LUKE Food Waste Monitoring Model for Food Services

The *model* refers to a **method** we have developed at Natural Resources Institute Finland (LUKE) for regular (edible and inedible) food waste measuring and monitoring in food services, and their management. It is adaptable to various food service types needs and across regions. Required information for implementing the model to operations are summarized in a matrix further below.

A food waste measurement application and scales are required in a restaurant for monitoring – or simply a spreadsheet to plot the records (e.g., Excel). Some food service enterprise resource planning (ERP) software can be integrated with food waste measuring applications. Singular measurements are insufficient for long-term waste reduction. Our model offers a **structure for continuous improvement**, following the Lean management PDCA cycle: planning, baseline measurement, waste reduction actions, re-measurement and evaluation, followed by further improvement actions.

Food Waste Monitoring

Food waste monitoring **follows the food preparation and serving process**.

Preparation generates:

- originally edible **kitchen waste** (**storage** and **preparation waste**)
- originally **inedible kitchen biowaste**.

Service phase generates:

- **serving waste** (buffet etc.)
- customer **plate waste**
- including additional **kitchen biowaste** out of inedible components

The matrix below lists required information to be collected for waste monitoring, according to the LUKE model. **Monitored output** refers to the parameters for which data is collected. The **Content** and **Required data** columns further specify what information is essential for efficient restaurant (waste) management.

Food service operators decide whether to only meet minimum requirements for Finland's waste legislation, dictating that originally edible and inedible food waste are regularly recorded. Or, if more detailed waste records are gathered to support data-driven management, enabling more sustainable hospitality operations. Produced results (waste reports) may be exploited for environmental impact analysis (e.g. Life Cycle Assessment, LCA), or to estimate how much nutrition was lost through wasted food.

End of the matrix, we emphasize that food waste monitoring involves more than just management with numbers in sight. It is essential to keep soft, **people-oriented management** elements in mind. Edible surplus food, which is redirected for human consumption, adds to restaurants' positive socio-cultural handprint. This is done by supporting food aid charities by sharing your excess, to be used at communal warm meals, or packaged for ready-to-eat meal

donations. Food waste concerns also reflect **socio-cultural sustainability** within restaurant work. Discarding products and meals often causes **negative emotions** among staff:

- fear for running out of food
- guilt from wasting food
- customer feedback-driven stress
- anxiety from managerial responses to personal mistakes (over-/underproduction, quality failures etc.).

Therefore, we have included **recommendations** for **empathetic management** when creating a safe working place:

- setting joint sustainability goals (for example waste reduction)
- caring, encouraging and rewarding management practices
- LUKE food waste mentoring programme (material only in Finnish) provides wider opportunities for peer support and management

The application of the matrix and its scheduling for operational management are summarized in a separate table below.

Required information for the monitoring model

Monitored output	Content	Required data
Food amount, prepared or ordered	Absolute quantity	Prepared / ordered food, kg
Prepared food quality	Service type: buffet or portion; combination	Served items or menu; food categories/product groups
Inedible FW amount (aka unavoidable)	Absolute quantity	kg total; g/customer; % of prepared food, etc. indices
Edible FW amount (aka avoidable)	Absolute quantity	kg total; g/customer; % of prepared food, etc. indices
Food waste quality	Food preparation stage (i.e. when FW is generated); food type	Kitchen waste (= preparation & storage waste), serving waste, plate waste, kitchen biowaste; food categories/product groups
Cost	Monetary cost for production and FW	Cost per customer, cost per kg; more precisely e.g. cost per dish, or per category
Area	Location and scale	Address

Standard Industrial Classification (FIN: TOL 2025; EU: NACE)	Food service subsectors (restaurants, cafés; education, health care etc.)	Outlet's TOL/NACE class; unusual catering formats: outdoors or passenger meals; festive catering
Operational scale	Number of outlets and customers; staffing input	Number of outlets, customers; staff working hours, or work years, full-time equivalent
Time scale	FW measurement length, seasonality	Dates: calendar, local events, weather data etc. factors affecting food provision and waste
Redistributed food: discounted sales, donations to food aid, used at staff dining, etc.	Edible surplus food redistributed for human consumption	Redistributed food after service: amounts, quality (categories) and value
Other impacts of food waste	Environmental impacts (e.g. LCA); nutritional loss	Ingredient information: environmental impacts (CO_2 etc.); nutritional values
Empathetic leadership: behaviour, values, attitudes and emotions	Behavioural settings that influence how FW is generated or evoked by FW. Organisational culture and people-oriented management practices: jointly tackling FW and setting targets, encouragement. Staff fears, shame, etc. arising from FW and customer service.	Narratives, descriptions, adjectives; obtained from polls, interviews, development discussions, etc.

Applying the Model to Operational Management

Task	Responsibility	Suggested schedule
Implementing regular FW monitoring	Restaurant management	Continuous; adjusting follow-up e.g. biannually, or seasonally
Linking FW results with management and planning	Restaurant management; contracting department (in public food services)	Continuous
Food-category-based analysis	Restaurant	Per measurement period

Redistribution practises: piloting and routinising	Food services / restaurant chains + food aid organisations	0.5–2 years
Harmonising FW terminology and monitoring methodology	Restaurant management; contracting department (in public food services); led by research and national FW coordinator (FIN: LUKE)	Immediately / next contract period

By comparing **prepared** (or ordered) **food** quantities to **originally inedible & edible food waste** quantities, food production efficiency can be assessed, and food waste hotspots, or reduction potential identified. It is essential to include **costs** into monitoring: in addition to ingredient expenses, the cost component should include suitable proportions of labour, energy, water, etc. variable expenses, which represent the used resources for a portion.

Waste management indices (key numbers) are easy to produce from **reporting results**, ideally comparable across hospitality service types, such as:

- food waste quantity per customer
- food waste cost per customer

These indicators provide insights into improving economic efficiency, as wasted resources directly reduce a restaurant's profitability.

In addition to monitoring waste just by weight, it is important to classify foods by **categories (product groups)**, since there is considerable variation between ingredient values and climate impacts. LUKE's model – and Lukeloki measurement application – allows up to 20 categories (Appendix 1), but even a smaller number of main categories help to identify:

- menu items that generate most waste (hotspots)
- impacts from them (financial and environmental)
- how to improve recipes and production planning for waste reduction

The most important and common categories are highlighted in bold in the appendix. Ingredient-based classification is particularly important when assessing environmental and cost impacts. **Beverages** often form a significant share of waste by weight, and many have substantial environmental impacts (coffee, dairy, alcohols), involving serious costs. A simplified categorization could divide products into:

- animal-based and plant-based foods
- main dishes and other food items

The model also considers **operational scale** by allowing to multiply spot-measurement results into chain-level, or to measure across a sufficient number of venues (restaurants). Based on LUKE's research, customer numbers and labour inputs (staff number as full-time equivalents, or hours worked) are reliable scaling factors.

Time scale recommends looking beyond just dates. Food waste generation is typically affected by numerous temporal and environmental factors, including:

- competing restaurants
- seasons and public holidays
- local events
- exceptional circumstances
- weather conditions

Despite forecasting, planning, and reduction efforts, some waste will always occur.

According to the waste hierarchy and Finnish waste regulations, edible surplus food should first and foremost be **redistributed for human consumption**. Following the Waste Act and LUKE's model, redistribution is also considered waste reduction, as that way the served food or side streams from cooking are prevented from becoming waste.

Redistribution options include:

- discounted sales at venue
- donations to food aid charities
- use for staff lunch etc.

It is recommendable to monitor the donated food quantities for calculating the restaurant's net waste. This facilitates waste accounting and profitability assessments what really is wasted. From a business perspective, donated or discounted food (with zero margin) may of course be considered lost value.

Food Waste Measurement

Food waste monitoring must be **conducted regularly over a sufficiently long period** to ensure reliable and representative results.

Measurement periods are difficult to standardize because many variables differ between periods, including:

- differing menus and planning variations
- different customer profiles
- seasonal and weather-related effects
- changes in customer behaviour

Therefore, measurements should represent daily operations across various periods and seasons. According to LUKE research, **a two-week measurement period** provides sufficiently reliable results when it is repeated multiple times throughout a year. Longer measurement periods may reduce data quality because staff motivation and measurement accuracy often decline over time.

Waste Fractions

Under the LUKE model, food waste is divided into the following fractions:

- kitchen biowaste (inedible parts)
- storage and preparation waste (together equals: kitchen waste)
- serving waste (aka buffet waste, overproduction)
- plate waste from customers

Prepared food is weighed, or its weight is determined through recipe information from the ERP system, before service begins. For replenished dishes during service, quantities are calculated by multiplying the number of containers/vessels used (e.g. GN pans). All **waste fractions** and inedible kitchen biowaste are weighed before disposal (net weight excluding serving vessels) during, or at the end of the service, and recorded on a monitoring form.

For **liquid waste**, measurement practices should be agreed, including:

- are frying oils included (collected for recycling?)
- are soups weighed after straining (or with stock)
- how coffee, milk, and other beverage waste is monitored

Efficient operational information is obtained when measurement fluency is ensured for staff and integrated into daily routines. A waste **results report** should allow easy understanding and data modification, for example in Excel or Power BI formats. Reports can also be used to create visualizations for internal and customer communications.

At best, the reports reveal how daily food waste is generated by dish, and by food category, and which service stages cause the highest environmental and economic impacts.

Appendix 1. Food Categories Used in LUKE Food Waste monitoring model

Most important categories are bolded.

Category	Description
Beverages	All beverages
Bread	Soft bread, crispbread, loaf bread, croutons, flatbread, bread rolls, sandwich crackers, rye crispbread
Breakfast cereals	Muesli, rice crispies, corn flakes, etc.
Cheese	Cottage cheese, cheese spreads, all other cheeses
Cold cuts	All meat charcuteries; liver pâté, meat pâté, cold-smoked reindeer, etc.
Dairy product	**Yoghurt, quark, cultured/fermented dairy products** *(viili)***; dairy-based dressings and dips: sour cream dressing**
Dessert	Puddings, custards, dessert porridges, smoothies, sweet buns, biscuits, ice cream, pancakes, apple crumble, milkshakes
Fish product	Tuna, shrimp, shellfish, seafood, salmon and other fish- and seafood-based appetizers that are not main courses
Fish soup	**Fish and seafood soups**
Fruits and vegetables	**Warm vegetables, fresh-cut vegetables, fruit salad, fruit and berry purees, berries, legumes (chickpeas, lentils, beans), vegetable side dishes**
Main course fish	**Fishballs, shrimp pasta; any dishes assumed to contain fish or seafood**
Main course meat	**Gravies with meat, meatballs, cabbage rolls; any similar dishes assumed to contain meat**
Main course vegetarian	**Veg. macaroni casserole, veg. cabbage casserole** *(makaronilaatikko; kaalilaatikko)***, vegetable patties; any vegetarian dishes without fish or meat. N.B: *not* limited to vegan dishes only.**
Meat soup	**Pea soup** *(hernekeitto)* **and other soups containing meat**
Other	Karelian pastries, jam, fruit soup, hummus, pizza, meat pies, spreads, margarine, vegan cheese, and items not falling elsewhere
Pastry, on display	Filled rolls and baguettes, sweet pastries

Porridge	Oatmeal, semolina porridge, rye porridge, rice pudding, barley porridge, whipped berry porridge (*vispipuuro*), gruel
Protein supplement	Eggs, egg butter, tofu
Salad	Mixed salads and grated root vegetables; items clearly intended as salads or salad components
Sauce	Condiments such as mayonnaise, ketchup, mustard; excluding dishes where the sauce is clearly the main dish (e.g. pasta with sauce)
Side dish	**Potatoes, mashed potatoes, rice, pasta, sweet potato, barley, noodles, oat grains**
Vegetable soup	Vegetable soups

Appendix 2. Sorting edible and inedible food waste