The Impact of Economic Drivers on Food Loss Management

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Abstract

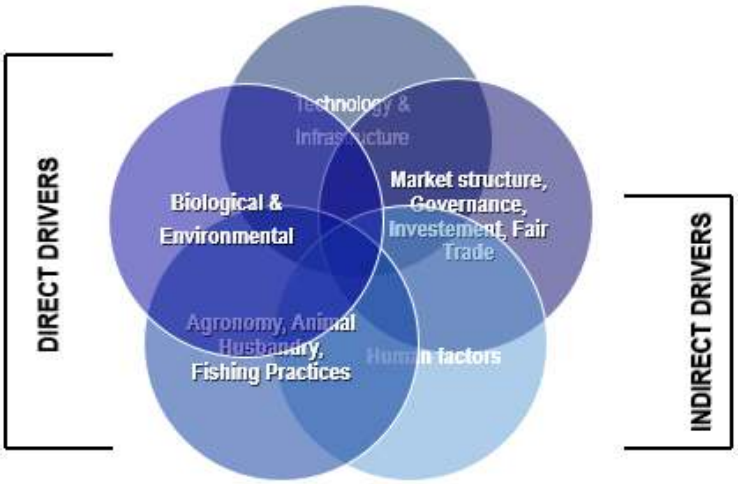
Food loss, a critical issue in the world, is especially used to describe the lost agricultural production. Primary agricultural production is inherently risky, being exposed to numerous pressures from weather and diseases. According to the Food and Agriculture Organization (FAO) about 1.3 billion tons of the food obtained for human consumption go uneaten yearly (nearly $2,6 trillion annually as a cost). The benefits of food loss reducing on farms are incontestable. This paper examines the food loss from an economic perspective by summarizing the economic drivers of food loss on the farm-level (costs and availability of workforce, consumers standards and preferences, price volatility, supply chain factors). The reducing of food loss is economically useful not only in terms of intervention costs, but also in terms of alternative means of achieving food security and environmental equilibrium.

Key words: agricultural production, food loss, price volatility, consumers' preferences, management.
J.E.L. classification: E30, J43, L66, M11, N50, O13, O15, Q13, Q17

1. Introduction

Billion tonnes of agricultural primary products across the world are lost even before leave the farm, never entering in the food supply chain (FSC) because of a variety of reasons (Franke *et al*, 2016, p.18; Ruiz, 2021). The food loss (FL) on farms represent an overlooked issue in Europe and numerous developed countries, which have a great attention on food waste (food lost in the final stages of the FSC, such as retail, household consumer and HoReCa services) (Ruiz, 2021). FL on the farm-level occur not only in non-industrialized countries (improper infrastructure, inadequate agricultural practices, inadequate storage facilities), as previously thought, more than half of the food lost on the farm occurs in countries with medium and high industrialization (rigurous aesthetic standards for agricultural products, farm labour, agricultural overproduction and market saturation, which lower prices and create an issues that sustains the food lost) (Nicastro and Carillo, 2021, p.3; Nicastro and Carillo, 2021, p.5; Ruiz, 2021). Numerous direct, as well as indirect drivers can influence the FL on farms, as illustrated in Figure 1.

Figure no. 1. Direct and indirect drivers of food loss on farm-level



Source: (WWF-UK, 2021)

While direct drivers can be: (*i*) biological and environmental (pests, diseases, insects, water availability extreme weather, natural disasters), (*ii*) technological and those related to infrastructure (poor infrastructure, inadequate technologies for harvest and post-harvest, inadequate storage of perishable crops), (*iii*) agronomic (inadequate harvesting and handling, harvesting time), indirect drivers are about market conditions and human factors (WWF-UK, 2021). The main economic drivers that influence FL at the primary agricultural production refers to market conditions and human factors, consisting of: labor costs and availability, price volatility, standards and consumer expectations, and FSC factors (Minor *et al*, 2020, p.5). Whereas many studies have examined FL caused by direct drivers, few have looked into the economic ones on farm-level. Economic drivers behind FL in the primary production stage should be thoroughly investigated to support the prevention and minimizing of FL, one of the priorities of the European Green Deal (especially F2F - the Farm-to-Fork Strategy). This paper explores the economic drivers, which indirectly impact of food loss on the farm-level, contributing to a growing area of inquiry.

2. Theoretical background

Any uneaten food, failure to use nutrients for human purposes, as well food preparation residues from houses or business establishments are considered FL and food waste (FW) (Alexander *et al,* 2013, p.472; Melikoglu *et al*, 2013, p.157). FL and FW have become a key issue, the food systems (FS) around the world being exposed to immense pressure due to population growth, accelerated urbanization, changing nutrition and lifestyle and also increasing living standards. It is estimated that the world's population will increase from 7 billion to nearly 10 billion by 2050 (Akerele *et al*, 2017, p.26; Alexander *et al*, 2017, p.190; Babbitt *et al*, 2021, p.317; FAO, 2017; Heng and Houseb, 2022, p.198; The Economist, 2011; WWF, 2017).

The population in a constantly growing is putting pressure on the global FS by generating conflicts regarding demanded food delivery, about a third of food being wasted or lost from production to consumption. Activities associated with the primary agricultural production affect the effectiveness of FS in creating agricultural biomass and using it for human nutritional needs. To achieve the purpose of these activities, could be considered some aspects related to changes in primary production systems and the role of nutrition and minimizing of FLW in developed and developing countries (Alexander *et al*, 2017, p.190; Alexander *et al*, 2017, p.191). The FL phenomenon is frequently used to describe a reducing in the quality or quantity of edible food weight because of errors, mismanagement and various inefficiencies in the agricultural primary production and industrial sectors because of some factors (improper agricultural practices and infrastructure, unpredictable weather events, natural disasters, pests, diseases, poor handling, inadequate storage facilities, etc.) and, by contrast, the FW phenomenon also refers to minimizing regarding quality and

quantity of edible food weight by either carelessness or a deliberate decision to reject food which is often generated at consumer level and HoReCa services (Chauhan *et al*, 2021, p.2; Dumitru *et al*, 2021, p.280; Ishangulyyev *et al*, 2019, p.297; Jungowska *et al*, 2021, p.976; Lipinska *et al*, 2019, p.2046; Ojha *et al*, 2020, p.601; Santeramo, 2021, p.1; Socas-Rodríguez *et al*, 2021, p.134; WWF-UK, 2021).

From agricultural production to final household consumption, food is lost or wasted throughout the FSC. In the earlier stages of the FSC the wasted food is called FL, while near the end of the FSC the lost amount of food is called FW (FAO, 2011). The most crucial point for FL is during the production phase, especially during product processing. In low-income (non-industrialized) nations, FL takes place during the primary production phase of FSC due to the lack of adequate infrastructure, but in high-income (industrialized) nations, FW occurs during final consumption, caused by a variety of socio-demographic factors, such as: household type and size, status of employment, education, gender, age, level of income (Nicastro and Carillo, 2021, p.3; Nicastro and Carillo, 2021, p.5; Przezbórska-Skobiej and Wiza, 2021, p.3601). The developing world is facing a major concern, being significantly exposed to the food insecurity (many people are still starving). FL affects food security especially of the poor people, and by reducing it, food security, as well as eliminating hunger and increasing incomes in the world's poorest countries can be improved (FAO, 2011).

3. Research methodology

The method used consisted of an exploratory research, which was performed by examining the current literature. The information was gathered from a variety of sources, including ScienceDirect, Web of Science, Scopus and specialized platforms or webpages like FAO, The Economist, etc. The analysis of literature served to clarify FL phenomenon around the world and to emphasize the economic drivers of FL on the farm-level.

4. Findings

4.1. Economic drivers behind FL on farms

The main economic drivers behind FL on farm-level include labor costs and availability, price volatility, standards and consumer expectations, and supply-chain factors (Minor *et al*, 2020, p.5) (as illustrated in Figure 2).

Figure no. 2. The main economic drivers of food loss on farms

Source: (Minor et al, 2020)

Costs and availability of workforce

Workforce, especially harvesting workforce, accounts for a significant portion of the cost of cultivating and marketing fresh products. The price of harvesting a field is increasing when wages are rising and labor availability is limited, causing growers to abandon some products in the field before harvest and take into consideration various production and marketing decisions that lead to FL. Moreover, when the expected harvest is quite limited, growers consider whether the additional money from future harvest will cover the associated expenditures and it is possible to leave a part of products in the field. Depending on the types of various crops that are growing to maturity in a given area, labor demand may rise during the season (e.g. peppers and tomatoes can be picked from 6 to 8 times each season). However, fresh produce harvesting is expensive and depends on the manual labor availability (Minor *et al*, 2020, p.10; Minor *et al*, 2020, p.11). The cost of inputs and labor availability are also mentioned in the literature as key factors determining FL (Astill and Minor, 2020, p.188; Baker *et al*, 2020, p.134; Hsu-Flanders *et al*, 2020, p. 175). Many fresh produce items are, in fact, gathered entirely by hand (Astill and Minor, 2020, p.189). An increase in workforce costs change the cost-benefit analysis of harvesting decisions, causing FL to rise indirectly (Zahniser *et al*, 2018, p.2). Much of the additional cost of recovery for fresh products is connected to the harvesting process itself, leaving growers exposed to variable labor costs. In addition to the steadily increase in workforce costs, FL can occur due to labor shortages at important times which can force growers to postpone harvesting (Baker *et al*, 2020, p.136; Dunning *et al*, 2019, p.3; Spang *et al*, 2019, p.126; Zahniser *et al*, 2018, p.2). Growers require work throughout the production process, but especially during harvest period, they have a constant, time-sensitive, and frequently larger demand for labor. The field can be leaved unharvested if workforce is not easily available or its cost is too high in relation to the harvest return. Like the increase in workforce costs and possible non-coverage of the expected harvest, when its limited, by the additional money coming from future harvest, growers can also abandon fields sometimes due to labor shortages, which can lead to a FL that lasts for years. From time to time, growers will sacrifice a piece of their field in order to ensure that the greatest quality produce reaches the market (Minor *et al*, 2020, p.11). Workers are well-trained to ensure that the product satisfies buyer standards, making it appealing to retail customers. But workers are not expressly educated to reduce product loss as a primary outcome. This means that the purpose of harvesting isn't to collect all of the edible products that can survive shipping and storage, because this isn't what purchasers and, ultimately, consumers are looking for (Astill and Minor, 2020, p.192).

Consumers standards and preferences

At any point along the FSC, products that does not fulfill aesthetic or other specifications are likely to be refused, either by purchasers or by ultimate customers. Farmers, shippers and retailers make culling decisions based on perceived customers preferences. If any of these supply chain actors believes their food will not be accepted by a buyer, the product will not be gathered or moved through the FSC (Minor *et al*, 2020). A product's look and other attributes of its are described exactly by retail specifications (e.g. grading standards). Purchasers have quality criteria, such as consumers' standards or food safety, and will refuse a deficient load. This results in a lost income and tarnished reputation (Calvin *et al*, 2001, p.1). These standards are intended to offer a consistent language for manufacturers and purchasers to communicate aspects regarding quality and to improve procurement and marketing efficiency. Grades, as well as standards, may help reduce expenses associated with unsaleable products by halting it as soon as possible in the FSC. Cosmetic flaws, that are obvious in the field, may increase over time, making the product unsaleable after it has been transported through the supply chain. While somewhat decaying or moldy product is technically edible, it has the potential to contaminate a neighboring product that satisfies requirements, making it unsellable. These situations lead to additional workforce, transportation and storage costs because of moving unsaleable products forward through FSC. Farmers tend to leave the product in the field because of the these costs, exacerbating FL. On the other hand, grades and customer standards and preferences, preclude some food products that are edible to progress through the FSC because they are regarded as unmarketable. Particularly, if consumers are averse to buy an "ugly fruit", stores are unlikely to take products that falls below certain cosmetic criteria that include the undesired trait. Thus, whether the products are cultivated under contract for a restaurant or they are intended for sale at farmers markets, FL can occur due to impossibility for a fresh product to meet aesthetic requirements (Minor

et al, 2020, p.14; Minor *et al*, 2020, p.15). Moreover, in-field FL is attributed to quality levels derived from strict consumers preferences, as well from rigurous retailer interpretations. Growers will not harvest food if they anticipate purchasers will not buy certain products because of failure to meet a specific standard. For example, retailers and consumers are familiarized with fruits and vegetables that are uniform and nearly flawless. This sometimes leads cosmetically deformed or too small or too large products that are abandoned in the field, although they may be nutritionally the same as most fruits and vegetables that are uniform. The result is leaving behind edible and satisfactory food for buyers who do not expect absolute uniformity in their product (Baker *et al*, 2020, p.140).

Price volatility

Fresh products prices are volatile. The current market price in relation to costs is a major market component that contributes to FL. The quantity of good available on the market is determined by the price of them. Because demand for fresh produce is inelastic (price changes rarely have a significant impact on a consumer's purchasing decision), fluctuations in availability cause prices to fluctuate fast. Because of the daily prices fluctuation, the production is no longer economically viable when the value of an edible product goes below the marginal cost of production. In particular, at the moment that prices fall below the cost of bringing additional products to market, growers are unable to advance products through the FSC because it is no longer profitable. By contrast, when prices are going up growers may be enticed to harvest more intensively (either by hiring more personnel or lowering product thresholds) and to bring lower-cosmetic-quality products to market, which can lead to significant loss further down the FSC. The harvesting workforce significantly contributes to the cost of cultivating and distributing fresh produce. Farmers abandon crops in the field before harvest and make a variety of other production and marketing decisions that directly affect crop losses or the produce can be wasted at a packing shed, or dumped off the back of a truck due to increased harvesting costs determined by labor availability, wage growth and the time and place when price fluctuations occur. Prices differ not just from year to year, but also from growing season to growing season. Some price changes are more predictable than others. For example, prices normally rise later in the season when total supply begins to drop, though there are exceptions, while other fluctuations of prices are more sporadic, making them more difficult to forecast (Minor *et al*, 2020, p.6; Minor *et al*, 2020, p.9; Segrè *et al*, 2014, p.55).

Supply chain factors

While workforce availability, price volatility, costs of inputs, as well as consumers standards are frequently identified as the primary drivers of FL, supply chain rigidities and market infrastructure also play a role (Kitinoja *et al*, 2018, p.7). Infrastructure investments in produce commodities (e.g. adequate logistics, refrigerated storage facilities) are significant, providing benefits for numerous growers. But for a single grower, incurring these costs for yield that would otherwise be thrown and often sold at lower prices is generally unprofitable (Minor *et al*, 2020, p.14). Regarding food production infrastructure, the differences between high-income countries and low-income ones are significant. Early research revealed that losses around the farm stage in high-income countries are quite minor (FAO, 2011). Therefore, FL in developed countries is at a lower level owing to modern and larger infrastructures, ultramodern technologies, agronomic proficiency that lead to higher yields, while in non-industrialized countries, FL occurs due to the lack of understanding of the most effective ways for properly agricultural operations, inadequate infrastructure, storage facilities and logistics (Nicastro and Carillo, 2021, p.5; Stoica *et al*, 2022, p.16). Following harvest, processes like shipping and packing can have a significant impact on whether or not food is left behind or removed from the market (Astill and Minor, 2020, p.194). Sustaining proper temperature, CO_2 levels, and humidity levels during the shipping process is critical to maintaining quality. When the products are shipped, quality might be lost due to bruising, mold development or other forms of deterioration. Particularly, the products near the bottom of a container can suffer damages or be destroyed by the products weight piled on top of them. To avoid these types of damages during shipping, growers can pick under-ripe products. In order to gather the more-ripe products, the transportation mechanism would have to be modified, which would certainly necessitate a significant investment in infrastructure (Baker *et al*, 2020, p.143). Growers are careful to select products that are well-suited for the long distance shipping because the risk of the lost products fall back to the farmer and not the

shipper in many times. Unfortunately, the issue of quality loss during transit can occur in large part due to poor product selection (Hsu-Flanders *et al*, 2020, p.179). In order to prevent post-harvest loss because of sensitive nature and acute perishability of many commodities, the fresh products industry has spent considerably on packaging processes. A lot of goods are freshly packed from the field and placed in vacuum cooling or in other climate-controlled storage within hours (Astill and Minor, 2020, p.195). There are also goods that are not field packed, but are rather stored in big open-air bins proper for truck transport. Upon delivery, retailers inspect the products and discard the damaged ones. Farmers and purchasers make frequent judgments on procedures that may reduce the risk of loss throughout the FSC by receiving periodic assessments and feedback from quality supervisors via several reports sent daily, weekly and monthly (Minor *et al*, 2020, p.13). Nonetheless, there is some loss. From the point of harvest to the end customer, the cold chain is essential for ensuring quality. Cold chains disruptions, such as power outages or defective equipment, cause quality to rapidly deteriorate and lead to FL. Cooling systems are used by many large growers located in significant production areas to provide fast cooling to products. Any lateness in entering the cold chain diminishes marketability. As a result, cooling facilities must be positioned next to central growing zones, if not on the farm itself (Hsu-Flanders *et al*, 2020, p. 181).

4.2. The FL management in achieving economic growth, food security, environmental equilibrium

By taking into consideration that the world's population is expected to reach over 10 billion by 2050, necessitating a 70 percent increase in food production, a major concern consists of preventing or lowering FLW (FAO, 2009, 2019). Individuals, as well as society as a whole, benefit from preventing or minimizing FLW. Thus, society can benefit from diminishing FL in three ways: an increasing in productivity and, as a result, economic growth, food security improvement, a decrease of environmental effects. Production of food that is subsequently lost leads to an economic impact, which can be linked to the costs of production. The resources used for commodities producing determine these costs and the price of products on the market, which are related to the products utility (Nicastro and Carillo, 2021, p.8). FL diminishing provides advantages for both farmers and consumers. Therefore, while producers can lower disposal costs by having fewer products to dispose of because they can sell more from the same resources amount, consumers could purchase cheaper food because of a potential falling in market prices (Garske *et al*, 2020, p.12; FAO, 2019). Farmers and consumers are not always capable to take steps for achieving certain benefits for themselves due to their unawareness regarding FL produced and its potential implications.

Although producers are frequently unsure of the true benefits of implementing recommended methods to reduce FL (e.g. modern harvesting equipment and storage, as well as processing infrastructure, better transport conditions, new packaging technologies, etc.), investing in this phenomenon reduction has a high economic return. This is emphasized by a study conducted in 17 countries, which revealed that for every dollar (or other cash) invested in FL diminishing, half of the commercial locations received a return of 14 dollars. Moreover, in some regions of Africa the techniques implemented to lower FL resulted in an increase in farmers supply (Nicastro and Carillo, 2021, p.11; Nicastro and Carillo, 2021, p.12). If farmers increase supply, consumers can spend less money on food (FAO, 2019).

Besides buying food cheaper, consumers must also have food security. Food security means a condition to physical, economic and social access to enough, balanced and safe food for all people, at all times. Increased levels of FL are jeopardizing the overall food system's equilibrium and affecting food supply regarding quality, quantity and prices. Food security can be improved by diminishing these amounts of FL, resulting in an enlarged food availability (FAO, 2011). In addition, a lower level of FL leads to a rise in accessibility of food owing to an increasing in supply and, as a result, higher income of those who sell a bigger quantity of certain products. FL reduction has effects on price changes. A larger part of the population will have access to food if prices fall, but growers will find a drop in their income.

Cheaper costs and increased supplies could be determined by a 20% reduction in FL in non-industrialized countries over 10 years, according to a study that looked how lowering FLW levels impacts the market (Nicastro and Carillo, 2021, p.8). To support economic growth, as well as food

security, FLW reduction contributes to maintaining the balance of the environment by improving the use of its resources. A significant depletion of environmental and economic resources and also a decrease in the amount of available products are highly related to uneaten food produced or FL during production processes, in an unfavorable context where the expanding population is predicted to cause the demand for food to nearly double by 2050 (Cattaneo *et al*, 2021, p.2; FAO, 2013).

There are 3 generally quantifiable indicators that need to be taken into account, each food produce might having a different influence on natural resources. These indicators stand for footprints regarding carbon (greenhouse gas emissions coming from operations like production, processing, transport of food), land (area needed to grow a particular food) and water (the quantity of freshwater needed to make a food).

A decrease in FL results in a huge potential for environmental improvement. For instance, if FL is reduced, farmers will still utilize the same amount of resources, but more commodities will be produced. It is crucial to know the goal when using interventions to reduce FLW since stages in the food chain where the food is produced, different types of food products and production methods have variable effects on carbon, soil, and water footprints. In the primary production phase, the most obvious are land and, especially, water footprints. It is possible that food processing will require a lot of water.

The type of product determines how much of an impact is made on certain natural resources. For instance, animal products and meat have a significant influence on the land footprint (exceeding 50% of the total production of other foods through land use), while pulses and cereals are responsible for approximately 90% of the water footprint (from the total production of other foods through water use). The steps required to lower FLW's negative environmental effects should be adapted according to food product type, production method and in which stage of the FSC it is produces (Nicastro and Carillo, 2021, p.10; FAO, 2013).

5. Conclusions

Numerous drivers (biological and environmental, technological and those related to infrastructure, market conditions, agricultural and human factors) influence the food loss at farm-level. Among them, the labor costs and availability, price volatility, standards and consumer expectations, and supply-chain factors are the main economic drivers behind food loss on farms. It is evident that the minimizing of food losse in the agricultural production is one of the priorities of the European Green Deal to improve food security and reducing the related economic and environmental repurcursions. This paper highlighted the economic drivers of food loss at the primary agricultural production. As pointed out in the paper, the economic drivers (labor costs and availability, price volatility, standards and consumer expectations, supply-chain factors) were explored. Properly monitored and managed, these drivers will no longer be at high risk of food loss on farms. However, food loss reduction strategies should focus on all factors that generate food loss throughout the food supply chain, food loss occurring along the food supply chain, not just on the farms. In addition, there are various opportunities that can both mitigate food loss and improve farmers' incomes, as evidenced by consumers' interest in imperfect agricultural products.

6. References

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