

# **The Lifecycle of Bread: Investigation into greenhouse gas emissions from Norwegian bread waste**

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## **Introduction**

Climate change is the largest threat to twenty-first-century life and the Anthropocene. It threatens to permanently harm our environment, economy, and social well-being. The United Nations' sustainable development goal 15 (Life on Land) aims to combat a portion of the issue by addressing sustainable use of the Earth around us (UN, 2022). Greenhouse gas emissions (GHGs) that exceed our Earth's carrying capacity currently threaten to destroy natural environments, diminish biodiversity, and degrade land systems, each of which are integral components to SDG15.

Food waste is currently considered the largest contributing factor to climate change as "*when food is discarded, all inputs used in producing, processing, transporting, preparing, and storing discarded food are also wasted*" (Buzby, 2022). The FAO reports that around one-third of all food produced for human consumption is wasted with 1.3 Gtonnes wasted yearly, resulting in 3.3-4.4 Gtonnes of CO<sub>2</sub> equivalent (FAO, 2013). This makes food waste the third largest emitter behind the USA and China. Food waste also has major impacts on land use degradation and biodiversity loss as externalities from production. Food waste "*is not only a loss within its own production chain, but squanders other valuable resources*" (Szulecka et. al., 2019) such as land, water, energy, and labor. Economically, global food waste translates to a loss of US\$1 trillion annually with additional indirect environmental costs of US\$700 billion and social costs of US\$900 billion (Szulecka et. al., 2019).

## **Why Bread?**

In Norway, bread accounts for 13% of all wasted food (Statista, 2016) and is an integral part of Norwegian life. As the highest consumers of bread in the world (38.5 kilos a year per person on average) we recognized that it is a natural representation of the effects of food waste (VisitNorway, 2022). Each of us throws 9.3 loaves of bread every year, amounting to 1 loaf every 3 seconds and 65 million loaves of bread every year – not including the 39 million more from grocery stores (Berg-Jacobsen, 2019). Almost everyone eats some form of bread (80% of Norwegians daily), but we do not always consider the process behind how it was made or what actually goes into each loaf. This paper will investigate each step of production, from 'cradle to grave', of a single loaf of bread. Namely, the impacts to SDG15 will be considered through the farming, harvesting, processing, transportation, selling, and consumption (or lack thereof) of a loaf.

However, the story is not that simple. While Norway grows around 60% of the wheat Norwegians consume (Encyclopedia of the Nations, 2007), they also imported US \$ 68.1 Million of wheat in 2020 (Graminor, 2023). Hence the production and consumption cycle have rich dynamics that permeate our simplified life cycle. There are also more complications when considering organic against more artificial/conventional forms of wheat and grains and the social impacts they have on health and well-being that the paper will not consider. We also recognize that the area of land used for production indirectly reduces land that could be dedicated to more biologically diverse land covers. Additionally, agriculture has many negative externalities, including pesticide/fertilizer leakage, soil nutrient degradation, and wastage from packaging (Svanes et al., 2018). This would yield an extensive set of impacts that cannot be deeply investigated. Therefore, the main focus will be on locally produced and consumed bread made from natural wheat, and the GHG impact of waste that households and supermarkets produce through a yearly time scale.

## **Production**

The first part of the life cycle takes place in agriculture where crops are planted and maintained before harvesting. As of 2019, emissions from agricultural soils in Norway amounted to 1.6 million tonnes of CO<sub>2</sub>, while emissions from manure management amounted to 0.5 million tonnes of CO<sub>2</sub> the same year. These factors accounted for 3.2% and 0.5% of the Norwegian greenhouse gas emissions, respectively (Bjønness, 2021). Agricultural soils often contain large amounts of nitrous oxide (N<sub>2</sub>O) as it is a key ingredient for most fertilizers. Even though the gas only makes up 0.03% of global GHG emissions (Yu, 2012), it has a global warming potential of 298 times higher than that of CO<sub>2</sub> (Nadeem, et al., 2015), and can therefore be damaging in small amounts.

## Processing and Transportation

Bread processing includes numerous steps, such as mixing, baking, fermentation, cooling, and packing. In addition, all the steps that involve bread processing are essential and have an important role in making bread (Zhou. W & Hui. Y.H, 2014). In connection to bread processing, grain and bread production have very low emissions of greenhouse gases. The total GHG emission that comes from Norwegian land use that produces grains is 0.36 percent. Furthermore, one kilogram of bread in Norway has a CO<sub>2</sub> footprint that is equal to 0.9 kilos. Another benefit of grain production which plays an essential role in bread processing in Norway is that the production from grains needs little water and a smaller area, compared to other foods from farmers that are being sold to the store (Bakerhuset, n.d.). Moreover, transporting bread is also a big part of the emissions, where 2 million kg of CO<sub>2</sub> is emitted transporting Norwegian bread waste back to farms and compost. This number is calculated by how much bread Norwegians throw every year, which is 104 million loaves each year, and the 49g of CO<sub>2</sub> emitted from a kg of bread (Weber et al., 2023; Jacobsen, 2019).

## Retail Sales and Household Consumption

The final stage in the life cycle of bread is consumption. This starts in supermarkets and bakeries, where the products are bought and then ends in the waste bins of private households and public food supply facilities such as canteens, restaurants and takeaways. The reason for this is, on one hand, a systemic failure. Nowadays, the food industry is based on a business model in which there is a higher profit if larger quantities of products are bought from farmers (Szulecka et al., 2016). In addition, there is a lack of coordination between different actors in the supply chain (Szulecka et al., 2016).

On the other hand, it is the expectations of customers in the shops that contribute to bread being wasted; according to a survey by the retail chain Coop, freshness is the most important factor for customers when buying bread. In addition, customers expect to receive any product at any time of the day. To meet these requirements, an overproduction of bread is necessary, which inevitably leads to waste (Berg-Jacobsen, 2019; Svanes, 2018). Unsold baked goods from the supermarkets go back to the bakeries where they were made. Due to the poor suitability of the raw materials for other uses, they are ground into animal feed there (Berg-Jacobsen, 2019). This take-back system is responsible for a significant proportion of the waste; around 39 million unsold loaves of bread end up as animal feed in Norway every year (Berg-Jacobsen, 2019). In addition, it is primarily the consumers who are responsible for bread waste. Some studies show that 58% come from private households (Elstad Stensgård et al., 2018 in Plasil, 2020), while others even came up with a proportion of over 70% (Gjerris & Gaiani, 2013).

Sociobiological factors such as age and gender influence peoples` consumption behaviour. Older people generally waste less than younger people, and women overall waste more than men (Hebrok & Boks 2017). Gjerris & Gaiani (2013) found that young adults aged 19-26 and young families are the population groups that waste the most food. Young people`s consumption behaviour is characterized by enjoyment, improvisation, and social activity as well as viewing food as a mere necessity (Hebrok & Boks 2017). According to a 2017 study by Hebrok and Boks, Norwegians over 40 are more likely to raise awareness and reduce waste. However, this is due to financial and moral reasons for waste rather than environmental concerns. People over 65 are more shaped by their past and may have experienced times of scarcity. Therefore, they bring with them a different consumption attitude than other age groups (Hebrok & Boks 2017).

Several studies have examined the direct reasons for Norwegian consumer behaviour (Gjerris & Gaiani, 2013; Stensgård & Hanssen 2016, Szulecka et al., 2016). 38% of respondents to the 2016 Stensgård & Hanssen survey said their main reason for throwing away bread was due to it being past its expiration date. This shows that many consumers do not have a rational relationship with dates, as they equate them with poor quality. This is even though many bread products, especially those from bakeries, usually do not even have a date label. The second most common reason was "*poor quality of the products*" in 25% of the answers. 16% reported "*parts of the product were damaged or inedible*" and 10 % "*poor storage of the product at home or in transit*". 9% indicated "*too large packaging size*" and 2% "*poor packaging*". According to Szulecka et al. (2016) one of the main reasons is poor planning and too many products bought due to discounts.

In addition to such direct reasons for food waste, indirect factors also play a role. This includes socio-cultural aspects such as consumer values, awareness, attitudes, experiences, upbringing, and lifestyle. Lifestyle includes household constellations and everyday practices such as household size and shopping planning, which influence the way food is handled and thus the quantity and composition of food waste. Lifestyle also depends

on where you live. A study looked at food waste in two different regions of Norway: Fredrikstad as an urban region and Hallingdal as a rural region. Significantly higher amounts of waste were produced in Fredrikstad than in Hallingdal, with fresh bread mostly contributing to the difference (Hanssen et al., 2016).

There are different scientific results on the influence of income on food waste. Some studies conclude that scarcity and rising food prices would reduce household food waste (Hebrok & Boks, 2017). Following this argument, poor countries can't afford to buy too much food, while high-income countries can. This would make it challenging for high-income countries to reduce waste. It was also found that wealthy households waste more food than low-income households (Hebrok & Boks, 2017). Furthermore, material and structural aspects such as storage, packaging, and the refrigerator's size and technology also impact food waste (Hebrok & Boks, 2017). In summary, the reasons that lead to bread wastage are complex and interrelated.

## **Solutions**

So, what can we actually do? The clearest solution is to simply stop wasting bread, but in reality, the confines of human living and consumption make this a more difficult task than it sounds. Interestingly, bread boxes and freezing methods have been shown to extend the life of a loaf of bread significantly (Lodige, 2021). Another solution is drying it and using it for alternative foods through fermentation (Dymchenko et al., 2023).

However, these solutions are based on behavioural and individual changes and are not feasible for everyone with different socio-economic or cultural backgrounds. Hence this naturally begs the question, does the responsibility lie with consumers? As mentioned before, overproduction is inherently a systematic problem with causes throughout the supply chain. As such, we must also consider broader, structural changes that companies can implement to reduce the carbon footprint of bread before it lands on individuals' plates. Furthermore, a study on six Swedish supermarkets found that reducing the storage temperature of food can prolong shelf life and reduce food waste (Eriksson et al., 2016). They can also sell less by taking more data on inventory and seasonal consumption spending as well as forecasting daily retail numbers. This could lead to more efficient selling with options such as half loaves (LinkRetail, 2022).

Lastly, donating the food to food banks, or back to farmers is a known way to reduce the waste produced despite the economic losses this may accrue. More locally, Norwegian grocery supermarket Meny has cut food waste from bread by 34% with their "*Bread Winning Project*". They figured out how to make "*stores bake the right amount of bread throughout the day with the help of automatic baking plans in each store, based on technology, algorithms, and sales in real-time*" (Das, 2021 p.1). This has a projected impact to reduce 600 tonnes of their CO<sub>2</sub> emissions.

## **Conclusion**

Overall, collating the emissions from each step of the process, as well as the consumer and business waste from bread, we find that with an average cost of 1.1105 kg of CO<sub>2</sub> per loaf, multiplied by the 104 million loaves of bread wasted yearly in Norway, added onto the additional 2 million kg of wasted CO<sub>2</sub> from transporting bread waste, we yield a total annual CO<sub>2</sub> waste of 117.492.000 kg. This is in addition to the numerous other impacts such as biodiversity loss, N<sub>2</sub>O emissions, and degradation of land. This culminates to significant impacts on Life on Land (SDG15), particularly affecting targets 15.5, 15.9, and 15.a.

It is also vital to recognize that bread waste was only a means to an end to analyse food waste in general. As a representation of waste, it was a tangible food to demonstrate the larger, far-reaching issue that food waste presents to sustainable development. The GHG emissions also impact every other SDG indirectly. Namely, there are massive externalities to achieving Zero Hunger (SDG2) by drastically reducing food security and the capacity to produce sufficient food for every human. Additionally, SDG12, Responsible Consumption and Production, is unquestionably unachievable with the level of food waste shown. Lastly, reducing food waste is a known component of Climate Action (SDG13) and is currently the largest opportunity for us to reduce scope 3 emissions (Knot, 2022).

In conclusion, to combat the rapid anthropogenic dangers of climate change, we must be more conscious of our relationship with bread and the negative externalities we cause by throwing it away.

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