

## Lecture 1

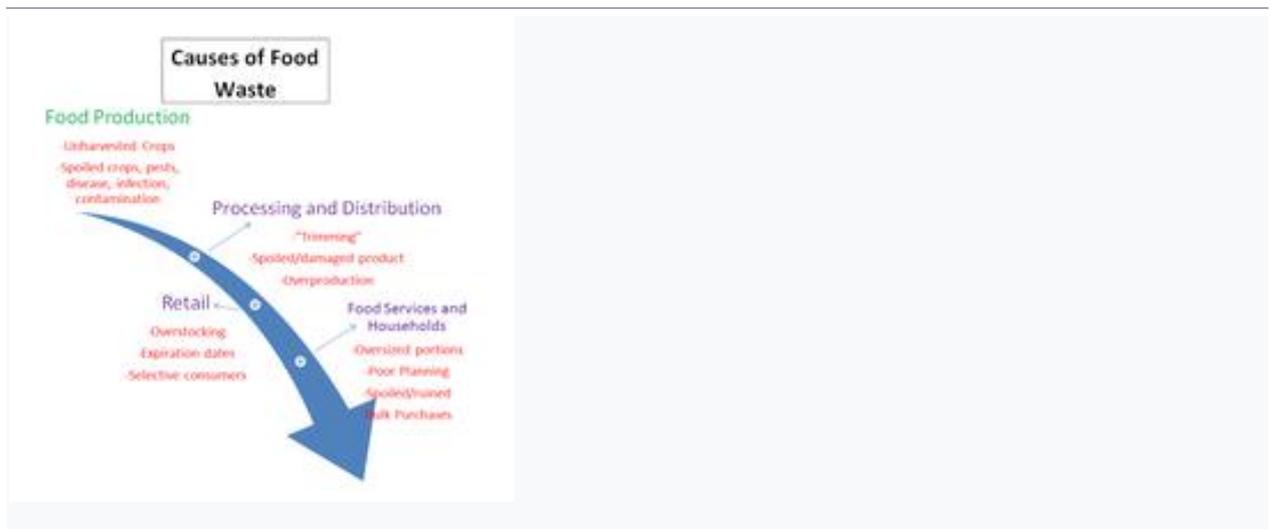
Food waste:

Food waste is food that is lost during any of the four stages of the food supply chain: (1) producers, (2) processors, (3) retailers, and (4) consumers.<sup>[5]</sup> Precise definitions are contentious, often defined on a situational basis (as is the case more generally with definitions of waste). Professional bodies, including international organizations, state governments and secretariats may use their own definitions.

The United States Environmental Protection Agency defines food waste for the United States as "uneaten food and food preparation wastes from residences and commercial establishments such as grocery stores, restaurants, and produce stands, institutional cafeterias and kitchens, and industrial sources like employee lunchrooms".

Among other things, in what food waste consists of, how it is produced, and where or what it is discarded from or generated by. Definitions also vary because certain groups do not consider (or have traditionally not considered) food waste to be a waste material, due to its applications. Some definitions of what food waste consists of are based on other waste definitions (e.g. agricultural waste) and which materials do not meet their definitions.

Cause



### Production

Food waste can occur at most stages of the food industry and in significant amounts. In subsistence agriculture, the amounts of food waste are unknown, but are likely to be insignificant by comparison, due to the limited stages at which waste can occur, and given that food is grown for projected need as opposed to a global marketplace demand. Nevertheless, on-farm losses in storage in developing countries, particularly in African countries, can be high although the exact nature of such losses is much debated.

In all the food industries, the food supply of which is the most diverse and abundant of any country in the world, waste occurs from the beginning of food production chain. From planting, crops can be subjected to pest infestations and severe weather, which cause losses before

harvest. Since natural forces (e.g. temperature and precipitation) remain the primary drivers of crop growth, losses from these can be experienced by all forms of outdoor agriculture. On average, farms in the United States lose up to six billion pounds of crops every year because of these unpredictable conditions. The use of machinery in harvesting can cause waste, as harvesters may be unable to discern between ripe and immature crops, or collect only part of a crop. Economic factors, such as regulations and standards for quality and appearance, also cause food waste; farmers often harvest selectively, preferring to leave crops not to standard in the field (where they can be used as fertilizer or animal feed), since they would otherwise be discarded later. This method of removing undesirable produce from harvest collection, distribution sites and grocery stores is called Culling. The USDA defines culling as “the individual removal of genetically undesirable, inferior, weak, diseased, or infested plants from a planting in order to ensure the level of genetic purity or vigor of the crop”. However, usually when culling occurs at the production, food processing, retail and consumption stages, it is to remove or dispose of produce with a strange or imperfect appearance rather than produce that is spoiled or unsafe to eat. In urban areas, fruit and nut trees often go unharvested because people either don't realize that the fruit is edible or they fear that it is contaminated, despite research which shows that urban fruit is safe to consume.

### **Food processing**

Food waste continues in the post-harvest stage, but the amounts of post-harvest loss involved are relatively unknown and difficult to estimate. Regardless, the variety of factors that contribute to food waste, both biological/environmental and socio-economical, would limit the usefulness and reliability of general figures. In storage, considerable quantitative losses can be attributed to pests and micro-organisms. This is a particular problem for countries that experience a combination of heat (around 30 °C) and ambient humidity (between 70 and 90 per cent), as such conditions encourage the reproduction of insect pests and micro-organisms. Losses in the nutritional value, caloric value and edibility of crops, by extremes of temperature, humidity or the action of micro-organisms, also account for food waste. Further losses are generated in the handling of food and by shrinkage in weight or volume.

Some of the food waste produced by processing can be difficult to reduce without affecting the quality of the finished product. Food safety regulations are able to claim foods which contradict standards before they reach markets. Although this can conflict with efforts to reuse food waste (such as in animal feed), safety regulations are in place to ensure the health of the consumer; they are vitally important, especially in the processing of foodstuffs of animal origin (e.g. meat and dairy products), as contaminated products from these sources can lead to and are associated with microbiological and chemical hazards.

### **Retail**

Discarded bagels

Packaging protects food from damage during its transportation from farms and factories via warehouses to retailing, as well as preserving its freshness upon arrival. Although it avoids considerable food waste, packaging can compromise efforts to reduce food waste in other ways, such as by contaminating waste that could be used for animal feedstocks.

In 2013 the non-profit Natural Resources Defense Council (NRDC) performed research that they state suggests that the leading cause of food waste in America is due to uncertainty over food expiration dates, such as confusion in deciphering best before, sell-by or use-by dates. Joined by Harvard Law, the NRDC produced a study called *The Dating Game: How Confusing Food Date Labels Leads to Food Waste in America*. This United States-based study looked at the intertwining laws which lead labeling to end up unclear and erratic. This uncertainty leads to consumers to toss food, most often because they think the food may be unsafe or misunderstand the labeling on the food completely. Lack of regulation on labeling can result in large quantities of food being removed from the market overall.

Retail stores throw away large quantities of food. Usually, this consists of items that have reached either their best before, sell-by or use-by dates. Food that has passed the best before, and sell-by date, and even some food that passed the use-by date is still edible at the time of disposal, but stores have widely varying policies to handle the excess food. Some stores put effort into preventing access to poor or homeless people, while others work with charitable organizations to distribute food. Retailers also contribute to waste as a result of their contractual arrangements with suppliers. Failure to supply agreed quantities renders farmers or processors liable to have their contracts cancelled. As a consequence, they plan to produce more than actually required to meet the contract, to have a margin of error. Surplus production is often simply disposed of.

Retailers usually have strict cosmetic standards for produce, and if fruits or vegetables are misshapen or superficially bruised, they are often not put on the shelf. In the United States, an estimated six billion pounds of produce is wasted each year because of its appearance. The USDA publishes guidelines used as a baseline assessment by produce distributors, grocery stores, restaurants and other consumers in order to rate the quality of food. These guidelines and how they rate are readily available on their website. For example, apples get graded by their size, color, wax residue, firmness, and skin appearance. If an apples rank highly in these categories and show close to no superficial defects, they are rated as “U.S. Extra Fancy” or “U.S. Fancy”, these are the typical ratings sought out by grocery stores when purchasing their produce. Any apples with suboptimal levels of appearance are ranked as either “U.S. Number 1” or “Utility” and are not normally purchased for retail, as recommended by produce marketing sources, despite being safe and edible.

The fish industry also contributes to the annual amount of food waste because of cosmetic standards that the fish are held up to. Nearly "2.3 million tonnes of fish (are) discarded in the North Atlantic and the North Sea each year." Approximately 40 to 60 percent of "all fish caught in Europe is discarded – either because they are the wrong size or species." Addressing this, there are many campaigns focused on raising retailer and consumer awareness about food that fails to meet certain standards for appearance.

## **Consumption**

Consumers are directly and indirectly responsible for wasting a lot of food, which could for a large part be avoided if they were willing to accept suboptimal food (SOF) that deviates in sensory characteristics (odd shapes, discolourations) or has a best-before date that is approaching or has passed, but is still perfectly fine to eat. **COSUS** (**CO**nsumers in a **SU**stainable food supply chain) is a SUSFOOD ERA-net research project under the topic 'Understanding consumer behaviour to encourage a (more) sustainable food choice'. There are organizations around the

country working to rescue and redistribute food to those in need. Many of these rely on volunteer support. Some of them are Feeding America, Food Recovery Network and Community Plates.

## Disposal

---

As alternatives to landfill, food waste can be composted to produce soil and fertilizer, fed to animals, or used to produce energy or fuel.

### **Landfills and greenhouse gases**

Dumping food waste in a landfill causes odour as it decomposes, attracts flies and vermin, and has the potential to add biological oxygen demand (BOD) to the leachate. The European Union Landfill Directive and Waste Regulations, like regulations in other countries, enjoin diverting organic wastes away from landfill disposal for these reasons. Starting in 2015, organic waste from New York City restaurants will be banned from landfills.

In countries such as the United States and the United Kingdom, food scraps constitute around 19% of the waste buried in landfills, where it biodegrades very easily and produces methane, a powerful greenhouse gas.

Methane, or CH<sub>4</sub>, is the second most prevalent greenhouse gas that is released into the air, also produced by landfills in the U.S. Although methane spends less time in the atmosphere (12 years) than CO<sub>2</sub>, it's more efficient at trapping radiation. It is 25 times greater to impact climate change than CO<sub>2</sub> in a 100-year period. Humans accounts over 60% of methane emissions globally.

### **Animal feed**

Large quantities of fish, meat, dairy and grain are discarded at a global scale annually, when they can be used for things other than human consumption. The feeding of **food scraps** to domesticated animals such as pigs or chickens is, historically, the most common way of dealing with household food waste. The animals turn roughly two thirds of their ingested food into gas or fecal waste, while the last third is digested and repurposed as meat or dairy products. There are also different ways of growing produce and feeding livestock that could ultimately reduce waste.

Bread and other cereal products discarded from the human food chain could be used to feed chickens. Chickens have traditionally been given mixtures of waste grains and milling by-products in a mixture called chicken scratch. As well, giving table scraps to backyard chickens is a large part of that movement's claim to sustainability, though not all backyard chicken growers recommend it. Ruminants and pigs have also been fed bakery waste for a long time.

Certain food waste (such as flesh) can also be used as feed in maggot farming. The maggots can then be fed to other animals. In China, some food waste is being processed by feeding it to cockroaches.

### **Composting**

Inevitable waste: peels of potato, onion, lemon, tangerine, banana, kiwi, egg shell

Food waste can be biodegraded by composting, and reused to fertilize soil. Composting is the aerobic process completed by microorganisms in which the bacteria break down the food waste into simpler organic materials that can then be used in soil. By redistributing nutrients and high microbial populations, compost reduces water runoff and soil erosion by enhancing rainfall penetration, which has been shown to reduce the loss of sediment, nutrients, and pesticide losses to streams by 75–95%.

Traditional composting uses microbes to perform the decomposition, a process that is most efficient using low, mid, and high temperature microbes (psychrophilic, mesophilic, and thermophilic – respectively). The high temperatures required by the thermophilic microorganisms are hot enough to kill pathogens, making the product of this traditional composting satisfactory for use in soil according to the United States Environmental Protection Agency's (EPA) standards. The traditional decomposition process requires a long length of time and additional energy expended to turn the material frequently and maintain the aerobic process. Composting by thermophilic microbes can lead to nutrient loss and the compost product is heterogeneous, with the potential for higher levels of contaminants which can be harmful if used in agriculture. An alternate method of composting is vermicomposting.

Vermicomposting is the practise of feeding scraps to worms who produce fertilized soil as a byproduct. The process of composting using earth worms is completed in a short duration of time and requires no additional energy to turn and maintain aerobic processes, as these actions are already performed by the worms. In order to keep the worms alive, the environment has to be kept below 35° Celsius, therein making this compost ineligible for use in agriculture according to the EPA standards. The product of vermicomposting is homogenous and generally contains lower levels of contaminants than traditional composting. Some look to integrate vermicomposting and traditional composting in an effort to maximize efficiency while producing a high quality organic product that can be used in agriculture.

Composting food waste leads to a decrease in the quantity of greenhouse gases released into the atmosphere. In landfills, organic food waste decomposes anaerobically, producing methane gas that is emitted into the atmosphere. When this biodegradable waste is composted, it decomposes aerobically and does not produce methane, but instead produces organic compost that can then be utilized in agriculture. Recently, the city of New York has begun to require that restaurants and food-producing companies begin to compost their leftover food. Another instance of composting progress is a Wisconsin-based company called WasteCap, who is dedicated towards aiding local communities create composting plans.

Municipal Food Waste (MFW) can be composted to create this product of organic fertilizer, and many municipalities choose to do this citing environmental protection and economic efficiency as reasoning. Transporting and dumping waste in landfills requires both money and room in the landfills that have very limited available space. One municipality who chose to regulate MFW is San Francisco, who requires citizens to separate compost from trash on their own, instituting fines for non-compliance at \$100 for individual homes and \$500 for businesses. The city's economic reasoning for this controversial mandate is supported by their estimate that one business can save up to \$30000 annually on garbage disposal costs with the implementation of the required composting. Composting is an economical and environmentally conscious step many homeowners could take to reduce their impact on landfill waste. Instead of food scraps and

spoiled food taking up space in trashcans or stinking up the kitchen before the bag is full, it could be put outside and broken down by worms and added to garden beds.

### **Anaerobic digestion**

Anaerobic digestion produces both useful gaseous products and a solid fibrous "compostable" material. Anaerobic digestion plants can provide energy from waste by burning the methane created from food and other organic wastes to generate electricity, defraying the plants' costs and reducing greenhouse gas emissions. The United States Environmental Protection Agency states that the use of anaerobic composting allows for large amounts of food waste to avoid the landfills. Instead of producing these greenhouse gasses into the environment from being in a landfill, the gasses can alternatively be harnessed in these facilities for reuse.

Since this process of composting produces high volumes of biogas, there are potential safety issues such as explosion and poisoning. These interactions require proper maintenance and personal protective equipment is utilized. Certain U.S. states, such as Oregon, have implemented the requirement for permits on such facilities, based on the potential danger to the population and surrounding environment.

Food waste coming through the sanitary sewers from garbage disposal units is treated along with other sewage and contributes to sludge.

Lost food may go to landfills, be put back into the food supply chain, or be put to other nonfood productive uses.

