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Understanding food waste behaviours along the food supply chain-a multilevel approach

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1. SUMMARY

More than 40% of food produced for human consumption in Europe is lost or wasted every year from farm to fork; 95-115 kg of food per capita and year according to FAO's report in 2011. The later coexist with limited access to food worldwide, which calls for finding a solution for this world-feeding conundrum. As a result, food waste started to be considered as an environmental, economic, social and food security problem. In 2012 Rio +20 conference it was recognized the need to significantly reduce post-harvest and other food losses and waste throughout the food supply chain. That is, food security needs a sustainable food management system which must be developed at both societal and individual levels, paying special attention to resource consumption, food consumption and waste management. In order to achieve a sustainable feeding society, efforts to understand the reasons of food waste at the regional level are required.

The present study aims at exploring and explaining the factors that influence the food waste generation along the food supply chain applying qualitative and quantitative methodologies. The thesis is divided in three specific modules plus two general ones. First an in-depth literature review will be developed, followed by three parallel analysis of the food supply chain approach. First a general view on the food supply chain will be settled in order to gain a broad view of the Catalan food waste issue, and testing food waste is a structural or cyclical problem. Since, consumer and primary production are the stages with higher controversial accordingly to food waste definition, a better quantification methodology regarding to food waste generation will be implemented

2. MOTIVATION

Is the food supply chain sustainable to ensure an adequate access to food for the entire population? In 2011 FAO reported that every year a third of the food produced worldwide are wasted or lost. Particularly in Europe 280-300 kg per person per year are lost throughout the entire food supply chain (Gustavsson et al., 2011). The later coexist with limited access to food worldwide, which calls for finding a solution for this world-feeding conundrum. As a result, food waste started to be considered as an environmental, economic, social and food security problem (Kosseva, 2013; Stuart, 2009). In 2012 Rio +20 conference it was recognized the need to significantly reduce post-harvest and other food losses and waste throughout the food supply chain (UNCSD, 2012). In addition, the European Parliament in the Resolution of Res.2011/2175(INI) calls for practical measures to reduce food waste by 50% by 2025 (European Parliament, 2012). That is, food security needs a sustainable food management system which must be developed at both societal and individual levels, paying special attention to resource consumption, food consumption and waste management. In order to achieve a sustainable feeding society, efforts to understand the reasons of food waste at the regional level are required.

FAO carried out a study on food waste at global level, elaborated by the Swedish Institute for Food and Biotechnology SIK (Gustavsson et al., 2011). In order to quantify the amount of FW, the world was divided into seven geographical areas. As for food, it was divided into FAO commodities: cereals (excluding beer), starchy roots, pulses and oilseed crops, fruits (excluding wine), meat, seafood, milk and eggs (excluding butter) and vegetables. For 2007 it was estimated that 1.6 Gt were lost, of which 1.3 Gt were edible. Per capita, North America & Oceania and Europe are the two regions with the highest FW rates being approximately 300-340kg per person per year lost or wasted.

Globally, cereals, starchy roots, fruits and vegetables are the groups with highest rates of FW. At harvest and post-harvest stages are where most tons of FW identified. Europe is the third region that generates most FW, being Industrialized Asia the first one, duplicating Europe's generation. Losses and wastes at agriculture stage represent a 35% of the total, the same as at consumer level (35%). Harvesting represents 10%, processing 13% and distribution 7%. Globally, 54% of FW occurs at the beginning of the chain: agricultural production and harvested, storage (upstream) and 46% at the end: processing, distribution and consumption (downstream).

According to European Comission investigation published in 2010 (Bio Intelligence Service, 2010a), food waste in Europe corresponds to 179 kg/pers./year (76kg at household level). The

42% of the volume are generated at households, 39% at the food industry, 5% at retailers stage and 14% in the hospitality service. It should be noted that in this study agriculture and fisheries FW was excluded (Bio Intelligence Service, 2010a; Kosseva, 2013).

The current study focuses on Catalonia as a case study taking into account the European context to be able to compare and to share strategies to reduce FW. Catalonia is an autonomous Community of Spain with a population of 7.5 millions of people in 2014 (Idescat, 2015). It has one of the most populated areas of Europe located along the Mediterranean coast, the metropolitan area of Barcelona, with a growing population accounting for more than 3.2 million of people and occupies an area of approximately 636 km^2, whose 48% is urbanized (AMB, 2012).

Regarding to agricultural production in Catalonia, this was 5.7 millions of tons were produced in 2013 including cereals, grain legumes, tubers, vegetables, citrus, sweet fruits, nuts, vineyard, olives and industrial crops; 1.9 millions of tons of meat and 32.0032 tons of fishing (Idescat, 2015). At the wholesale level, Mercabarna, a Food Unit located in Barcelona, managed 1.24 millions of tons of food in 2013 (Mercabarna, 2013). At the consumer level, in Catalonia it is estimated that 728kg/l of food are consumed per person and year (2013) corresponding to 1,743€ (Magrama, 2015).

Food industry, beverages and tobacco are the major generator of industrial waste in Catalonia, generating 921 millions of tons of waste, 25% of the industrial waste in 2013 (ARC, 2014a). At the municipal level, 475kg/capita/year are estimated for each Catalan in 2013, being the main fraction the organic waste (24%) (ARC, 2014b). Food waste was quantified during 2010 by the Catalan Waste Agency (ARC; UAB, 2012) from retailers to consumers, results showed that about 262.471 tons of food are wasted every year in Catalonia, 35 kg per capita/year. This study points out that, if not considering agriculture and industry, 60% all food waste generated in Catalonia is generated by households.

A critical point to define a path toward food supply chain efficiency is the lack of a consensus on quantifying food waste and losses as conceptual definitions and calculation methodologies are not common. Different concepts are used to define the food fraction which finally, due to different reasons, is not consumed by humans. Three notions: food wastage, food loss and food waste are randomly used in the different reports published(FAO, 2013; FUSIONS, 2014; HLPE, 2014). As a consequence of this lack of agreement, discrepancies among published data exist, and consequently, it is difficult to develop efficient strategies to handle food security. Nevertheless, an agreement exists in that responsibility does not only lie at the European Commission or state level, but at local and even individual levels.

Collaborative networks between scientific actors, European authorities, local authorities and citizens are needed to tackle food waste. In line with Århus Convention (signed by the European Community and its Member States in 1998 (2005/370/EC [1]))(European Union, 2005) on behalf of the Community a greater public awareness of and involvement in environmental matters will improve environmental protection. The Århus Convenion was designed to help protect the right of every person of present and future generations *to live in an environment adequate to his or her health and well-being.*

The HLPE recommends undertaking four parallel mutually supportive tracks, in an inclusive and participatory manner: 1)Improve data collection and knowledge sharing on FW 2) Develop effective strategies to reduce FW, at the appropriate levels 3)Take effective steps to reduce FW 4) Improve coordination of policies and strategies in order to reduce FW (HLPE, 2014).

Finally, as Parfitt et al., (2010) advocates it would be interesting to identify individual's attitudes, values, behaviours and motivations towards wasting food. Taking into account that food waste is an interdisciplinary issue, it has to be addressed from both waste and feeding perspectives (Kosseva, 2013; Langley et al., 2010). However, the magnitude of the influence of waste and feeding perspectives on building behaviour towards wasting food is unknown.

Considering everything that has been mentioned, the following general and specific objectives are proposed:

[1] http://europa.eu/legislation_summaries/environment/general_provisions/l28056_es.htm

3. OBJECTIVES

The main objective is to explore and explain the factors influencing the food waste generation identifying if the diversity of food waste behaviours exerts a significant influence on the FW generation all over the food supply chain. In order to shed light on this, we pursue different specific objectives as detailed below:

1) To develop a better understanding of the current status of FW generation information and stakeholders' behaviour. This is achieved by the following objectives:

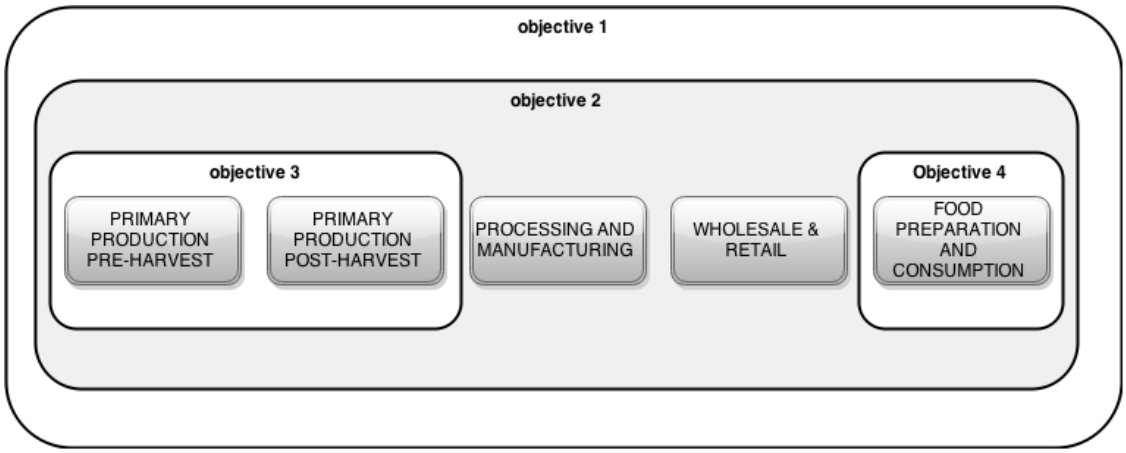
2) To clear up the main causes and possible solutions of food waste in Catalonia tacking into consideration the whole food supply chain, from producers to consumers, including the policy bodies.

3) To understand the awareness of producers about the amount of food waste generated. To better understand the concepts they have, the causes and to define a methodology to quantify the food waste in the primary sectors in Catalonia.

4) To develop a better understanding of consumer behaviour in relation to waste generation, handling, reuse and by-product valorisation.

In order to cover all of the detailed objectives, a top-down approach will be undertaken as shown in Figure 1. The thesis is divided in three main modules: the food supply chain, the primary sector and the consumer sector.

Figure 1 Specific objectives



4. STATE OF THE ART

4.1. FOOD SUPPLY CHAIN DIAGNOSIS

Analysing FW behaviours entails a broad view of the food supply chain. It is needed an integrated perspective considering each stage a part of a whole. Some of the studies to date published the amount of FW in different stages of the food supply chain, but as HLPE, (2014) points out "it is important not to confuse "where" a specific loss or waste is occurring, with its "cause"". The food supply is compressed by all the elements that interact, people, infrastructures, institutions, etc.

Recently, three outstanding institutions have published their "self-definition" (FAO, 2013; FUSIONS, 2014; HLPE, 2014). FAO, (2013) and HLPE, (2014) are on the same wavelength, they differentiate amongst food loss, food waste and food loss and waste in HLPE Report or food wastage in FAO's. Neither institutions take into account inedible parts of food as it does FUSIONS.

FAO 2013	Food loss: "a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption." Food waste: "food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. " Food wastage: "any food lost by deterioration or waste. Thus, the term "wastage" encompasses both food loss and food waste."
FUSIONS 2014	*Food waste:* is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea"
HLPE 2014	Food loss and waste (FLW): "a decrease, *at all stages of the food chain from harvest to consumption* in mass, of food that was originally intended for human consumption, regardless of the cause." Food losses (FL) : "a decrease, at all stages of the food chain prior to the consumer level, in mass, of food that was originally intended for human consumption, regardless of the cause." Food waste (FW) "food appropriate for human consumption being discarded or left to spoil *at consumer level* – regardless of the cause." Food quality loss or waste (FQLW): "decrease of a quality attribute of food (nutrition, aspect, etc.), linked to the degradation of the product, at all stages of the food chain from harvest to consumption. Inedible fractions removed from the food supply chain (e.g. side streams) are not considered as FLW"

FAO was the precursor of the food waste framework, and since 2011 all investigations has started from its report. Since then it has increased initiatives that quantify, define or try to reduce FW worldwide. It is important to point out two of them, one European and other international. FUSIONS (Food Use for Social Innovation by Optimizing Waste Prevention Strategies) is a project about working towards a more resource efficient Europe by significantly reducing food waste. The project runs for 4 years, from August 2012 to July 2016. It is funded by the European Commission Framework Programme 7. And HLPE *High Level Panel of Experts/HLPE* established in 2010 as the science-policy interface of the UN Committee on World Food Security (CFS). The HLPE aims to improve the robustness of policy making by providing independent, evidence-based analysis and advice at the request of CFS.

FUSIONS has developed a framework for the definition of the concept based on the definition of the food supply chain, differentiating from agri-food system. Food waste is defined by the final destination of all food, and inedible parts of food, removed from the food supply chain. Any food, or inedible parts of food, sent to animal feed, bio-material processing or other industrial uses are termed 'valorisation and conversion' and are distinct from 'food waste'. It includes fish discarded to sea and any material ready for harvest, liquid and solid. The food supply chain starts when the raw materials for food are ready to enter the economic and technical system for food production or home-grown consumption. It ends when the food is consumed or removed from the food supply chain. The framework is developed as from the definition of food in the EU Regulation Nº 172-2002 as well as the FAO/WHO Codex Alimentarus Commission on food safety (ALINORM 04/27/33A) Article 3.

HLPE did a specific food waste policy-oriented that presents a synthesis of existing evidences about the causes and the possible solutions to food waste and losses in order to improve food and nutrition security and the sustainability of food systems, worldwide. It takes into consideration that food losses and wastes could be approached by two different angles, either from a waste perspective or the associated with food security concerns. This report proposes to organize the complex and diverse causes extracted from a range of different studies (focused on different regions and products) amongst three different levels: Micro (household or individual enterprise), Meso (food chain) and Macro (food system and beyond). It classifies all the causes within the different food supply stages (harvest, retail, consumption, etc.) and it also proposes examples of potential impacts on the economic, social and environmental dimension of food systems.

Recently, different investigations have tried to shed light to factors that influence FW along different stages of the food supply chain. A compilation of the most relevant studies to date has been done (see Table 1). The causes are organised in four levels: technological, business and

economy, legislative and policy measures and social causes. Nevertheless at consumer level different organization has been done.

Table 1 Causes of food waste along the food supply chain worldwide.

	Meso and macro along the FSC	Pre-harvest
TECHNOLOGICAL	· Logistics [22] · Technical issues [22] · Market infrastructure-(efficiency of markets)[10] · Storage infrastructure along the chain[10] · Cold chain infrastructure[10] · Processing infrastructure (not having enough capacity to process and preserve fresh garm produce)[10]	· External drivers (floods, drought, prolonged rains, pests, birds)[1, 20] · Poor agronomic and cultural practices, mainly due to lack of information, inappropriate choice of varieties for the region or target market [2, 3, 4, 10, 16] · Spillage and damage, such as by equipment malfunction or inefficiencies during harvesting, drying, milling, transporting, or processing [1] · Livestock mortality [4,20] · Non selective fishing [20] · Standardization of the production [21]
BUSINESS AND ECONOMY	· Power imbalances between the stakeholders in the chain [21] · Market conventions: High expectation of constant availability of a broad range of fresh products [22] · Contractual practices [2] · Lack of investment and/ or lack of implementation of good practices[10] · Lack of private and public infrastructure for well-functioning food chains (not adapted to chain conditions) [10] · Lack of integrated food chain approaches and management [10] · Standardization of produce [10] · Lack of coordination among different actors in the supply chain [10]	· Poor market access [10,20] · Lack of organization among farmers in groups, cooperatives or associations to access to services and position their products better in the market or to get better contracts [10] · Over production [4, 6, 7] · To leave unharvested due to lack of demand [4, 16] · Low market prices: fluctuations in prices; the price of harvesting the crop or the cost of storing cooling are higher than its selling price [1,7,16,20] · Consumer demand (preferences, "cosmetic" standards, underutilization of products for cultural reasons, etc.) [20] · Supply and demand forecasting [7,20] · Conventional agrifood system [21] · Expectation of high delivery readiness of the retailers [22]
LEGISLACTIVE POLICY	· Policies [21, 22] · Legal framework requirements [22] · Private regulations[10] · Lack of coordination of policies at regional level [10] · Agricultural investment policies, and planning [10] · Constraints on valorisation of food waste to due to animal feed regulations[10] · Waste disposals policies [10]	· Industry or government food safety regulations or standards may cause some products to be rejected for human consumption[1] · Cosmetically-appealing demand [1,20] · Quality standards [4,6,16,20,21,22] · Government subsidies (favouring production surpluses) [20,21] · Tax on donations [20] · Tax policy [20]
SOCIAL	· Human errors [22] · Cultural influence [22] · Confusion around food date labelling[10] · Low value of food related to other goods[10] · Time saving priorities[10]	· Consumer preference[20]

	Harvest and initial handling stage	Processing
TEC.	· Premature or delayed harvesting [10] · Improper harvesting techniques and practices [7, 10, 16, 20] · Improper drying of grains resulting in fungal infection [10] · Poor choice of containers and packaging materials [10] · Poor implementation of sanitation and hygiene standards [10] · Improper use of agro-chemicals [10]	· Losses during manufacturing process [2, 22] · Errors during processing resulting in defects [10, 18] · Contamination during process [2] · By product losses during the process not diverted to other food uses [1, 7] · Lack of processing facilities or problems with these [7, 8,20] · Logistic [8] *(continue)*
BUSINESS AND ECONOMY	· Lack of knowledge and capacity on good post-harvest treatments [10] · Lack of access to processing areas[10] · Poor infrastructure for roads, energy and markets[10] · Lack of control over the process [19] · Do not meet product specifications [19] · Poor management in supply-demand inventory[19] · Profitability (non profitability of best practices) [20]	· Lack of control in the process [19] · Quality controls [2, 8] · "Sell-by" intern data (1/3) [6] · Packaging [2, 6, 7, 8, 10, 18, 19] · Food safety precautions [7] · Adaptation to get the desired size or shape [1,10] · Planning, inventory supply and demand management [19,20] · Knowledge and communication [20] · Profitability- Cost pressure (discarding of low economic value components and by-products) [20, 22] · Health pressure during processing of certain types of food [22] · Expectation of high delivery readiness of the retailers [22]
L&B	· Lack of schemes that promote or facilitate utilization of unmarketable foods e.g. donation, cottage processing, etc. [10] · Government regulations [20]	· Market requirements: size, cosmetic, etc. [1, 6, 18,20] · EU and national government legislative and taxation policy [20]
S.	· Poor communication (information exchange)[20] · Consumer preference[20]	· Consumer preference[20]
	Wholesale and transport	**Retail**
TEC.	· Improper containers and packaging to transport [10, 19, 20] · Poor ventilation during transport [10] · Poor transport infrastructure; roads, refrigerated trucks [10] · Deterioration of food (characteristics of food) [20]	· Poor storage devices [1,2, 3, 4, 8] · Inefficiencies on the cold supply chain [2, 3, 8] · Packaging: [2, 3, 4, 5, 8,10, 17, 19, 20]

BUSINESS AND ECONOMY	· Improper manipulation during packing or transport from trucks[10, 20] · Delays at the off-loading docks where no cooling facilities are provided [10] · Delays at port of entry for imported products due to inspection for phytosanitary, veterinary or food safety regulation compliance [10] · Supply cold chain inefficiencies [20] · Market demand [20] · Forecasting of stocking [20] · Specific market standards [20] · Low cost for discarding food [20] · Expectation of high delivery readiness of the retailers [22]	· Damages during transport [1,2,3,17, 20] · Large pack sizes which force some consumers to buy what they may not use [1,8,10] · Marketing: [4, 17,20] o Pressure to stock "perfect" and fresh products [10] o Wasteful displays: large piles, mixes produce [10] o Marketing strategies, promotions (2x1) [3, 9, 10, 19, 22] o Labelling [4, 8, 19] o Date labelling [20] ° Commutation campaigns [4] o Great variety of products available [3] o Lack of acceptance on lineal gaps, they seem full all day; constant assortment of products, allowing the consumer always to buy the freshest product [3, 7, 9, 10] · Stock management: [7, 8] o Lack of demand forecast [2, 3, 7, 8, 10, 17, 19, 20] o Variability of demand in touristic areas [3] o Shelf life [4 8] - very short (bread) [3] Expired dates [17, 19] o Internal sell by date [5] o Seasonal food, low sales in certain periods [8, 3] o Contracts cancelation at last minute [5, 8, 9, 20] o Stock management inefficiencies, overproduction, damages[10, 19] · Price dumping [21, 22]
L&B	· Non-compliance with phytosanitary, veterinary or food safety regulations [10] · Legal restrictions with respect to best before/consumption dates [20]	
SOCIAL	· Behaviour [20] · Staff training and communication [20]	· Higher quality standards than necessary [7, 8, 22] · Consumers' expectations, demand and marketing strategies related to consumer behaviour. [20,22] · Trust, transparency, communication and information [20]
others		· Limited redistribution: o Of unsalable food to food banks [7] o Donor's responsibility with food security [7] o Lack of alternatives to sell products next to the consumption date [7] o Lack of opportunities for donation [10] o Lack of policies favouring the redistribution [10]

<table>
<tr><td></td><td colspan="4">Catering services</td></tr>
<tr><td>TEC.</td><td colspan="4">· Storage [20]
· Equipment [20]
· Packaging [17]</td></tr>
<tr><td>BUSINESS AND ECONOMY</td><td colspan="4">· Bad practices [20]
· Difficulties to calculate the amount of food you need to cook [20]
· Demand forecasting [20]
· Lack of portions' flexibility [20]
· Situational reasons (food served but uneaten) [20]
· Operational reasons (food being prepared but not served) [20]

Hospitals
· Lack of control in schedules and menu [8]
· Low menu quality [8]

Schools
· Small budgets [8]
· Size of portions [8, 20]
· Schedule for recreation and lunch [8]

Hospitality
· Size of portions [8, 9, 17]
· Lack of knowledge of the environmental impact of waste generated [8, 9]
· Difficulties in designing meals [8, 9, 20]
· Lack of knowledge to redistribute the food to charity entities [8]
· Food exposure [17]
· Sell-by date [17]</td></tr>
<tr><td>L&B</td><td colspan="4">· Consumers' expectations [20]
· Ban on feeding ABP and catering waste to animals [20]
· Expiry dates (insufficient information in labelling) [20]</td></tr>
<tr><td>S.</td><td colspan="4">Schools
· The value of food (students) [8]</td></tr>
<tr><td></td><td colspan="4"><u>Consumption</u></td></tr>
<tr><td></td><td>Food purchasing</td><td>Storage</td><td>Preparation</td><td>Table</td></tr>
<tr><td>TEC.</td><td>· Portions of the products do not meet the needs [13]</td><td>· Do not keep the fridge cold enough [13]</td><td></td><td></td></tr>
<tr><td>BEHAVIOUR</td><td>· Offer temptation (2x1), product about to expire, etc. [2, 12]
· To buy more fresh products than need it [13]
· Do not look to sell-by and best before dates in the supermarket [13]
· To buy more products than need it [2, 13, 22]
· Shopping routines [23, 24]</td><td>· Having the need to make space in the refrigerator and cabinets due to new purchases [13]
· Improper food conservation [2, 10,11, 13]
· Leftovers intended for use that finally end up in the trash [11]
· Expired products [11, 12]
· Best before expired products [11]
· Spoiled food [12]</td><td>· Improper dish portions [2, 8]
· The food has spoiled while cooking [13]
· Experimenting with new ideas and recipes [13]
· Cook more food than need it [2,9,11,13]
· Inefficient cook [1, 2, 11, 12]</td><td>· Leftovers [11, 12]
· The food has not good taste [13]
· Kids or family do not like the food prepared [13]</td></tr>
</table>

KNOWLEDGE	· Poor purchase planning [2, 9, 10, 13, 24]	· Do not know the best before dates of the products in the fridge and cupboards [13] · Lack of knowledge of the preservation of certain products [9, 13] · Poor storeroom planning [1, 2, 13, 20] · Confusion or lack of understanding of food labeling [1, 2, 8] · Improper use of packaging [20] · Confusion between best-before and expiry dates [1,2,8,14]	· Improper meal planning [1,2,8,13] · Excess of food safety [13] · Date confusing [10] · Lack of knowledge about how to cook with leftover [10] · Lack of confidence to cook with leftovers [13]	
LIFESTYLE	· Loss of food value [2,9,14,15] · Socioeconomic factors [9] · Attitudes [8, 10, 20, 24] · Lack of awareness [10, 20, 24] · Cultural attitudes [9, 22] · Knowledge [8] · Food preferences [8, 20] · Concerns about food safety [20] · Waste awareness [23] · Dietary conscientiousness [23]		· Lifestyle [14, 23] · Family structure [2, 23] · Proportion of income spent on food [2,14, 20, 23] · Demographics [1,2,9,12,14, 20, 22, 23, 24] · Seasonability [1] · Cosmetics standards [2,14, 22] · Social norms [20, 24] · Dietary guidance (education programmes) [20] · Preference for a variety of foods [20, 22] · Eating out [23]	

Source: Elaborated from 1:(Buzby and Hyman, 2012); 2:(Parfitt et al., 2010); 3:(Mena et al., 2011); 4:(Beretta et al., 2013); 5: (WRAP and Quested, 2009); 6: (Garrone et al., 2014); 7: (FAO, 2013); 8: (Bio Intelligence Service, 2010b); 9: ARC & UAB 2012; 10:(HLPE, 2014); 11:(HISPACOOP, 2012); 12: (WRAP, 2009); 13: (WRAP, 2007); 14: (European Union, 2013); 15: (Stuart, 2009); 16: (Magrama, 2014a); 17: (Magrama, 2014b); 18: (Magrama, 2014c); 19: (Mena et al., 2014) 20: (FUSIONS 2014) 21: 21: (Montagut, Xavier; Gascón, 2014) 22: (Göbel et al., 2015) 23: (Parizeau et al., 2015) 24:(Stefan et al., 2013)

It is important to consider the impact of different policies, laws and regulations on the generation of FLW and its reduction whether they are waste or food policies. There are no closed list of regulations that directly affect the generation of FW along the food chain due to its complexity and diversity of products. In addition, once the food intended for human consumption are discarded for whatever reasons are considered as waste and are regulated by a set of specific rules for them. Table 2 and 3 show some of the laws and regulations that could affect the FW generation from a food and waste perspective.

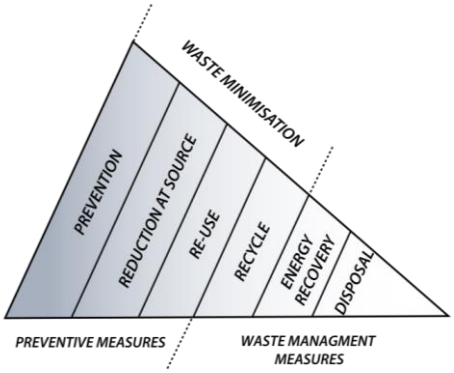
Table 2 Regulations and common laws related to waste that could have an influence on food waste generation

Waste resolutions	*Waste laws*	*Food waste resolutions*	*Waste Plans and strategies*
COM (2005) 666 final (Waste prevention and recycling)	2008/98/CE (Waste Framework directive)	2013/C 161/08 (CESE Reduction food waste)	"Estrategia más alimento menos desperdicio" (Magrama (Spain) food waste strategy)
A/RES/66/288 (The future we want, 2012 UNCDS)	LRSC 22/2011(Spanish waste law)	EU Res. 2011/2175(INI) Avoiding food waste	PRECAT 2020 (Catalan Waste Plan; include food waste)
COM(2010) 2020 (A strategy for smart, sustainable and inclusive growth)	Legislative Decree 1/2009 (Catalan waste law)		
	SANDACH (3 categories of animal origin waste) -EC 1069/2009 -UE 124/2011 -Real Decreto 1528/2012		

Regulation of food waste could be characterized as recent and unspecific. Even though there are some documents that highlight the urgency of its reduction. The 7th Environment Action Programme (EAP)[2], *which* defines how the environmental policy must be lay out until 2020, includes the food waste issue in its second priority action in order to achieve a resource-efficient economy by reducing the environmental impact of consumption. It includes subjects such as cutting food waste, among others. The Waste Framework Directive *(WFD-2008/98/EC)* (EU, 2008) clearly defines a waste hierarchy (see Figure1) and sets a clear waste prevention procedure as a priority. Waste prevention is defined as *"the measures taken before a substance, material or product has become waste, which reduce the quantity of waste"*, including strict avoidance of waste generation**,** qualitative and quantitative reduction at source, and reuse of products. It does not include material recycling and separate waste collection (Pre-waste, 2014). Within the Waste Framework Directive, the distinction between prevention and minimisation could be misunderstood. Therefore, Figure 3 allocates within the waste hierarchy the different preventive measures that encompass prevention, reduction and re-use, and waste management measures including from the recycle to disposal. It is important to highlight that the action of recycle minimises the waste notwithstanding to be a waste management measure (Jacobsen et al., 2002).

[2] Brussels 29 November of 2013 COM(2012) 710 final

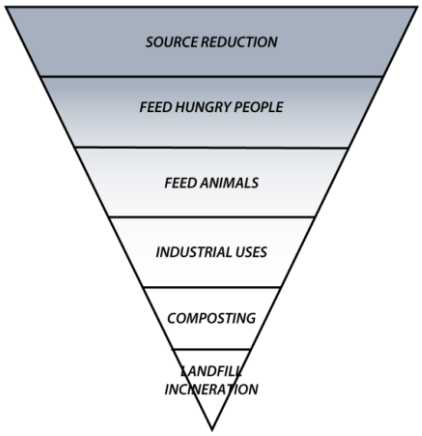
Figure 2 Preventive measures allocated within the waste hierarchy



Source: UE 2008/98/EC adapted to OECD EEA 2002: Case studies on waste minimisation practices in Europe

In this sense, to tackle food waste, is important to differentiate between recycling and prevention concepts. Evidences from the UK indicate that among all strategies to prevent waste, food waste is one of the greatest potential (Cox et al., 2010) .There is a specific food waste hierarchy (see Figure 4) which transposes the hierarchy preferences to food management *(UE Res. 2011/2175(INI))* (European Parliament, 2011).

Figure 3 Food waste recovery hierarchy



Source: UE Res. 2011/2175(INI)

The Regulation EC nº 178/2002 defines food at European level. There are different regulations that could influence the generation of FW due to hygienic, safety or aesthetic requirements. In particular, Regulation EC No. 1580/2007 specifies marketing standards for 10 fruits and vegetables: apples, citrus fruit, kiwi fruit, lettuces, peaches, pears, strawberries, table grapes and tomatoes. Furthermore, although FW is not mentioned directly in the new PAC 2014-2020, the improvement on productivity and competitiveness of agriculture could affect indirectly to FW (House of Lords, 2014).

Table 3 Regulations and common laws related to food that could have an influence on food waste generation

General	Hygiene and food safety	Marketing standards	Others
EC 178/2002 (Food law)	EC 852/2004 (Hygiene of foodstuffs)	EC 1580/2007	Regulation nº 1169/2011 (Food information for Consumers)
Codex Alimentarius	EC 853/2004 (Food of animal origin)	EC 1221/2008 (10 product standards)	"Plan Ayuda Alimentaria" FEGA Spain
12/2013 (Food supply chain)	EC 882/2004 (feed and food law, animal health and animal welfare)	UNECE (international recommendation)	Good Samaritan law (Italy)
PAC 2014-2020	EC 2073/2005 (microbiological criteria for foodstuffs)		EC 1182/2007 (fruit and vegetables sector, include market withdrawls)

A part from the data of international or regional studies that quantify FW generation, in Catalonia it was held a diagnosis in 2011. The Table 4 shows the amount of waste quantify by means of secondary data and waste characterization. More information is needed, but with the preliminary analysis it is observed that Agriculture and consumer stages are the most responsible of the total FW.

Table 4 Approach volume of food waste in Catalonia in 2010

	Food waste (t)	Food waste (%)
Agriculture	303.728	**40,0%**
Transformation	177.382	**23,4%**
Wholesale	15.794	2,1%
Retailer -markets	3.671	0,5%
Retailer -molls	42.987	5,7%
Retailer -others	23.391	3,1%
Distribution-total	85.843	**11,3%**
Hospitality	30.976	4,1%
Institutions	9.574	1,3%
Households	151.872	20,0%
Consumer total	192.422	**25,3%**
Total	759.375	100%

Source: (Muñoz, 2012)

4.2. AGRICULTURE FOOD WASTE

At the agriculture level two concepts are used indistinctly: food waste and food loss. Despite primary stage is one of the most contributors of food waste/food loss along the food supply chain is one of less studied stages. There are few works that study agriculture FW deeply. This can occur due to difficult to quantify it in addition to a lack of consensus on the concept.

As it is mentioned above, FUSIONS project has established a definition and guidelines to quantify food waste from agriculture to consumer but at the first stage there is where more

controversy exists. Methodologies applied to obtain the variety of numbers are diverse. FAO employed the Food Balance Sheets to obtain the amount of food loss for each commodity (Gustavsson et al., 2011). Similarly, Kummu et al., (2012) did using FAO study, but they expand it in analysing FW at country level and included the food supply in terms of kcal to quantify resource (water, land, fertilisers) use for FSC losses. Beretta et al., (2013) quantified food waste along the food supply chain in Switzerland by means of key informants' interviews. The losses at primary production are estimated at 14%, thereof 5.5% being avoidable or possibly avoidable. The study distinguished among 22 food categories. In UK a combination of semi-structured interviews and data base has been used to elaborate eleven resource maps to different fruit and vegetables from primary stage to consumer. Taken as a whole, loss and waste in the supply chain is typically less than 10%, though it can approach 25% for some products. For certain products however, loss is more significant at different points in the supply chain. In Africa, APHLIS (The African Postharvest Losses Information System) is a project that has developed a database and online platform that integrates a network of local experts who provide food waste and loss data. The database calculator loss is shared. It estimates the weight of cereals losses in sub-Saharan Africa by country and province. The estimation are shown in maps and tables (APHLIS, 2014). Other studies, as Garrone et al., (2014) are focused on the processing sector. In this study they have a model of the degree of recoverability by means of interviews to experts that could be implemented to different stages of the food supply chain.

In Spain a research has analysed the loss and waste at the agriculture level (Magrama, 2014a). Table 5 shows the results obtained from 390 telephone interviews to producers. We have identified some critical points that make the study replicable. Firstly, the FW concept it is not clear and is not comparable to the rest of studies. Secondly, in the table it is shown the percentages of FW but the production it is not given. And, finally, the meat sector and sugar sector has been excluded from the study. Nonetheless the meat sector is one with the highest environmental impact as noticed in FAO, (2013); Mena et al.,(2014).

Table 5 Percentage of loss and waste at primary stage in Spain

Subsector	*Citrus fruits*		*Rest of fruits*		*Vegetables*		*Fats and oils*		*Wine*		*Cereals and legumes*	
Stage	*% loss*	*%waste*	*% loss*	*%waste*	*% loss*	*%waste*	*% loss*	*%waste*	*% loss*	*%waste*	*% loss*	*%waste*
Farm	17.8		18.9		21		21.5		17.2		21.9	
Harvest	0.74	1.86	0.32	1.9	5.06	1.54	0.39	4.35	2.07	1.88	1.48	1.61
Post-harvest		2.08		1.98		1.61		2.19		1.57		1.72
Total	18.5	3.94	19.22	3.88	26.06	3.15	21.89	6.54	19.27	3.45	23.38	3.38
Total loss and waste	**22.5**		**23.1**		**29.2**		**28.4**		**22.7**		**26.7**	

Note: *Loss: percentage of production that is lost through inefficiency, eg the weather conditions or pests*
Waste: part that cannot be recovered
Source: (Magrama, 2014a)

Further research is needed in this stage of the food supply chain in order to be able to implement efficient measures to reduce it. A consensus among all stakeholders is a key point. In this sense, the Catalonia Waste Programme PRECAT20 2013-2020 contemplates actions related to food waste. In particular it has to be establish, before the end of 2016, a goal of reducing food waste in primary and food sectors, including wholesale distribution and food waste diagnosis at primary sector must be performed (ARC, 2014c).

4.3. CONSUMER FOOD WASTE

Published data revealed that about 50% of the total amount of food wasted is generated in the last stage of the food supply chain: household and out-of-home food consumption. Therefore, in order to achieve an efficient food management system we need to understand consumers' behaviour and attitudes towards food waste generation and prevention.

Some of the studies that quantifies food waste household generation are (see Table 6): Gustavsson et al. (2011) and FAO (2013) at the international level, Bio Intelligence Service (2010) at the EU level and Langley et al., (2010) for UK, HISPACOOP, (2012) for Spain and ARC & UAB (2011) for Catalonia among others at country level. Up to the moment an international database on food waste do not exist and therefore the different studies use a variety of methodologies to quantify it, such as dietary cooking books; questionnaires; organic waste counting; environmental impacts and so on. Bio Intelligence Service (2010) reported that for the case of Europe 60% of household food waste could be avoided.

Consumer behaviour regarding food waste perspective has not been studied in depth since most of the existing academic literature on food waste has focused on estimating the amount of food loss (Griffin et al., 2008), with little attention to the factors driving these food losses. WRAP studies have demonstrated that there isn't a single behaviour that may lead food waste (Quested et al., 2013; WRAP, 2011). Instead, a variety of actions and motivators could affect the amount of food loss generated as it is not only a food related issue but waste management skills have to be considered. Some authors have studied food waste and waste management behaviours applying the Theory of Planned Behaviour (TPB) (see Barr, 2007; Godfrey et al., 2012; Karim Ghani et al., 2013; Stefan et al., 2013; Tonglet et al., 2004b). It has been noticed by Zorpas & Lasaridi (2013) that a weak explanatory power of these models it is caused by a failure on explaining consumers' complete decision making process.

Table 6 Consumer food waste quantification studies

Country	Study	Methodology	Kg food wasted/person/year
Spain	HispaCoop (2012)	Personal and online questionnaires + dietary cooking panel	32.3
Catalonia	ARC (2011)	Organic waste quantification	34.9
World	Gustavsson et al. (2011)	Estimations from FAO database on production and consumption of food + previous literature	95-115
UK	Langley J. et al. (2010)	Dietary cooking panel	72.6
Austria	Lebersorger and Schneider (2011)	Waste quantification	18.8
UK	WRAP (2009)	Previous literature+ questionnaires+ Dietary cooking panel+ available data analysis	303 per household/year
EU 27	Bio Intelligence Service (2010)	Analysis of Eurostat waste data.	76
EEUU	Buzby and Hyman (2012)	Statistical data from questionnaires.	124
Germany	iSuN et al. (2012)	In depth questionnaires + statistical data analysis	146

Household food waste can be considered the output of a particular behaviour resulting from inefficient management food consumption. Some studies intent to determine, by means of different analytical tools, which are the main causes of household food waste. The most frequent identified causes can be grouped in five categories such as: food purchase (inefficient cooking, lack of a proper food purchase planning, promotions 3x2,...), food storage (poor storage planning, ignorance of expired date, confusion in food information label …), food preparation (incorrect portions, excess of food security, poor planning of the meals…), food consumption and a particular lifestyle (loss of food value, lifestyle, familiar structure, knowledge, attitudes, socioeconomics factors…) (see Table 1) Most of the causes emerged from these studies are focused on an inefficient household food management.

The relationship between food waste and feeding behaviour has also been considered at the European Parliament with instruments such as the European Roadmap towards resource-efficient (European Comission, 2011). Besides Parfitt et al., (2010) cite Brook Lyndhurst (2007) and Hamilton et al. (2005), for UK and Australia noticed that consumers' attitudes, values, knowledge and behaviour towards food have an effect on the propensity for food waste. According to Kosseva, (2013) reducing food waste in developed countries is a challenge because it is related to individuals feeding behaviour and attitudes.

Finally, Stefan et al. (2013) have shown that planning and shopping routines explain most of the variance in food waste in their study in Romania. Furthermore, other studies have found noticeable conceptual links between food waste and other food related issues such as nutrition and food safety (e.g., HLPE 2014). Indeed, in the WRAP study Food and drink waste from households in the UK 2011, more people cite eating a healthy diet as an encouraging factor of reducing food waste than those who wanted to reduce their environmental impact (Quested et al., 2011).

Individual behaviour in relation to food waste management has also been linked to lifestyle. Evans (2011) identified that lifestyle do have an influence on the amount of food wasted. Indeed, lifestyle is a broad concept related to food behaviour in different ways being materialistic and consumeristic food values and habits important elements that shape individuals lifestyle. This is the case of mass consumption and the rapid turnover of products, along with a personal identity based on ownership of commercial goods.

There is a common tendency to relate waste reduction with recycling although they are not the same concepts. Some studies suggest that only the most environmental encouraged or committed "recyclers" are who act to prevent waste. Yet, there are no evidences to ensure that recycling promotes prevention (Cox et al., 2010). Importantly, research has recommended that waste prevention behaviours are poorly associated with recycling, and are sometimes even negatively correlated (Barr, 2007) such that recycling may become a reason for not doing more to reduce waste. Some authors as Barr, (2007); Refsgaard and Magnussen, (2009); Tonglet et al., (2004a); Zorpas and Lasaridi, (2013) suggest that recycling behaviour is influenced primarily by opportunities, facilities and knowledge and secondly by not being deterred by issues of physically recycling (e.g. time, space, inconvenience). Meanwhile factors that influence waste prevention, most cited in the literature (*see* Barr, 2007; Cox et al., 2010; Tonglet et al., 2004b), are: universalism values and moral motivations; self-responsibility to act; auto-efficacy; the cost; social norms; habits; strong environmental values; the knowledge of environmental politics. There is no single activity involved in waste prevention, but many little actions (Barr, 2007; Tonglet et al., 2004a; Wilson and Williams, 2007). Additionally, prevention behaviour tends to be private and invisible, so there are few probabilities to develop a social *norm* (Cox et al., 2010).

Studies like Barr, (2007); Tonglet et al., (2004b) covered the issue of prevention and recycling behaviour in a global scope, not focusing in one single act as it is wasting food. Barr (2007) in his investigation examined three waste management behaviours separately (waste reduction, reuse and recycling).The study noticed that environmental values, situational characteristics, and psychological factors play a significant role in the prediction of waste management behaviour. Tonglet et al. papers (2004a and 2004b) try to understand the householders' attitudes to recycling as a general act. The findings suggest that pro-recycling attitudes are the major contributor to recycling behaviour.

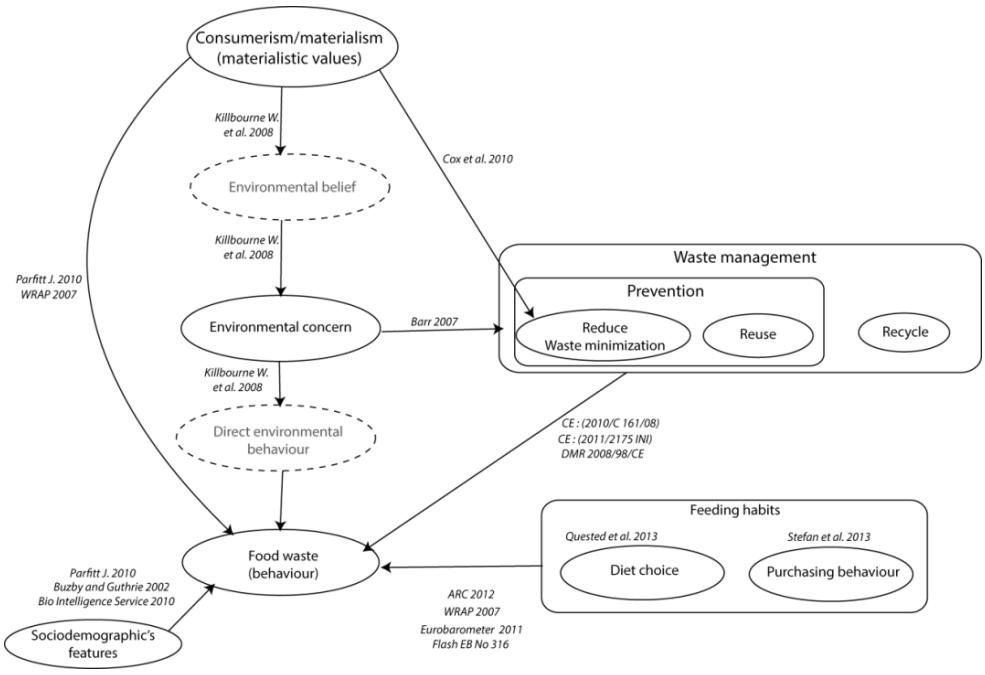
Another factor that seems to be important when forming food waste behaviour is individuals' environmental concern. Barr, (2007); Kilbourne and Pickett, (2008) directly linked environmental awareness to positive environmental behaviour. In the same line Tonglet et al., (2004a) and Barr et al. (2001) suggest that environmental awareness is linked to waste

minimization. More recently Cecere et al. (2014) noticed a positive effect of Green Attitude on the perceived production of food waste using Eurobarometer Report of 2011[3] data.

Consumption habits in general could influence food waste as mentioned by Parfitt et al., (2010) and WRAP, (2007). Consumerism has been conceptualized as a value which attaches importance to material's possessions and pursuits of personal wealth. Self-interest and lack of concern for others are related to consumerism (Hirsh and Dolderman, 2007 citing Richini & Fournier, 1991). In this line Kilbourne and Pickett, (2008) show, based on their research, that materialism has a negative effect on environmental beliefs, and these beliefs affect environmental awareness and environmentally responsible behaviour.

We have brought together the published evidences from different studies and the different identified behaviours towards food waste; and develop a decision making structure considering three main issue: feeding habits, waste management (distinguishing between prevention and recycling) and citizens values (environmental concern and consumerism). Figure 6 summarizes the framework.

Figure 4 Theoretical Food waste behaviour framework model

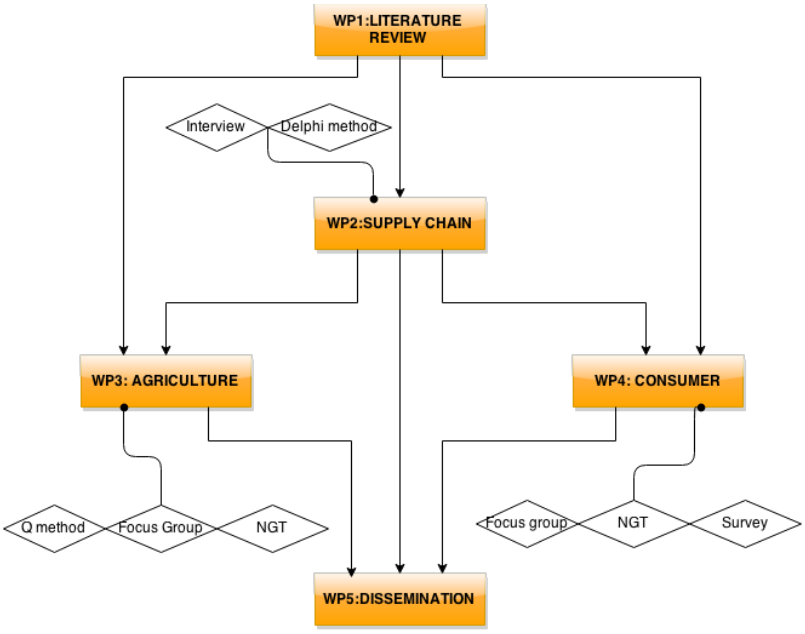


[3] Flash Eurobarometer 316. Attitudes of Europeans Towards Resource Efficiency

5. RESEARCH METHODOLOGY AND APPROACH

The thesis is divided in three specific modules plus two general ones (Figure 7). First an in-depth literature review will be developed, followed by three parallel analysis of the food supply chain approach. First a general view on the food supply chain will be settled in order to gain a broad view of the Catalan food waste issue, and testing food waste is a structural or cyclical problem. Since, consumer and primary production are the stages with higher controversial accordingly to food waste definition, a better quantification methodology regarding to food waste generation must be implemented. Hence, two specific work packages (WP3, WP4) will use quantitative and qualitative techniques as follows: WP2 is based on a two-stage qualitative approach consisting of: 1) in-depth interviews; and 2) Delphi method to arrive at a consensus. Firstly, **semi-structured interviews** will be held to evaluate different perspectives of the problem through **instrumental stakeholder** analysis stakeholders. Moreover the data will be analysed through the **qualitative content analysis** method to distinguish the main causes of FW in the region as well as different measures to minimize FW. The latter is used to develop the second part consisting on the implementation of **Delphi method** to forecast the most effective solutions to tackle food waste along the different food supply stages. By means of two rounds, the consensus among stakeholders is expected. Based on the literature research and the results obtained in WP2 andWP3, the **Q methodology** will be implemented to identify social discourses in the first stage of the food supply chain. Likewise, **focus groups and Nominal Group Technique** will serve to a better understanding of the agricultural stage according to FW generation and quantification methodology, since in WP2 we are going to obtain a macro view. Based on results from both activities, proper indicators to perform FW temporal and geographical comparisons will be defined. Finally, WP3 will address consumer approach. As mention during the state of the art, previous experiences have shown that consumer FW quantification has different difficulties depending on the methodology used to. Therefore, **focus groups and Nominal Group Technique** will qualitatively explore consumers' heterogeneity in perceptions, motivations and practices. The findings will serve for further refinement of the **survey** to understand consumers' FW behaviour. Appropriate **econometric models** will be estimated and allow us to disentangle the amount of food generated as the factors promoting it. **Secondary data** (Eurobarometer, national and EU datasets) would be also employed on analysing producers and consumers' behaviour.

Figure 5 Research methodology and approach



5.1. *WP1: LITERATURE RESEARCH*

Objectives

The main objective of WP1 is to develop a better understanding of the current status of FW generation information and stakeholders' behaviour. This is achieved by the following objectives:

- **WP1.1.** Understanding of all conceptual frameworks of FW and the main causes worldwide
- **WP1.2.** Understanding of different methodologies to quantify FW and comparison of the data
- **WP1.3.** Identify and understand the database available related to FW generation along the food supply chain

Description of work

Task 1.1. *Collection of relevant food waste generation information and stakeholders awareness towards food waste* (month 1- month 12)

As explained above food waste issue was revealed since FAO's 2011 Report. By then, different disciples started to treat the issue from different perspectives: food, waste, politics, etc. An exhaustive literature research is needed to better understand the FW current status and to

propose rigorous studies that facilitate the understanding of the problem. Specific reports and platforms dealing with FW (FUSIONS, HLPE, FAO) will serve as reference, as well as scientific literature. The definition of food waste will be discussed and defined by the consensus of the actors involved. However, FUSIONS framework is taken as reference when it is necessary to give a definition or methodology. Compilation of databases related to sectors will be analysed.

The information analysed will serve as basis for the rest of workpages development and to compare the "Catalan context" with the rest of the experiences.

Methodology:

Four different types of datasets will be employed: food production, food consumption, EU food import and export main flows, stakeholders' perceptions and finally waste flows. The representative FW streams will be identified and used as information to perform WP2 (agriculture) and WP3 (consumers). Secondary database (Eurobarometer, national and EU datasets) amount FW generated along food supply chain will be analyzed.

Milestones:

M1.1.Report on the current status of FW generation patterns (input for WP2, WP3 and WP4)
M1.2. Review manuscript on waste and dietary patterns and different food landscape scenarios definition (input for WP2 and WP3)
M1.3. Completion of a database of indicators for identification and quantification of FW patterns

5.2. *WP2: FOOD SUPPLY ANALYSIS*

Objectives

The main objective of WP2 is to clear up the main causes and possible solutions of food waste in Catalonia tacking into consideration the whole food supply chain, from producers to consumers, including the policy bodies. This is achieved by the following objectives:

- **WP2.1.** Food supply chain stakeholders' identification and relationships.
- **WP2.2.** Identification of stakeholders' role in the food waste generation.
- **WP2.3**. Critical points detection and main causes of food waste definition along the food supply chain
- **WP2.4.** Joint solutions proposal and definitions of new policies and actions to reduce food waste.

Description of work

A critical point to define a path toward food supply chain efficiency is the lack of a consensus on quantifying food waste and losses as conceptual definitions and calculation methodologies are not common. Different concepts are used to define the food fraction which finally, for different reasons, is not consumed by humans.

This WP aims at clearing up the main causes and possible solutions for food waste taking into consideration the whole food supply chain, from producers to consumers, including the policy bodies. As a case study we restrict our study to the Barcelona metropolitan area. To achieve the mentioned objective the following research steps will be followed: 1) food supply chain stakeholders' identification; 2) identification of stakeholders' role in the food waste generation; 3) critical points detection and main causes of food waste definition along the food supply chain; and finally 4) consensus about solutions and definition of new policies and actions addressed to reduce food waste along the food supply chain.

WP2 is based on a two-stage qualitative approach consisting of: 1) in-depth interviews; and 2) Delphi method to arrive at a consensus based on a stakeholder analysis. There are three main tasks explained below:

Task 2.1. *Stakeholder's identification in the metropolitan area (month 1- month 12)*

The different stages of the food supply chain to take into account are: primary producers, food industry producers, wholesalers, retailers, hospitality service, social redistribution entities, institutional departments at different levels (regional, provincial and local), experts, social enterprise and social collectives.

The task will be implemented during all the WP2 execution as it is an iterative process.

Methodology:

We employ instrumental stakeholder research method to analyse the food system functioning and identify all stakeholders that are directly or indirectly related with food waste generation. As proposed by Reed et al., (2009) the instrumental stakeholder research is devoted to understanding and explaining the behaviour of stakeholders whether they are individuals, organisations, policy-makers, etc. and it is particularly addressed when consensus need to be reached among them as in our case. Involving stakeholders in the decision process could lead to the development of understanding and trust between participants. The steps proposed are divided in three phases and six steps. The first phase is to understand the context in which the investigation is going to be conducted: identifying the focus and the system boundaries. The

second phase is the application of stakeholder's methods: identify stakeholders and their stake, differentiate between and categorise them and investigate their relationships. And finally is the action phase in which it is possible to engage stakeholder to decision-making processes.

Stakeholders analyses is a process of qualitatively analysing information to determine whose interest and relationships should be taken into account when making a decision or implementing a policy (Caniato et al., 2014 citing Schmeer, 1999, p.3). Caniato et al. (2014) point out the adequacy of applying this process to waste management systems as the system is usually steered by social roles and stakeholders' communication.

Intentional sampling is chosen to carry out the two-stage qualitative approach. Intentional sampling is a non-probabilistic procedure in which the selection of sampling units attends to subjective criteria related to the aim of the study. It is commonly used in qualitative studies where experts' judgments are necessary as in our case. As explained by Del-Val-Cid, (2009) there is a variety of strategies as: extreme case sampling, less common case sampling, maxim variability case sampling, homogeneous subgroups sampling, structural sampling or key informants sampling. The latter is the most appropriate for developing the Delphi method as it focuses on selecting stakeholders with the maximum information about a topic and it is performed using the snowball technique which individuals from initial interviews identify new informants.

Task 2.2. *In-depth interviews to stakeholders along the food supply chain (month 3-month 7)*

In order to achieve a sustainable feeding society, efforts to understand the reasons of food waste at the regional level are required. It is important to clear up the main causes and possible solutions of food waste an related them to stakeholders interest, responsibility, knowledge and influence.

The main causes of food waste generation will be identified and compared to the literature review summary (Table 1). An extraction of the possible solutions proposed by participants will serve as a start point of the Task 2.3. All the information obtained will be used to develop and guide WP3 and WP4.

Methodology:

Semi-structured interviews are useful for in-depth insights in which the researcher asks to interviewee by means of "interview guide" which is not fixed. Thus the researcher could modify the order of the questions or add new ones depending on the conversation. The interviewee answers all questions without any limitation. This type of interview is appropriate, specially, in

exploratory studies like in our case. One of the weaknesses is that it is time-consuming and hence costly (Viedma, 2009).

The sampling will be intentional as explained above. The value of each respondent is related to their particular understanding of the phenomenon studied. Therefore, it is important that more than the number of interviews or heterogeneity, the sample represents all perspectives. The sampling is finished when interviewee are not offering alternative answers in explaining the phenomenon.

All interviews are recorded and verbatim transcript. Subsequently, the meaning of the texts will be determined through qualitative content analysis which is a systematic approach which follows different steps allowing us to identify the key concepts of discourse (Viedma, 2009). Concepts are coded and classified attending to discussion guide, tendencies and observed patterns. Then, all the categories are related with all previously identified, until obtaining a model with structure and dynamic. In order to validate the results obtained triangulation method will be employed by looking for outcomes that are agreed upon by all stakeholder groups (Guion et al., 2011).

Task 2.3. *Delphi method implementation to define future scenarios* (month 5- month 12)

The solution for FW reduction is not a unique one centred in one stage of the food supply chain. However to define better policies to reduce FW all the system in a macro perspective should be considered. The Delphi method will be implemented to reach a consensus among the different stakeholders in order to forecast the most effective measures. To do so a two-round questionnaire will be implemented. The questionnaire will be based on the results from the first stage in which stakeholders identify alternative measures to reduce food waste along the food chain. In the Delphi questionnaire, stakeholders will have to assess the effectiveness of each of the alternatives using a Likert scale from 0 to 100.

A battery of consensual measures to reduce FW in the metropolitan area will be obtained and analysis and these will be analysed in relation to stakeholders' characteristics.

Methodology:

The Delphi method is a technique of collecting information aimed at obtaining a consensus among experts on a complex issue. Traditionally, it has been applied to forecast, exploring ideas and trends and to reach consensus among experts on a complex issue. Likewise, it is also used to analyse the relative importance of a problem (Worrell et al., 2013). The process of obtaining results requires the participation of experts over 2 or 3 rounds of data collection through a more

or less structured (depending on the phase of the study) questionnaire. The peculiarity of this method is that Delphi questionnaire responses of each round completed feed the next round, which will be applied in the same consulted sample. The three key elements to take into account are: a) communication between moderator and participants; b) continuous feedback of results; c) anonymity of participants, as the opinions expressed are presented only in aggregate form (Callejo Gallego, 2009).

The expert panel will be formed in relation to the participant's ability to assess the issue in question and to be able to forecast the different options to reduce food waste. In our case the prior in-depth interviews and stakeholder analyses will serve to select the panel. The panel should be either experts, scholars, interested or directly affected by the subject matter (Pill, 1971). The number of experts can vary between 10 and 30 depending on the complexity of the topic.

Milestones:

M2.1. Stakeholder's analysis related to food waste generation
M2.2. Identification of the main causes of FW in the metropolitan area and a comparison to literature.
M2.3. Establishment of possible solutions to reduce FW

5.3. WP3: AGRICULTURE FOOD WASTE PERCEPTION

Objectives

The main objective of WP3 is to understand the awareness of producers about the amount of food waste generated. To better understand the concepts they have, the causes and to define a methodology to quantify the food waste in the primary sectors in Catalonia. This is achieved by the following objectives:

- **WP3.1**. To obtain a complete picture of the discourses on food waste behaviour at the agricultural level
- **WP3.2:** To define the recoverability degree of FW and identify the most important fractions.
- **WP3.3:** To design a battery of indicators that can be implemented to monitor the evolution of FW at the primary stage.

Description of work

Although FUSIONS proposes a common definition and guidelines for quantify food waste in the primary sector. It should be adapted the geographic and cultural context with the maximum consensus among all the stakeholders. Only then effective FW prevention objectives and policies could be established. The WP will have a global view of the food supply chain although it will focus on the primary sector.

It is interesting to better understand the reality and the variety of discourses through the Q method implementation. Once it is identified it is important to focus on the products with a higher degree of recoverability or prevention. Therefore focus groups will be implemented. And jointly with the data studied in WP1 and all the information obtained from ask 3.1. and 3.2. a battery of indicators will be design to better monitor and compare spatially and temporary FW generation.

A deep understanding of FW dynamics in the primary sector in Catalonia will be obtained as well as robust indicators to measure it.

Task 3.1. *Q method implementation* (month 12- month 16)

A percentage of reduction must be defined by policy makers to reduce food waste by 2020 as it is explained in the literature review. To define a quantity is important to understand all the variables that affects the generation as all different discourses existing about the issue. As "discourses" we mean a way to approach or to identify a problem or reality.

As stated by Barry and Proops, (1999; p.345) "Q method allows a responsive but statistically rigorous approach to the subjective perceptions of human-nature relationships, and its results could be extremely useful in forming environmental policy making".

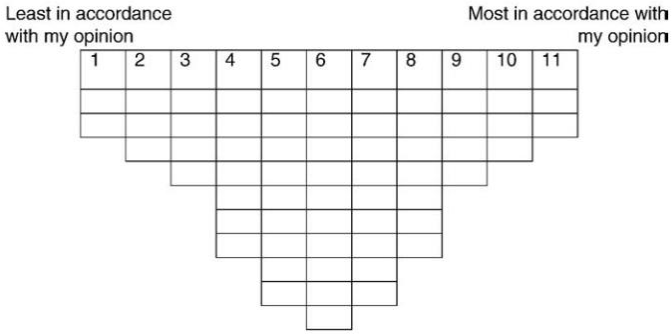
Methodology:

Q methodology informs about coexisting discourses, and not about what a particular percentage of the population attaches to each discourse. Therefore, Q requires sample sizes that are relatively small. Since the units of analysis are discourses instead of individuals, Barry and Proops (1999) claim that samples as small as 12 participants provide statistically significant results.

The point is soon reached when adding an additional participant does not necessarily increase the diversity of discourses. Participants are not chosen randomly, but to maximise the diversity of opinions and profiles. We will took into account people engaged in all economic sectors, as well as local politicians, NGO members and civil servants. Q is usually implemented in five

stages: 1) generation of a pool of statements by means of semi-structured interviews. Q methodology can be combined with different qualitative research tools (e.g. focus groups, in-depth interviews, participant observation, etc). 2) from these statements a manageable selection of 36 should be chosen It often consists of 30–50 statements; 3) the selected statements should be ranked by participants on a scale 'Most agree' to 'Most disagree' to generate a 'Q sort' per participant which, it is assumed, is a good representation of his/her standpoints; (Figure 6) (4) Q sorts are statistically analysed to group them through extracting factors, which represent ideal-type Q sorts that capture the common essence of different sets of Q sorts; and finally 5) the factors extracted are interpreted as discourses. During the second interview (step 2) participants will be asked to rank the statements on a scale +4 to -4, with +4 corresponding to "Most agree", 0 to "Neutral or non-important" ,and -4 to 'Most disagree'. A pack of randomly numbered cards, each of them representing one selected statement, and a standard Q-sorting grid (see Van Exel and de Graaf, 2005), as shown in Figure 6, will be provided.

Figure 6 Q sort distribution



Task 3.2. *Focus group implementation* (month 16- month 24)

Once we have analysed the database available and the variety of discourses it should be essential to have an insight of the possibilities to quantify the amount of FW generated and the degree of recoverability of the different products produced in Catalonia. By means of focus group technique we will better understand the sector and, hence, design a battery of indicators proposed. We will combine a Nominal Group Technique with focus group during the task.

Methodology:

Focus groups technique could be defined as a meeting of people planned to obtain information about participants' perceptions, opinions about a certain topic; it is a planned discussion in a permissive and nonthreatening environment (Krueger and Casey, 2000). This technique will help us to understand the origin and nature of food waste phenomenon, behaviour, attitude or

belief of different groups of people. The technique allows us to collect less rational and more spontaneous information that is generally not collected in quantitative questionnaires.

The questions should have two main characteristics: 1) they should be affined with all the basic points the research is focused on; the aim is to be able to define whether the points are critical points or not, without conditioning participants with preconceived notions and 2) it should allow all members of the group express their views freely and without prejudice.

Sampling should ensure external heterogeneity among groups and homogeneity inside each group. Internal homogeneity aims people to share experiences and communes interests, therefore the greatest affinity as possible. People should be unknown but at the same time they have to share economic, cultural situations, as well as have similar experiences. Both general features and specific ones should be taken into account during the sampling process. In our case from 3 to 5 groups will be constituted depending on the variety of discourses have found in the prior task (Q method) as proposed by Cuppen et al. (2010). Each group will have from 7 to 9 participants despite small groups could work better as participants could express themselves better. We will regard the contacts made in WP2 to form the groups.

The Nominal Group Technique NGT is a structured method for capturing and aggregating opinions emerging from a group of experts who physically coincide in terms of place and time. It could be considered as a particular case of the focus group. The NGT is oriented towards the generation and sorting of ideas. The process summarized by Landeta et al., (2011, p.1631) is divided in five steps: 1) the study leader presents a question or subject for discussion; 2) the experts in silence and individually answer in a paper and develop a list of ideas; 3)the experts expound and clarify the individual ideas one by one, taking turns and without any comments from any of those present to judge the proposals 4) experts individually do a ranking of all the ideas that appear in the dynamic; and 5) integration and exposition of the results by the study leader. NGT results will be analysed using statistical procedures and will be represented in table or chart format.

Milestones:

M3.1. Variety of discourses representing the definitional frameworks of different groups and their interest

M3.2. Potential of reduction of different products

M3.3. Battery of indicators to measure FW in the primary sector

5.4. WP4: CONSUMERS FOOD WASTE PERCEPTION-KNOWLEDGE

Objectives

The main objective of WP4 is to develop a better understanding of consumer behaviour in relation to waste generation, handling, reuse and by-product valorisation. This is achieved by the following objectives:

- **WP4.1**. To identify and measure the factors that influence consumers' FW decisions and quantify its importance
- **WP4.2.** To better understand the relationship between waste recycling and prevention behaviours and its effect on FW generation behaviour
- **WP4.3.** To understand how new attitudes that result from the deepening of a consumer society, such a materialistic and consumerism food values, influence FW generation
- **WP4.4.** Based on the latter, we specifically aim at identifying how the effect of food prices more general compares to the new consumers' attitudes towards FW associated with a consumer society.

Description of work

Based on our results from my master thesis, in which we developed and tested a behavioural model (Figure 6), we want to deepen in the motivations and factors that lead people to waste food and to reach a better understanding of the factors that influence consumers' food waste decisions in order to define policy recommendation for developing efficient strategies to handle food security and at understanding food waste behaviours at the consumer level and within the food supply chain.

We specially focused on obtaining a better scale to measure FW consumers' generation applying focus groups and to develop a model that defines FW consumer behaviour.

Task 4.1. *Qualitative insight into food waste behaviour and knowledge (*month 18-month 23)

It is important to understand the awareness of consumers related to FW generation and to obtain a robust measurement scale to measure using survey methods.

Methodology:

Focus groups will be held to qualitative analyse the issue. The methodology is the same as explained in Task 3.2. but the sample will be consumers. Intentional sampling will be used

attending to sociodemographic factors and awareness indicators previously studied during the master thesis.

Task 4.2. *Research for quantified consumer food waste understanding* (month 23-month 32)

A behavioural FW model will be tested by means of a survey implementation in order to define which are the indicators that, positively or negatively, influence the FW generation.

Methodology:

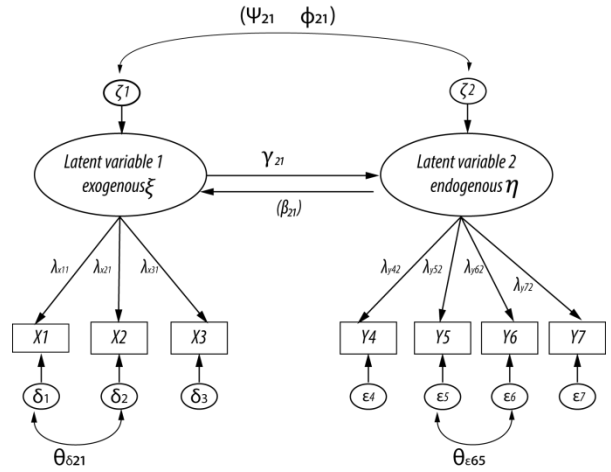
To test the hypotheses mentioned above, we will conduct a survey in Catalonia (Spain). Cross-sectional data will be collected through the distribution of 1000 questionnaires to individuals responsible of cooking or food purchase in their household. The survey will be implemented by quotas selecting representative factors, such as gender, age, area of residence, education, income and children in charge, etc.

The data will be analysed using different econometric models. One proposed is Structural Equation Modelling (SEM) approach which has been considered to test the causal links that will be specified in the theoretical model.

SEM is one of the most widely applied techniques in consumer research, as it allows modelling simultaneously many relationships and includes latent constructs in the analysis as dependent or explanatory variables. Enabling a multivariate modelling of key consumer's behaviour determinants which cannot be measured directly, like attitudes, social pressure and lifestyles (Lobb et al., 2007).

SEM involves the use of confirmatory factor analysis, path analysis and multivariate or simultaneous equation systems (Batista Foguet and Coenders, 2000). Following Jöreskog and Sörbom, (1999), we specify a Structural Equation Modelling which consists on three main types of relationships. First, a measurement model is identified after performing confirmatory factor analysis. The outcome relates, on one hand, observed indicators with the exogenous latent variables (Equation 1: . $\mathbf{x} = \boldsymbol{\Lambda}_x\boldsymbol{\xi} + \boldsymbol{\delta}$**).** And on the other hand, observed indicators are related with the endogenous constructs (Equation 2: $\mathbf{y} = \boldsymbol{\Lambda}_y\boldsymbol{\eta} + \boldsymbol{\varepsilon}$). A third equation (Equation3: : $\boldsymbol{\eta} = \boldsymbol{\Gamma\xi} + \mathbf{B}\boldsymbol{\eta} + \boldsymbol{\zeta}$) defines the structural model, which specifies the causal relations that exist among the latent variables, describes its causal effects and assigns the explained and unexplained variances (Jöreskog and Sörbom, 1999) (See Figure 7).

Figure 7 Schematic structural model concepts



Indicators

$\mathbf{X_1 X_2 X_3}$: exogenous indicators

$\boldsymbol{Y_4 Y_5 Y_6 Y}$:endogenous indicators

Constructs

$\boldsymbol{\xi}$: exogenous constructs

$\boldsymbol{\eta}$: endogenous construct

Measurement model

Exogenous construct equation: $\mathbf{x = \Lambda_x \xi + \delta}$ **(1)**

Endogenous construct equation: $\mathbf{y = \Lambda_y \eta + \varepsilon}$**(2)**

$\boldsymbol{\lambda}$: correspondence (weightings)

$\boldsymbol{\Lambda_x}, \boldsymbol{\lambda^x}_{\boldsymbol{pm}}$ **:** exogenous indicators

$\boldsymbol{\Lambda_y}, {\lambda^y}_{qn}$: exogenous indicators

$\boldsymbol{\theta^{\delta}}_{\boldsymbol{pp}}$: error prediction for exogenous constructs

$\boldsymbol{\theta^{\varepsilon}}_{\boldsymbol{pp}}$: error prediction for endogenous constructs

Structural model

Equation: $\boldsymbol{\eta = \Gamma \xi + B \eta + \zeta}$ **(3)**

$\mathbf{B}, \boldsymbol{\beta_{nm}}$**:** relationships from endogenous to exogenous constructs

$\boldsymbol{\Gamma}, \boldsymbol{\gamma_{mn}}$**:** relationships from exogenous to endogenous constructs

$\boldsymbol{\phi_{mm}}$**:** correlations between exogenous constructs

$\boldsymbol{\psi_{nn}}$**:** correlations between endogenous constructs

$\boldsymbol{\zeta_{mm}}$**:** disturbances in the structural relationship between endogenous and exogenous constructs

Source: Own elaboration from (Hair et al., 1998)

Milestones:

M4.1. Measurement scale to quantify consumer's FW auto evaluation

M4.2. Consumer food waste behaviour model

5.5. W5: DISSEMINATION

The main objective of this WP is to reach all the potential audiences of the project, in particular consumer organizations, the scientific community, food supply chain stakeholders and policymakers, to ensure that the project results as exploited in the best way.

Milestones:

M5.1. Workshop with food supply chain stakeholders, producers and consumers

M5.2. Publications will be submitted to indexed journals

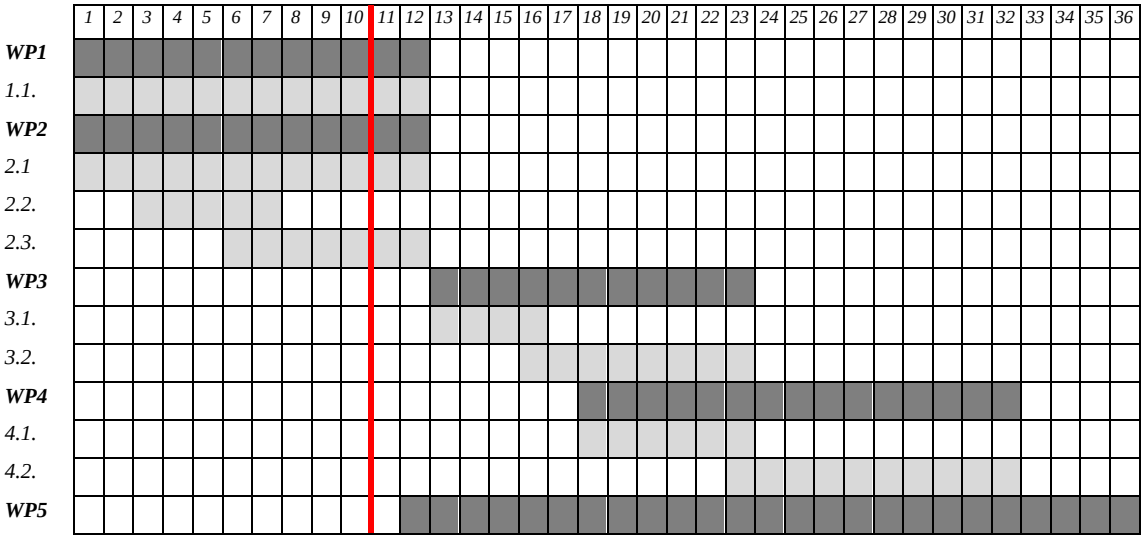
M5.3. Participation in seminars and congress

M5.4. Collaboration with social platform: Plataforma Aprofitem els Aliments in different dissemination acitivities.

5.6. PLANNING

The thesis is organised to be submitted in 36 months and the Tasks are organised as Table 7 summarizes.

Table 7 Overview of the action



6. PUBLICATIONS AND PRELIMINARY RESULTS

6.1. PRELIMINARY RESULTS

We are at month 10th of the research and hence we have developed part of WP1 and WP2.

WP2 consists on two-stage approach: 1) in-depth interviews; and 2) Delphi method to arrive at a consensus. In the first stage a total of 25 semi-structured interviews were conducted from October 2014 to January 2015 to relevant stakeholders. Data have been analyzed through the qualitative content analysis method. Results indicated an increasing concern about food waste; however, this is not the agents' major problem. Four conceptual definitions about food waste have been identified. Finally, the main causes of food waste generation in the metropolitan area for each food value chain stage are identified, for example the lack of agricultural planning or aesthetics standards.

In the second stage, two-round Delphi questionnaires have been distributed among 20 stakeholders. The field work was held from March to June in order to find a consensus about the most effective solutions to tackle food waste along the different food supply stages, including redistribution entities and institutions. The questionnaire was based on the results from the first stage in which stakeholders identified 47 alternative measures to reduce food waste along the food chain. In the Delphi questionnaire, stakeholders had to assess the effectiveness of each of the alternatives using a Likert scale from 0 to 100.

Preliminary results indicate the following: first, responsibilities about food waste generation are shared among all stakeholders in the metropolitan area of Barcelona; second, food waste is a very complex phenomenon and there is not a unique and most preferred solution to minimize the amount of food waste along the food chain. Third, preliminary analysis of the first round of the Delphi method suggest a huge heterogeneity. The coefficient of variation in each of the 47 alternatives ranges from 9.8% to 62.8%. We are now finishing data collection corresponding to the second round. In general terms, however, more agreement is observed about the potential measures that can be implemented at the consumer's level, being the most mentioned: *"Educating in values and food values. Promote healthy diet as it nourishes responsibility and awareness"*.

6.2. PUBLICATIONS

Reports

Díaz-Ruiz, R. (2014). Som conscients del malbaratament alimentari que generem? Percepció social i proposta de mesura. In R. Díaz-Ruiz, A. Nualart Nieto, A. Pou Gutiérrez, T. Vidal Moranta, G. Pocoví Labarra, & D. Teruel Roca (Eds.), *El malbaratament alimentari Treballs de recerca* (p. 81). Barcelona: Àrea Metropolitana de Barcelona.

Congress

Díaz-Ruiz, R., Costa-Font, M., Gil, J.M., Lòpez-i-Gelats F., 2015 ***The Sustainability of the Food Supply Chain through a Deep Understanding of the Food Waste Behaviour*** (accepted) To be presented in 5th World Sustainability Forum World 7–9 September 2015, Basel, Switzerland

Díaz-Ruiz, R., Costa-Font, M., Gil, J.M., 2015 ***Are households feeding habits and waste management practices determinant in order to swing over food waste behaviors? The case of Barcelona Metropolitan Area*** (Visual presentation accepted). To be presented in 29th ICAE International Conference of Agricultural Economist. Agriculture in an interconnected world August 2015

Díaz-Ruiz, R., Costa-Font, M., Gil, J.M., 2014. ***Consumers' behaviour towards food waste: individuals decision making analysis***. Presented in 14th EAAE Congress Agri-Food and Rural Innovations for Healthier Societies. Ljubljana, August 26-29 2014.

Díaz-Ruiz, R***.: Som conscients del malbaratament alimentary que generem a l'àrea metropolitan de Barcelona?*** Presented in Seminario Ambiental Área Metropolitana de Barcelona 2014, Área Metropolitana de Barcelona. Barcelona 2014

Courses

International Advanced School of Economic Psychology: Theory, Methods, Statistics. 143rd Joint EAAE-AAEA Seminar Consumer Behavior in a Changing World: Food, Culture and society 18/03/2015-25/03/15

7. EXPECTED CONTRIBUTIONS

A broad view of food waste dynamics along the food supply chain is expected through the consecutives milestones:

- **M1.1**.Report on the current status of FW generation patterns (input for WP2, WP3 and WP4)
- **M1.2.** Review manuscript on waste and dietary patterns and different food landscape scenarios definition (input for WP2 and WP3)
- **M1.3**. Completion of a database of indicators for identification and quantification of FW patterns
- **M2.1.** Stakeholder's analysis related to food waste generation
- **M2.2.** Identification of the main causes of FW in the metropolitan area and a comparison to literature.
- **M2.3.** Establishment of possible solutions to reduce FW
- **M3.1.**Variety of discourses representing the definitional frameworks of different groups and their interest
- **M3.2.** Potential of reduction of different products
- **M3.3.** Battery of indicators to measure FW in the primary sector
- **M4.1.** Measurement scale to quantify consumer's FW auto evaluation
- **M4.2.** Consumer food waste behaviour model
- **M5.1.** Workshop with food supply chain stakeholders, producers and consumers
- **M5.2.** Publications will be submitted to indexed journals
- **M5.3**. Participation in seminars and congress
- **M5.4.** Collaboration with social platform: Plataforma Aprofitem els Aliments in different dissemination activities.

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