal, followed by fruit & vegetables and milk, where these three commodity groups account for 80% of all FLW. While for the FSC, 54% of all FLW takes place at the at the consumption stage, 24% at the agricultural stage and 10% at the packaging & processing stage. A total of 143,375 kilotonnes is lost or wasted in the North America & Oceanian FSC annually, this represents 27% of the total production of food.

Appendix G: Average Global Diet FLW Summaries

Central & Western Asia

Table 275: Summary of FLW in global diet commodities in Central & Western Asia (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***32% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**

Fruit & Vegetables	22,379	9,103	89	3,296	2,966	1,876	**17,330**	**42%**
Maize	2,875	251	157	423	78	224	**1,133**	**3%**
Wheat	25,074	2,296	1,079	5,608	1,019	2,935	**12,937**	**32%**
Milk	1,355	1,355	2,241	641	2,511	577	**7,325**	**18%**
Rice	0	-	-	-	-	-	-	-
Roots & Tubers	3,652	823	387	230	293	427	**2,160**	**5%**
Soyabeans	0	-	-	-	-	-	-	-
Total FLW	**55,335**	**13,828**	**3,953**	**10,198**	**6,867**	**6,039**	**40,885**	
% of total FLW	**32%*** **	**34%**	**10%**	**25%**	**17%**	**15%**		

This table shows that for Central & Western Asia, the commodity groups with the largest proporation of FLW is fruit & vegetables, followed by wheat, where these groups, representing three commodities account for 60% of the total FLW. While for the FSC, 34% of all FLW takes place at the food production stage, 25% at the packaging & processing, the consumption stage accounts for only 15% of all FLW.

Latin America

Table 276: Summary of FLW in global diet commodities in Latin America (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***52% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	17,297	7,881	6	2,141	1,539	1,087	**12,654**	**18%**
Maize	61,182	2,497	391	3,869	776	1,864	**9,397**	**14%**
Wheat	14,132	577	271	3,865	687	1,650	**7,050**	**10%**
Milk	2,743	2,743	4,537	1,338	5,246	2,413	**16,277**	**23%**
Rice	11,147	455	285	275	579	1,390	**2,984**	**4%**
Roots & Tubers	15,140	6,447	1,980	2,203	598	459	**11,687**	**17%**
Soyabeans	84,525	729	34	5,813	1,336	1,313	**9,225**	**13%**
Total FLW	**206,166**	**21,329**	**7,504**	**19,504**	**10,761**	**10,176**	**69,274**	
% of total FLW	**52%*** **	**31%**	**11%**	**28%**	**16%**	**15%**		

This table shows that for Latin America, the commodity groups with the largest proporation of FLW is in milk, followed by fruit & vegetables and roots & tubers, where these groups, representing five commodities account for 58% of the total FLW. Should maize, wheat and rice be aggregated ito the cereals commodity group, their proportion of total FLW would be 28%, making them the largest source of FLW. While for the FSC, 31% of all FLW takes place

at the food production stage, 28% at the packaging & processing, the consumption stage accounts for only 15% of all FLW.

South & Southeast Asia

Table 277: Summary of FLW in global diet commodities in South & Southeast Asia (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***29% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	73,161	27,171	3	1,783	14,393	8,779	**52,129**	**28%**
Maize	22,923	2,630	5,356	2,121	308	453	**10,868**	**6%**
Wheat	44,944	5,156	162	11,143	1,588	2,334	**20,383**	**11%**
Milk	5,878	5,878	9,724	2,733	13,390	1,205	**32,930**	**18%**
Rice	99,429	11,407	14,297	6,722	3,299	4,850	**40,575**	**22%**
Roots & Tubers	29,905	6,737	15,831	586	5,184	1,399	**29,737**	**16%**
Soyabeans	-	-	-	-	-	-	**-**	**-**
Total FLW	**276,240**	**58,979**	**45,373**	**25,088**	**38,162**	**19,020**	**186,622**	
% of total FLW	**29%*** **	**32%**	**24%**	**13%**	**20%**	**10%**		

This table shows that for South & Southeast Asia, the commodity groups with the largest proporation of FLW are fruit & vegetables, followed by rice and milk, where these groups, representing five commodities account for 68% of the total FLW. Should maize, wheat and rice be aggregated ito the cereals commodity group, their proportion of total FLW would be 39%, making them the largest source of FLW. While for the FSC, 32% of all FLW takes place at the food production stage, 24% at the postharvest handling & storage and 20% at the distribution stage, the consumption stage accounts for only 10% of all FLW.

Eastern Asia

Table 278: Summary of FLW in global diet commodities in Eastern Asia (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***36% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	180,521	48,944	4,405	295	30,256	52,827	**136,727**	**81%**
Maize	68,387	2,031	14,930	2,153	285	2,791	**22,190**	**1%**
Wheat	47,971	1,425	1,396	18,239	1,199	11,751	**34,010**	**3%**
Milk	-	-	-	-	-	-	**-**	**-**

Rice	59,566	1,769	867	584	2,334	22,867	**28,421**	**6%**
Roots & Tubers	30,047	15,999	448	2,216	3,472	4,591	**26,726**	**9%**
Soyabeans	-	-	-	-	-	-	**-**	**-**
Total FLW	**386,491**	**70,168**	**22,046**	**23,487**	**37,546**	**94,827**	**248,074**	
% of total FLW	**36%*** **	**28%**	**9%**	**9%**	**15%**	**38%**		

This table shows that for Eastern Asia, the commodity groups with the largest proporation of FLW is without a doubt fruit & vegetables accounting for 81% of all FLW. While for the FSC, 38% of all FLW takes place at the consumption stage and 28% at the food production stage.

Europe

Table 279: Summary of FLW in global diet commodities in Europe (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***29% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	45,325	20,651	62	945	4,193	12,392	**38,243**	**45%**
Maize	55,137	560	882	931	192	2,358	**4,923**	**2%**
Wheat	150,015	1,631	1,598	14,597	1,057	12,951	**31,834**	**11%**
Milk	8,909	8,909	2,138	1,624	1,608	11,142	**25,421**	**17%**
Rice	-	-	-	-	-	-	**-**	**-**
Roots & Tubers	47,648	25,371	4,059	6,634	2,208	6,342	**44,614**	**24%**
Soyabeans	-	-	-	-	-	-	**-**	**-**
Total FLW	**307,034**	**57,122**	**8,739**	**24,731**	**9,258**	**45,185**	**145,035**	
% of total FLW	**41%*** **	**39%**	**6%**	**17%**	**6%**	**31%**		

This table shows that for Europe, the commodity groups with the largest proporation of FLW are fruit & vegetables, followed by roots & tubers and milk, where these groups, representing four commodities account for 86% of the total FLW. While for the FSC, 39% of all FLW takes place at the food production stage, and 31% at the consumption stage.

North America & Oceania

Table 280: Summary of FLW in global diet commodities in North America & Oceania (1000 tonnes), 2009. *Agricultural Production FLW includes FLW from food production. **Total FLW includes only food production FLW and not other Agricultural Production FLW. ***47% represents the the amount of FLW compared to initial total agricultural production.

	Agricultural Production*	Food Production	Postharvest Handling & Storage	Processing & Packaging	Distribution	Consumption	**Total FLW****	**% of total FLW**
Fruit & Vegetables	16,314	7,433	2	366	1,918	4,959	**14,678**	**29%**
Maize	174,861	3,497	3,427	815	2,838	37,550	**48,127**	**43%**
Wheat	55,751	1,115	1,093	5,488	365	6,087	**14,148**	**5%**
Milk	4,354	4,354	600	1,089	448	13,386	**19,877**	**7%**
Rice	-	-	-	-	-	-	**-**	**-**
Roots & Tubers	9,961	5,304	636	2,009	624	2,451	**11,024**	**9%**
Soyabeans	81,055	2,202	0	2,376	451	1,788	**6,817**	**7%**
Total FLW	**342,295**	**23,905**	**5,758**	**12,143**	**6,644**	**66,221**	**114,671**	
% of total FLW	**47%*** **	**21%**	**5%**	**11%**	**6%**	**58%**		

This table shows that for North America & Oceania, the commodity groups with the largest proporation of FLW is maizewith 49% of the total FLW. While for the FSC, 58% of all FLW takes place at the consumption stage, and 21% at the food production stage stage.