LOWINFOOD

Multi-actor design of low-waste food value chains through the demonstration of innovative solutions to reduce food loss and waste

GA No. 101000439

D5.8 – Report on Demonstration – Mitakus

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LIST OF PARTNERS THAT HAVE CONTRIBUTED TO PRODUCE/REVISE THE DELIVERABLES

ISUN, SLU, MITA, BOKU

LOWINFOOD Consortium

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1	Università degli Studi della Tuscia	UNITUS	Italy
2	Alma Mater Studiorum Università di Bologna	UNIBO	Italy
3	Sveriges Lantbruksuniversitet	SLU	Sweden
4	FH Munster University of Applied Sciences	ISUN	Germany
5	The James Hutton Institute	JHI	United Kingdom
6	Universitaet Fuer Bodenkultur Wien	BOKU	Austria
7	Tampereen Korkeakoulusaatio SR	TAU	Finland
8	Charokopeio Panepistimio	HUA	Greece
9	Osterreichisches Okologieinstitut	AIE	Austria
10	Elhuyar Fundazioa	ELH	Spain
11	Matomatic AB	MATO	Sweden
12	Unverschwendet GmbH	UNV	Austria
13	Akademie Deutsches Baeckerhandwerknord GGmbH	ADB	Germany
14	Foresightee (terminated on 30/01/2023)	FOR	Belgium
15	Leroma GmbH	LER	Germany
16	Mitakus Analytics UG	MITA	Germany
17	Kitro SA	KITRO	Switzerland
18	Regione Emilia Romagna	RER	Italy
19	Pianeta Cospea srl	PICO	Italy
20	Cogzum Bulgaria OOD	COZ	Bulgaria
21	Uppsala Kommun	UPP	Sweden
22	Recuperiamo srl	REG	Italy
23	Antegon GmbH	FT	Germany
24	Confederazione Nazionale dell'Artigianato e della piccola e media impresa Associazione di Viterbo e Civitavecchia	CNA	Italy
25	Assemblee des Regions Europeennes Fruitieres Legumieres et Horticoles	ARE	France
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Summary

This deliverable reports on how the innovation Mitakus, provided by the German company Mitakus Analytics UG, which aims at reducing food waste in the food service sector, was applied in the LOWINFOOD project. Mitakus uses sales data provided by the users and combines this with external factors such as the weather or holidays to calculate a sales forecast. This can help users plan their production more accurately. Food waste can be reduced if the users avoid producing surpluses by utilizing the Mitakus forecast.

In Germany, two users tested the Mitakus innovation as part of the LOWINFOOD project. Both users are university student canteens of differing sizes. This report presents the methodological approach to testing. The results of an initial food waste measurement in the businesses, an assessment of the forecasts' performance, and the results of a survey on user-friendliness and potential improvements are presented. The innovation was highly affected by the COVID pandemic. Thus, the demonstration of Mitakus faced several challenges, such as acquiring businesses for testing or providing usable historical sales figures to create the forecasts. The opportunities offered by Mitakus included, for example, the company's responsiveness to customer requirements.

The waste measurement in the businesses discovered that 46 and 41 grams of food were initially wasted per serving including plate, serving, and preparation waste. The user survey revealed that the implementation of the app was initially perceived as somewhat difficult. In contrast, use by management was described as rather simple. The dashboard and its features also received a good rating. The performance of Mitakus' short-term forecasts is better than those predicted by the users themselves. In contrast, the quality of the long-term forecast depends on the circumstances in the company and is strongly influenced by short-term changes to the menu.The current status of testing is that Mitakus is continuously improving the prediction models created.

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Introduction to the deliverable

LOWINFOOD is a project committed to co-design, together with actors of the food chain, low-waste value chains by supporting the demonstration of a portfolio of innovations in a set of value chains particularly concerned by food loss and waste (fruits & vegetables, bakery products and fish), as well as in at-home and out-of-home consumption. Each of these value chains corresponds to a single Work Package (WP) of the project.

The innovations are selected among promising solutions that have already been developed and tested by some partners of the consortium, with the aim to provide the necessary demonstration and upscale to allow market replication.

The LOWINFOOD consortium comprises 27 entities, located in 12 different countries, and ranging from universities and research institutes to start-ups, foundations, associations, and companies working in the food sector. During the 52 months of the project, the partners are committed to complete 30 tasks and to deliver 60 outputs (deliverables).

This deliverable (D5.8) is part of WP5, which is dedicated to reducing food waste within household and foodservice consumption settings. Specifically, D5.8 is related to the innovation of task 5.2 (T5.2) which aims to reduce food waste in food service facilities by facilitating the process of production planning. Mitakus targets to forecast the businesses' sales, i.e. the number of meals sold, and by doing so, allows the businesses to better fit the number of produced meals to the actual demand which should contribute to causing less food waste.

This deliverable includes a report on the methodological approach used in the task and describes the challenges and opportunities encountered during the demonstration. It also presents the results of a food waste measurement in two participating catering businesses and the results of a survey on the user-friendliness of the innovation. In addition, the improvements made to the innovation as part of LOWINFOOD are presented and insights into the performance assessment of the forecasts are provided.

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Introduction to Mitakus

Mitakus was founded as part of the Founder Institute in 2018. Lead by Roman Wolkow and based in Munich, Germany, this innovation aims to lower food waste and improve planning security for managers of restaurants or canteens. One of the major motivations for founding Mitakus was the personal experience of the founders, as they worked in the food service sector and have seen large amounts of food being wasted. The technologies to overcome the challenges mainly responsible for surpluses already existed and were used in other industries. This combination lead to the idea of Mitakus, to reduce food waste in food service. This is done by providing a tailored sales forecast based on an artificial intelligence algorithm. By being able to predict sales more precisely, food waste and overproduction can be avoided.

The algorithm is fed with internal (historical data on sales) and external factors, such as the weather or holidays. Mitakus' web-based software platform supports chefs, production and purchasing managers, and operations personnel in the design of menu plans based on customer preferences and customer flow, while predicting ingredient quantities needed.

The forecasts calculated by Mitakus can be accessed by the users via a web-based application. The predicted sales values reach one to six weeks into the future, with minor adjustments based on the most recent sales happening daily. Kitchen managers view the predictions and can make adjustments, if needed. Mitakus can be a useful tool especially for businesses that use fresh and perishable ingredients. The forecasts provided by the Mitakus software are expected to reduce overpreparation and overstocking, thus preventing the waste of raw and prepared food, and making restaurants more profitable and sustainable.

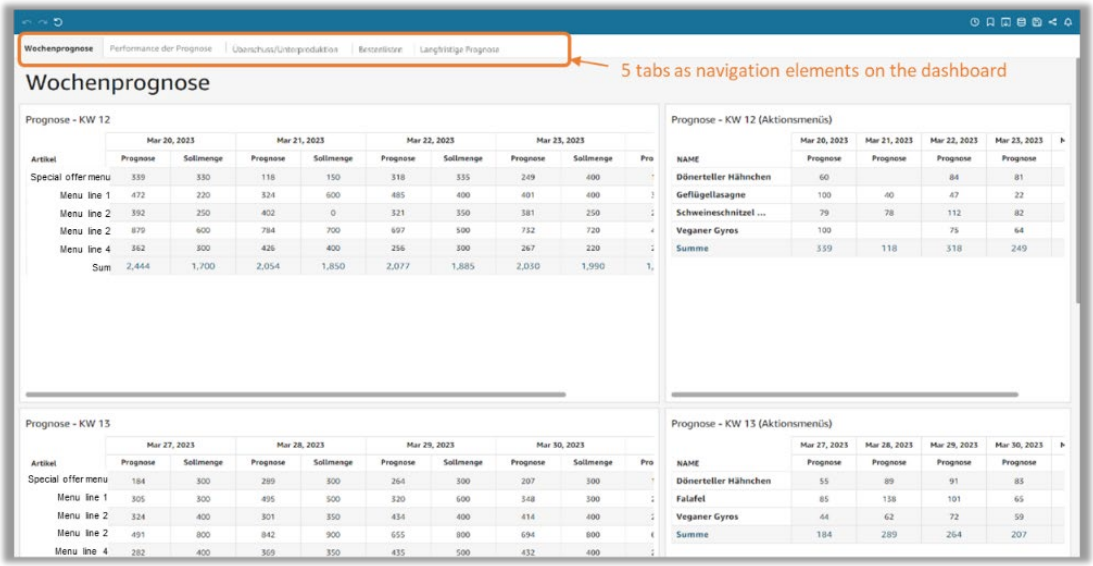

Figure 1: Current dashboard version, realized with quicksight; showing weekly forecasts

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The Mitakus dashboard comprises five tabs (see top of Figure 1). The first one is called "Wochenprognose" in German which means weekly forecast. The second shows the performance of the forecast (in German "Performance der Prognose"). The third tab is named "Überschuss / Unterproduktion" in German, which indicates the surplus / underproduction of the forecast respectively. The fourth tab "Bestenlisten" shows a list of the best or worst performing menus. On the last tab figures on the long-term can be found (in German "Langfristige Prognose").

The weekly forecast in Figure 1 is shown for the calendar weeks 12 and 13 for the menus of a public caterer (student canteen). The first line on the left side of this figure is related to a special offer menu that varies on a daily basis. The individual dishes in this menu line are itemised on the right-hand side of this figure (see lines Dönerteller, Geflügellasagne, Schweineschnitzel, and veganer Gyros). As an example: for March 20th, 2023, the total number of sales forecasted by Mitakus (in German "Prognose") was 2.444 meals with 339 for the special offer menu, 472 for menu line 1, 392 for menu line 2, 879 for menu line 3, and 362 for menu line 4.

The target quantity (in German "Sollmenge") that is also shown in this figure shows the long-term planning basis of the caterer that is used as the basis for the procurement of raw materials. This target quantity is the predicted quantity that the users themselves forecast based on their working experience. The target quantity also receives adjustments when the planned week is getting closer. The adjustments are made by management to take account of changes to target quantity planning that arise in the short term. For example, when it is clear how many portions of stored overproduction will be used for the buffet. As can also be seen in this Figure 1, the forecast provided by Mitakus can either be higher or lower than the target quantities. For example, the Mitakus forecast for menu line 1 on 20 March was 472 compared to a target quantity of 220 assumed by the user, while on 21 March it was it was exactly the opposite with a Mitakus forecast of 324 compared to the target quantity of 600 assumed by the user.

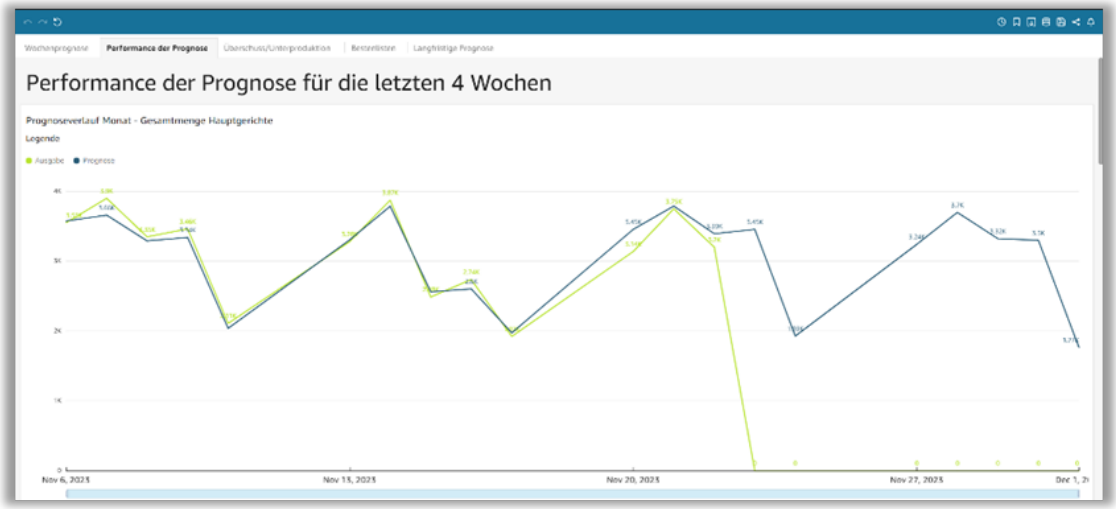

Figure 2: Dashboard showing the performance of the forecast

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The screenshots of the dashboards presented in Figure 2 and Figure 3 show the performance of the forecast. In Figure 2 the total forecast numbers of meals and the actual sales over a longer period are compared in form of a line chart. Figure 3 provides more detailed figures included in tables displaying the forecast, the planned number of meals and the actual sales for each week per menu line.

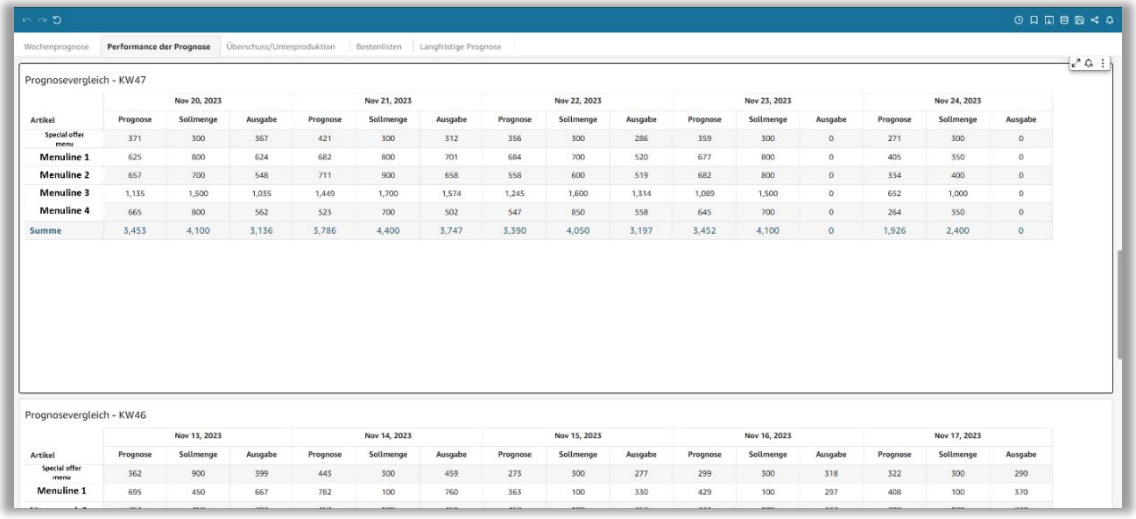

Figure 3: Dashboard with a comparison of forecasted, planned and sold number of meals

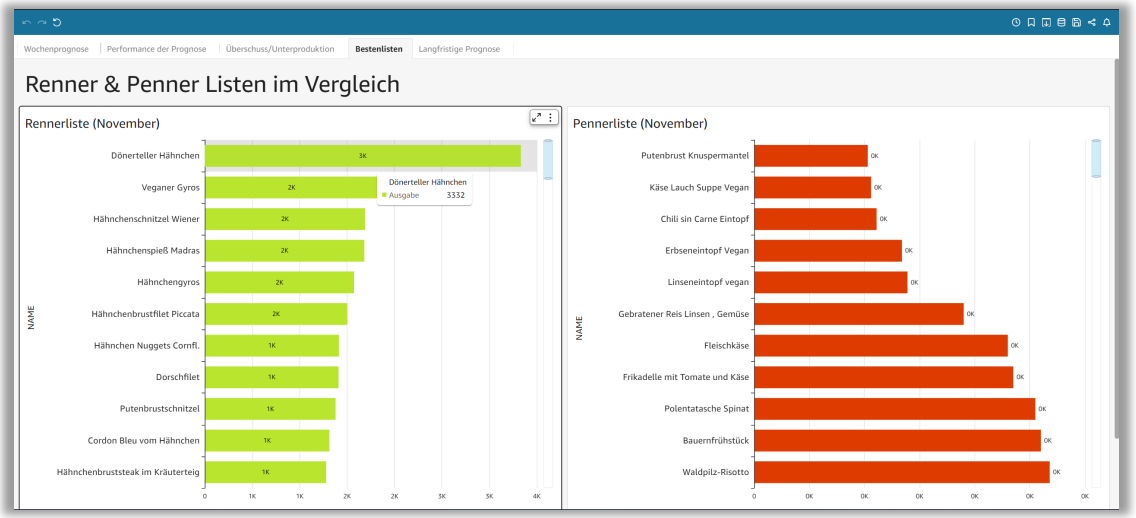

Figure 4: Dashboard showing best and worst selling menus

The screenshot of the fourth tab (see Figure 4) is dedicated to showing the best and worst selling dishes for a specific period. The user can filter the time period and search through the data.

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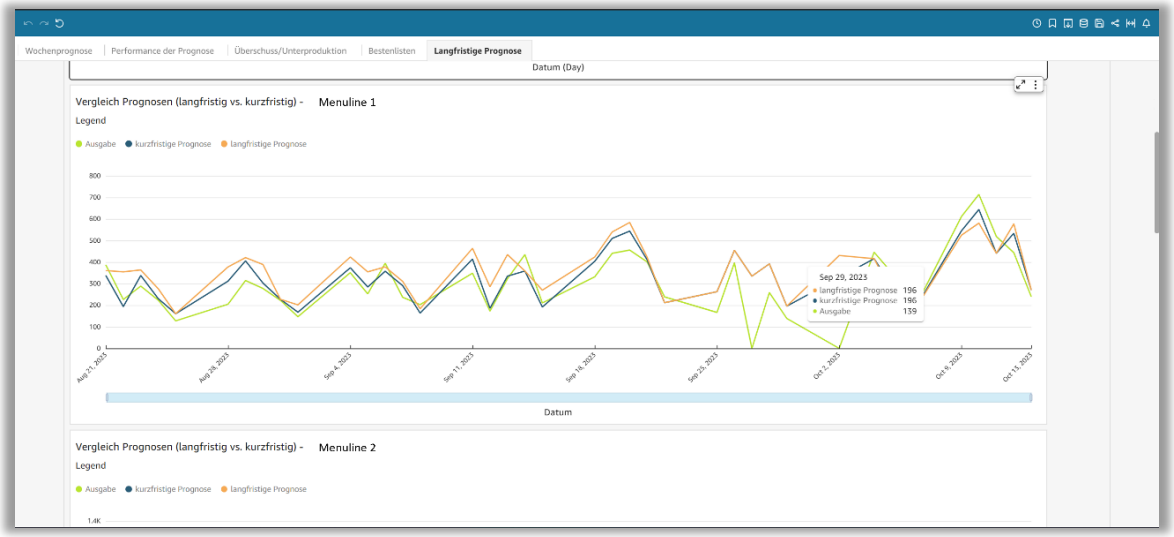

Figure 5: Dashboard showing long-term vs. short-term forecast and actual sales

The final tab shown in Figure 5 presents the long-term and short-term forecast vs. the actual sales for each menu line. The user can identify major deviations in the forecast for each day and meal. Moreover, they can export the data of any chart or figure in CSV format.

Methodology

Scope of the demonstration

As part of the LOWINFOOD project, Mitakus should be tested in German and Swedish food service businesses. Testing comprises the implementation and usage of Mitakus in the businesses, determining its efficacy to reduce food waste and assessing the socio-economic and environmental effect of its use. Figure 6 shows the planned and the actual approach of testing Mitakus in the LOWINFOOD project. The implementation of Mitakus faced unexpected difficulties with the customisation of the forecasting model. Those difficulties are described in the section about „challenges" further below. Consequently, the usage of Mitakus was limited.

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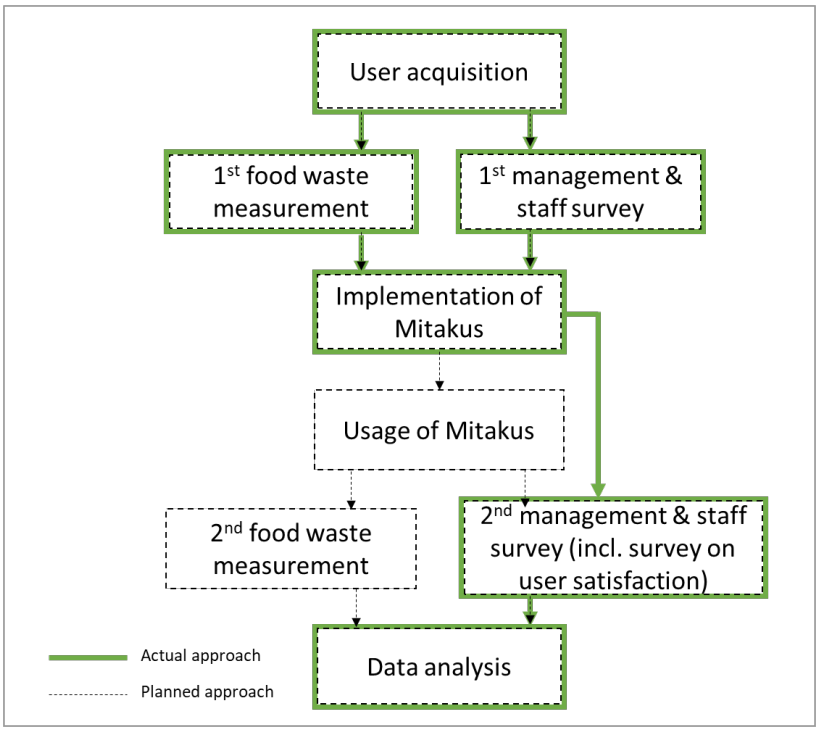

Figure 6: Planned and actual approach of testing the Mitakus innovation in LOWINFOOD

Users of the demonstration

The two German users that tested Mitakus in the context of LOWINFOOD were acquired in June 2021. Both are student canteens on university campuses. The contact was made via ISUN. Interest in the Lowinfood project was initially aroused during a telephone call. Further information on the innovation was then explained in joint calls with the innovation partner Mitakus.

The first canteen, DE1, is one of five canteens of a university with around 32,500 students and serves about 4000 people a day at a maximum in March of 2022. The canteen in total offers five different menu lines. Menu line 1 offers vegetarian or vegan meals while menu lines 2 and 3 offer mixed cost also including meat products. Menu line 4 is a subsidised line to make sure all students may effort a meal. The special offer menu line is priced higher, allowing for the kitchen managers to use more expensive ingredients for this menu line.

The second user, DE2, is located on a 9,500 students-campus with a total of four canteens. The canteen using Mitakus has 298 seats and can serve a maximum of 900 portions per day. At the date of writing this deliverable, 350-600 meals were served daily, which is still lower than pre-pandemic guest flow. DE2 describes itself as a smaller canteen with a volatile menu that is subject to short-term changes due to procurement problems, staff shortages and large surpluses from the previous day.

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Although both users officially operate under the same organisation, the circumstances under which they work vary. This means menu planning, procurement, production, and serving of food is organized separately and specifically for the respective organisation. Besides the different size of their customer base, the time frame of semesters and break between semesters also varies, and the menus comprise a different number of lines. This requires an adaptation of the Mitakus algorithm to the respective settings.

In addition to those two users, it was only shortly before this report was completed that another business caterer was persuaded to test Mitakus at two locations (status as of Sept. 2023). Acquisition of this user was done by Mitakus via a telephone call. Due to the advanced stage of the project, it was no longer possible to collect baseline data for this partner in time for the finalisation of this report. If the collaboration with this user is successful, data collected at this business can be analysed in WP1 so that it can be included in deliverables 1.6 and 1.7 (due in Oct. 2024).

Food waste measurement

In order to assess Mitakus' efficacy to reduce food waste the level of food waste was supposed to be measured before the innovation was used. This measurement was meant to be repeated after about six to twelve months of using Mitakus. The first measurement functions as a baseline to compare the results after the innovation. The duration of this baseline period was scheduled for one month.

Although first meetings with the users were held in August of 2021, the baseline measurement was delayed until May 2022. This decision was made due to the COVID-19 pandemic, which lowered guest numbers on the campus significantly. The users conducted the measurement themselves with close communication to Mitakus and ISUN. Users measured plate waste, serving waste, and preparation waste manually with an electronic scale and documented the results in an MS Excel file (see Annex 1). In addition, they documented overproduction, which was not part of the waste but used otherwise instead. The number of served portions was recorded to calculate waste per guest.

The control measurement was supposed to take place after Mitakus was implemented successfully in the businesses and tested for six to 12 months. As the implementation could not be completed during the project as planned (see previous section, Figure 6, and "challenges" section in the results) the control measurement of food waste was suspended.

Surveys to assess the user-friendliness of Mitakus

Besides assessing Mitakus' efficacy to reduce food waste, it's social and economic impact is assessed by the means of a management and a staff survey (see protocols for collection - LOWINFOOD Deliverables 1.2-1.4). Results on this analysis will be presented in deliverable D1.7 of the LOWINFOOD project due in October 2024. This deliverable focusses on the part of the management survey that addresses the topic of user satisfaction with the innovation. This data was collected through personal interviews with the management of the users at the end of the

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task, i.e. after the users had tested Mitakus in their respective working environment. Here, the person that mainly dealt with Mitakus was interviewed in each organisation. The following questions related to user-satisfaction were included in the management survey:

User satisfaction with Mitakus

1. Did you have to train staff on how to use Mitakus? (free text/open question)
2. How difficult was it to start using Mitakus (1 – very difficult; 5 - very easy)?
3. How satisfied are you with the following features of Mitakus (scale 1-5: 1 hardly satisfied, 5 very satisfied)?
    - Dashboard of the innovation
    - Functionality / features of the innovation
    - Ease of use for managers
    - Quality of service
4. Do you think Mitakus helped you reduce food waste? (free text/open question)
5. Would you recommend Mitakus to others? (free text/open question)
6. Will you continue using Mitakus (even) after the project ended? (free text/open question)
7. If you could start the project again with today's knowledge, what would you do differently and why?

Implementation of Mitakus

After the baseline measurements, the implementation phase started. With this approach, Mitakus should be integrated into the processes of the businesses. In order to do so, the users exported their historical and recent sales data to Mitakus. Mitakus received different type of data, i.e. recipe data, production data and sales data, which had to be inspected and cleansed in order to be used for forecasting. The cleansing process involved an exploration phase, to understand the structure, dimensions, and basic statistics, identify missing values, outliers, and anomalies. Each data-set had to be brought into an understandable structure, which also involved removing unnecessary values in consultation with the partner. The final structure then served as a template for future exports by the partner and was enriched by additional features, like calendar data and weather data, to serve the forecasting model.

On the basis of the processed data, Mitakus calculated forecasts and improved them according to the users' needs, which were discussed in iterative meetings between the partner (users, Mitakus and ISUN). The forecasts provided by Mitakus comprise a short-term forecast and a long-term forecast.

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Usage of Mitakus

The usage of Mitakus should have followed implementation. After successful implementation, Mitakus should be used as a planning tool by the managers for their purchasing and production planning for a period of six to 12 months. During this time, the managers should use the forecasts as the basis for ordering raw materials and planning the quantities of meals produced on the day of their production. Usage of Mitakus does not mean that no independent decisions can be made. However, the predicted values should be viewed daily and a decision made as to whether these values should be used or adjusted at short notice, for instance due to unexpected events (e.g. a power cut, or additional large visitor groups at short notice).

Data analysis

This task involved collecting data on food waste, data on the quality of the Mitakus forecast as well as data on user satisfaction with the Mitakus innovation. Data is analysed as follows:

- Data obtained from food waste measurement (with Σ: sum)
  - Total food waste (kg) = Σplate waste (kg) + Σpreparation waste (kg) + Σserving waste (kg)
  - Share of plate waste = Σplate waste (kg) / total food waste (kg)
  - Share of preparation waste = Σpreparation waste (kg) / total food waste (kg)
  - Share of serving waste = Σserving waste (kg) / total food waste (kg)
  - Total food waste per serving (kg / serving) = total food waste (kg) / Σnumber of servings
  - Plate waste per serving (kg / serving) =Σplate waste (kg) / Σnumber of servings

- Data used to assess the quality of the Mitakus forecast
  - MAPE long-term (compares the Mitakus long-term forecast and the actual sales)
  - MAPE short-term (compares the Mitakus short-term forecast and the actual sales)
  - MAPE target-value (compares the target quantity projected by the user and the actual sales)

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{forecasted\ value - actual\ value}{Actual\ value}\right|$$

With MAPE: Mean absolute percentage error of forecasted values (percentage mean value of the absolute difference between forecasted and true values, divided by the true value, where the true value indicates the actual sales)

- Data obtained from survey on user satisfaction
  - Quantitative data: descriptive analysis
  - Qualitative data: qualitative data analysis

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Outcomes of demonstration phase

This section is dedicated to the results obtained from testing the Mitakus innovation in LOWINFOOD. These results also include the experiences gained during the implementation phase. This includes positive experiences that led to an improvement of the innovation through the collaboration with the practice partners, but also negative experiences that influenced the demonstration of the innovation. In addition to the results of the food waste measurement and the user satisfaction survey, the opportunities and improvement as well as the challenges are therefore also presented in this section, as these also made a valuable contribution to the further development of the innovation.

Opportunities and improvements made to the innovation

- Quick adaption to customer's needs

Mitakus has proven in the demonstration with German canteens that it can adapt to the needs of customers. In this context, Mitakus has enhanced its web-based dashboard for the users. Notable improvements include an extended forecasting period of up to 6 weeks, enabling users with more comprehensive insights into future demand.

- Continuous improvement of sales forecast

The continuous meetings with the business partners revealed that the timing of the forecast proved to be a critical point. While at the beginning predictions could only be made a short time in advance, users stated that they needed a long-term forecast in order to be able to adjust their purchases accordingly. For this reason, Mitakus adjusted the forecasts to 2 weeks, and then 4 weeks and finally 6 weeks ahead. This included calculating a short-term and a long-term forecast, which was necessary for the users to order raw materials around six weeks ahead. The short-term forecast provides higher accuracy as recent sales and unexpected changes or influences, like public strikes, can be considered. It can be used to precisely plan production numbers for each day. During the implementation phase, the users compared the forecasted values with their actual sales based on their working experience. The forecast model has undergone refinement, ensuring a more reliable long-term projection, while short-term forecasts with updates enables users to adapt quickly to changes. The user interface has been adapted to accommodate both short and long-term forecasts in the forecasting tab, but also in the tab showing a retrospective view of the data for the last 4 weeks. To further improve the understanding of impact by short-term and long-term forecast, a dedicated tab was introduced to show both values in comparison to actual sales for each menu line for a chosen time period.

Challenges experienced during the testing of Mitakus

A major challenge that affected the testing of Mitakus in LOWINFOOD was the COVID-19 pandemic. This affected the Mitakus task in three ways.

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1. Company acquisition in the period of restrictive pandemic policy

Firstly, the company acquisition period fell within the period of a restrictive pandemic policy. This made it very difficult to find companies that were willing to participate in the project. In Germany Mitakus should have been tested in three food service businesses. Only for the two partners DE1 and DE2 data could be collected in due time for this deliverable.

2. Historical sales figures from pre-pandemic situation

The second effect of the pandemic for the organisations that could be recruited as practice partners, was that the historical sales figures were not well suited to deriving a prediction model. Although stay-at-home orders lifted, it became apparent that guest flow would not return to how it was before the pandemic, but settle for a "new normal", rendering any previous data useless for predictions. The revenue chart (Figure 7) for the years 2018 to 2022 clearly shows how the pandemic has affected the business activities of university catering (revenue includes a total of 12 student canteens operating under the same organisation as DE1 and DE2).

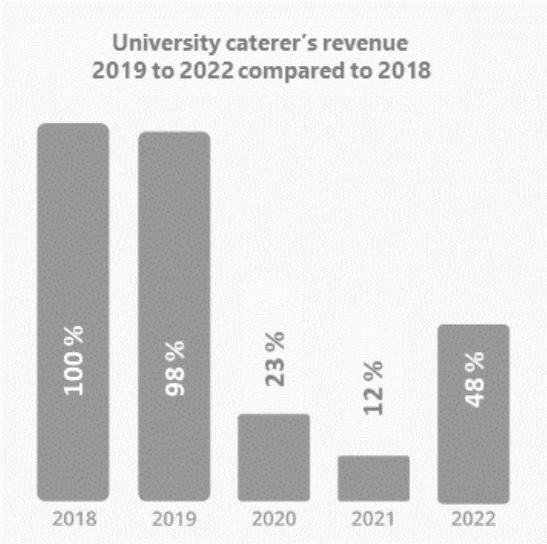

Figure 7: Development of university caterers' revenue before and during COVID-19 pandemic (source: own illustration based on confident data provided by caterer).

In addition, the data structure in 2022 and onwards has changed in comparison to 2019. New menu-categories and meals were introduced, the unique IDs for meals, which are used to identify meals, have changed or were assigned to other meals. Thus making the use of pre-pandemic data unusable.

Because of this data situation and the longer forecast needed by the users, Mitakus had to calculate the forecast in new ways, using less historical data but predicting further into the future than before. Although the quality of Mitakus' projected sales figures improved steadily during the implementation process, they did not provide companies with a reliable alternative to the previous

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planning process. While the forecast became more and more accurate over time, it never reached a level of accuracy at which the kitchen managers would trust Mitakus predictions blindly. For this reason, Mitakus could not be tested in real business and the actual usage of Mitakus did not take place during LOWINFOOD

3. Scheduling the food waste quantification

The third challenge related to the COVID-19 pandemic was scheduling the baseline measurement of food waste. When the businesses DE1 and DE2 were recruited in June 2021, the canteens were still heavily affected by the pandemic. Therefore, baseline measurements were pushed back to May 2022. As can be seen in Figure 7, business activity in 2022 was still not as it was before the pandemic. It was therefore not possible to estimate at the time whether the baseline measurement period would be representative. Nevertheless, this period was chosen for the baseline measurement, as the plan was to establish comparability of the data using normalised key figures (e.g. waste per guest).

4. Replication in Swedish food service sector

A fourth challenge that became apparent during the project was the testing of Mitakus in Sweden. The initial aim was to work with Swedish school caterers, as there was already a basis of trust with one responsible organisation, and this institution was also a partner in the LOWINFOOD project (UPP). One school canteen was selected as an example and historical data on food waste, menus and guest attendance was collected and transferred to Mitakus. The test forecast was communicated with the selected school canteen. A routine to collect recent data and share this with Mitakus was established, but since the data had to be transferred manually with some delay and due to the limited amount of data available, the forecasts was deemed insufficient to create any actual value for the school canteen. The plan to implement the innovation in three similar school canteens was therefore canceled. Instead, it was decided to wait for Mitakus to improve its predictions in the participating German businesses. As Mitakus was still unable to make satisfactory predictions for the participating German companies at a later stage in the project, the implementation in Sweden was completely suspended.

5. Automatic import of data from users to the software

A fifth challenge experienced by Mitakus was the initial import of the partners historical sales data and the menu data to the database of Mitakus. The historical sales data and menus were sent manually by e-mail in the beginning. The menus were in PDF format, which meant that they could only be partially read automatically and required a lot of additional manual work to copy the data from PDF to a format, which then could be imported to the Mitakus database. The problem with the menus was solved by providing an API where Mitakus could see the daily updated menus and these could also be read out automatically. . Historical sales data was sent in excel-format to Mitakus, which also required manual work to re-structure it and import to the MItakus database. This approach was prone to error, as for example the partner sometimes forgot to send the data

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in time for next week. The problem with the historical data was also solved once Mitakus had found a standardised structure for the data and provided a code-script to the partner,, so that an automatic export was set up that uploaded the new data to Mitakus servers every day.

Results of the food waste measurement at baseline

Originally, it was planned for the users to fully use the Mitakus forecast, with a second food waste measurement taking place to compare food waste before and after use of the innovation. As users started to view the forecasts, it became clear that some adjustments to the Mitakus forecasting algorithm still had to be made. While the forecasts became more and more accurate over time, they never reached a level of accuracy at which the kitchen managers would trust Mitakus predictions blindly (see "challenges" section). For this reason, only an initial food waste measurement took place.

The food waste baseline was measured from May 2nd, 2022 to June 3rd, 2022 in both businesses DE1 and DE2. There was no business during the weekends and for two days of public holidays, i.e. the number of measurement days was 23. Results are presented in Table 1.

Table 1: Results of food waste measurement (baseline) for the users DE1 and DE2

Location	**Served portions**	**Total food waste**	**Food waste per serving**	**Plate waste per serving**	**Share of plate waste**	**Share of serving waste**	**Share of preparation waste**
DE1	64735	2987 kg	0.046 kg / serving	0.023 kg / serving	49%	46%	5%
DE2	8612	354 kg	0.041 kg / serving	0.025 kg / serving	61%	21%	18%

Preparation waste arises while food is being prepared in the kitchen. This may also include unavoidable food waste such as vegetable peels or bones. For DE1 it was 5 percent and for DE2 18 percent of the total food waste. Plate waste describes the waste left on plates after eating by patrons of the restaurant or canteen. For DE1 almost halve of the food discarded (49 %) was plate waste, and for DE2 it was even 61 percent. Taking a closer look at the actual quantities per serving reveals that plate waste only accounts for 23 and 25 grams per portion for DE1 and DE2 respectively. Mitakus does not aim to reduce plate waste. Instead, Mitakus may reduce serving waste, which is food that is already cooked and prepared, but not served to the guests. This kind of waste made 46 percent (1371 kg) in case of DE1 and 21 percent (73 kg) in case of DE2 of the total food

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wasted respectively during the 23 days of measurement. With the help of a reliable forecast, kitchen chefs might plan food quantities with a lower safety or error margin, lowering food waste.

The businesses also documented the amount of overproduction, i.e. food that was produced and not sold that day, but as it has not reached the serving area could be stored for further use on other days (e.g. by freezing or cool storage). For DE1 the amount was 4513 and for DE2 1633 kilogram in total over the entire measurement period. On a per day basis this makes 196 and 71 kilograms respectively. Compared to serving waste this is a huge amount which indicates that the businesses already have worked out their own strategies not to waste too much food due to unpredictable guest fluctuations.

Results of the forecast assessment

Mitakus provides the users with a long-term (up to six weeks in advance) and a short-term forecast (up to one week in advance). The user itself generates and uses the target quantity as a forecast in order to plan the raw material procurement. In this analysis the three forecasts are compared for the two users DE1 and DE2 respectively. The mean absolute percentage error (MAPE) is used as an indicator to assess the forecasts' performance. Data covers the months of February 2023 to October 2023.

Table 2: MAPE values for Mitakus' and the users' forecasts

User	Number of entries, n	MAPE (Mitakus long-term forecast)	MAPE (Mitakus short-term forecast)	MAPE (business' own forecast)
DE1	1337	26% (SD 34%)	20% (SD 27%)	57% (SD 94%)
DE2	982	73% (SD 48%)	30% (SD 36%)	34% (SD 80%)

As can be seen in Table 2, the Mitakus forecasts for DE1 are better than the business' own forecast. While the long-term forecast deviates on average 26 percent from the actual sales value, the company's own forecast deviates more than twice as much from this value at 57 percent. Mitakus short-term forecast performs even better, with an average absolute deviation from the actual value of 20 percent.

However, for DE2 the situation is different. For this user, the long-term forecast shows a high MAPE value with 73 percent, while the companies own forecast performs better with 34 percent deviation. By contrast, Mitakus' short-term forecast of 30 percent is even better.

Figure 8 shows the development of the MAPE values over time for DE1. A clear trend that the deviation of Mitakus' forecasts is decreasing, which indicates that the forecasts have improved over time, is not confirmed by the available data.

In Figure 9 MAPE values over time for DE2 are presented. In contrast to the forecast of DE1, it can be seen that MAPE of Mitakus' long-term forecast here is always greater than that of the user's own prediction. For the short-term forecast it is sometimes higher and sometimes lower than from

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the user's prediction. This figure shows that the dispersion of MAPE for the short-term forecast is lower than that of the user, which can also be seen in *Table 2* from the lower standard deviation (SD of 36% compared to 80%).

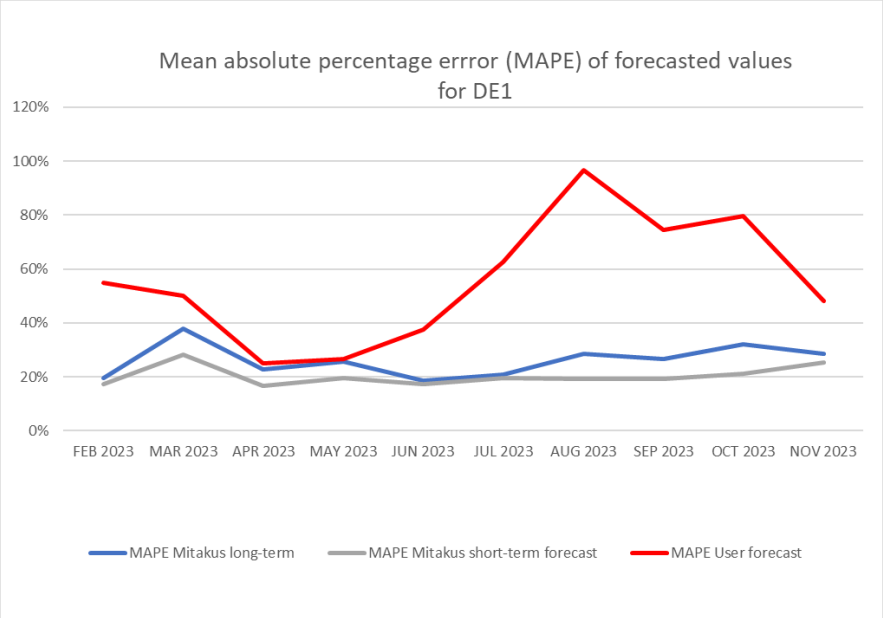

Figure 8: Comparison of MAPE values for DE1 for Mitakus long-and short-term forecasts, and the user's own forecasted target quantity

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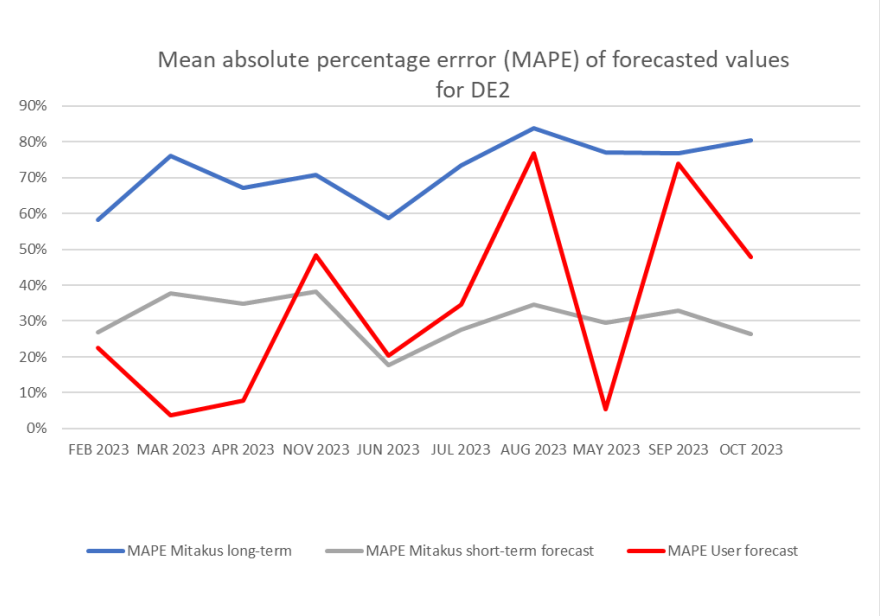

Figure 9: Comparison of MAPE values for DE2 for Mitakus long-and short-term forecasts, and the user's own forecasted target quantity

The differences in the quality of the forecasts for DE1 and DE2 can be explained by the fact that DE2 frequently made spontaneous changes to the food on offer. For example, surplus stock was added to the menu at very short notice, which cannot be taken into account in the forecasts. Forecasts that were made 6 weeks in advance differ significantly, as the meals are altered a couple of days before the actually forecasted period or on the same day. This leads to the situation, that some meals that were forecasted 4-6 weeks ahead, are no longer in the menu on the actual day.

Survey results for user satisfaction with Mitakus

Questions 1 and 2 refer to the phase of implementing Mitakus. The first question asks for the required effort necessary to train the staff that uses the device. Both DE1 and DE2 say no training was necessary, as the dashboard is easy to understand for people who work with computers regularly.

The second question delivers information regarding the perceived level of difficulty to implement Mitakus, results are shown in Figure 8. Here, DE1 rated the difficulty of implementation with a 2, meaning rather difficult and DE2 with 3. This is because the data export on the user side requires some effort and communication from the users. After the data export is agreed upon, the data is sent to Mitakus, who have to import the data on their side to the database. Then the forecast needs to be calculated as a next step, making the implementation of Mitakus a longer process.

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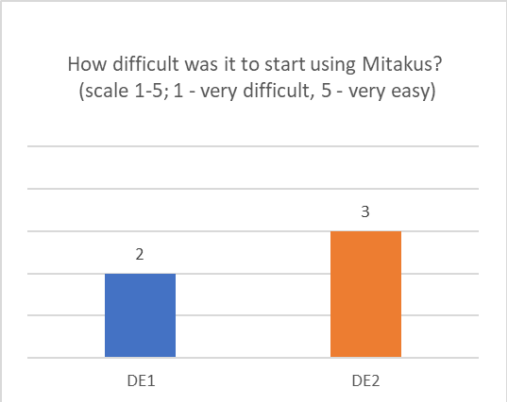

Figure 10: Level of difficulty to implement Mitakus innovation

Question 3 studies the users' satisfaction with different features of the innovation. Answers from both users are shown in Figure 9. Both users are very satisfied with the dashboard of the innovation and somewhat satisfied with the ease of use for managers. Both the quality of service and the features of the innovation were rated as a 3, meaning neither satisfied nor dissatisfied, by user DE1. User DE2 rates these features higher: the user is mostly satisfied with the features of the dashboard and very satisfied with the quality of service.

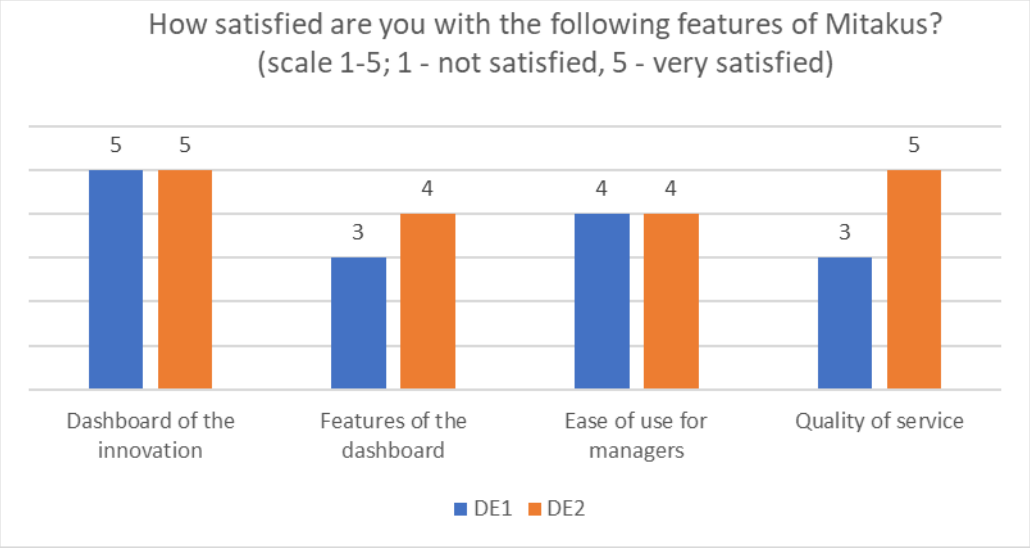

Figure 11: User satisfaction with various features of Mitakus

In the fourth question of the survey the users were asked if they thought that Mitakus helped them reduce food waste. The user DE2 answered affirmatively, saying that using the tool is both good for improving awareness of food waste and to improving planning, which is an economic as well as an environmental goal. The user DE2 said that Mitakus did not help them to reduce food waste, in part because awareness of food waste was already high among employees before the project.

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Answering question 5, in which users were asked if they would recommend Mitakus to other facilities, both users said they would do so. User DE1 would recommend Mitakus to smaller facilities with less awareness of food waste. When recommending Mitakus, user DE2 would choose a facility with a less volatile menu plan.

Neither user gave an answer to question 6 as to whether or not they would continue to use Mitakus after the end of the project. Both stated that a decision had not yet been made (as of 13/12/2023).

When asked in question 7 what they would do differently if they were to start over the project, user DE1 answered that their facility does not fit Mitakus' abilities. The interviewed kitchen manager sees higher value of Mitakus for small facilities with smaller or no capacities for reusing unserved food the next day. Because DE1 serves 4000 people on a full day, using up a small amount of extra portions can be easily done. In a smaller facility, this might not be the case, which means that Mitakus could have larger effects in such a small facility. The kitchen manager further says that their facility focuses on reducing food waste, while other facilities might not be sensitive to this subject yet, which also would mean that Mitakus could change more in such a facility. The user DE1 would have profited the most from an accurate long-term forecast for planning six weeks into the future. The short-term forecast does not offer a great value for the user, as short-term adjustments can confidently be made by the experienced kitchen managers, taking sales from the last days into account. The user considers whether it would have been useful to collect sales data over a longer period of time after the pandemic in order to calculate accurate forecasts, which would mean that the timing of the project would make it more difficult to utilise the innovation.

The user DE2 answered question 7 saying that staff shortages are a reason why the Mitakus implementation did not go as smoothly as planned. To improve this, they would have preferred to shorten the project to three months and leaving out the months of October until January, as these are the fullest and most stressful for the student canteen. Asked for the reason, the kitchen manager stated he did not find the time to compare the Mitakus dashboard to their own predictions when the kitchen and canteen were very busy. The kitchen manager further said that Mitakus might work better in a kitchen with a set menu plan, excluding short-notice alterations.

Learnings and recommendations for future applications

The testing of Mitakus revealed insights highlighting the significance of tailoring a forecasting application to the specific attributes of partner food service businesses.

The demonstration phase indicated that factors such as the size of the location or the number of guests may not be as crucial as the existing processes and the attention given to food waste management. Partners with a pre-existing focus on efficient production and waste reduction seem to derive more incremental benefits from the Mitakus application. Furthermore, it is recommended to consider the total required forecasting period. These types of projects require an extensive amount of historical sales data, ideally surpassing a year for short-term forecasts and

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at least two years for long-term forecasts. This extended historical perspective ensures an adequate volume of data for the training and testing of forecasting models, enhancing the application's accuracy and efficacy.

Another important learning is an easy data accessibility. Fortunately, the partners DE1 and DE2 were able to easily export the required data and automate this process. Therefore, a key recommendation for future applications is to clarify with partners how the necessary data can easily be exported or, preferably, automate the data export through APIs (Application Programming Interfaces) or other automated mechanisms. This not only streamlines the integration process but also fosters a more user-friendly experience for partners, contributing to the overall success and adoption of the application.

A further learning is the importance of having dedicated personnel on both sides of the partnership, provider and user, that is actively engaged throughout the project. Committed personnel not only enhance responsiveness but also prove crucial in overcoming technical challenges, like data export or data adaptation. The recommendation for future applications is to ensure all partners allocate personnel interested, dedicated, and technically adept, ensuring smooth implementation and success. In particular, the circumstances of the food service sector, which is characterised by staff shortages and a lack of time, must also be taken into account here. Solutions must be offered that relieve the burden on companies when implementing the application.

One lesson the scientific partners ISUN and SLU have learnt from their collaboration with the business partners is how important it is to create a basis of trust for cooperation. The personal contact of the researchers proved to be crucial in keeping contact and receiving information on time. One learning is therefore the importance of regular, personal contact and a good understanding of each facility to ease the data transfer and increase trust by users.

Conclusion

In conclusion, while the project has presented various challenges, it also offers a valuable source of learnings and insights into food service operations and their strategies for managing food waste. Despite the obstacles caused by the pandemic, which, for example, rendered historical data useless for forecasting, the project has yielded essential understanding of user requirements for planning and how to support these processes. Recommendations for future applications include tailoring solutions to the unique characteristics of partner businesses, emphasizing the significance of historical data, streamlining data accessibility through export capabilities or APIs, and ensuring the active involvement of dedicated personnel on both sides, provider and user of the application. The outcomes of the project not only contribute to the ongoing refinement of forecasting applications but also offer a blueprint for enhancing collaboration and effectiveness in the realm of food waste reduction and inventory optimization.

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Annex

Institution / Code	Date	Dish	Menu line	Quantity planned (pcs.)	Quantity sold (pcs.)	Overproduction, stored (kg)	Plate waste (kg)	Production waste (kg)	Serving waste (kg)	food waste total (kg)
DE1	02.05.2022	dish 1	veggie line	700	633					0
DE1	02.05.2022	dish 2	menu line 1	500	538					0
DE1	02.05.2022	dish 3	menu line	700	815					0
DE1	02.05.2022	dish 4	daily special offer	200	205					0
DE1	02.05.2022	Buffet			495					0
DE1	02.05.2022					160,9	47,8	8,6	34	90,4
DE1	03.05.2022	dish 5	veggie line	800	622					0
DE1	03.05.2022	dish 6	menu line 1	600	625					0
DE1	03.05.2022	dish 7	menu line	750	1039					0
DE1	03.05.2022	dish 8	daily special offer	400	435					0
DE1	03.05.2022	Buffet			550					0
DE1	03.05.2022					88,55	70	2,6	37,6	110,2
DE1	04.05.2022	dish 8	veggie line	400	484					0
DE1	04.05.2022	dish 9	menu line 1	500	786					0
DE1	04.05.2022	dish 10	menu line	800	878					0
DE1	04.05.2022	dish 11	daily special offer	400	355					0
DE1	04.05.2022	Buffet			524					0
DE1	04.05.2022					175,57	54,2	12,2	61,4	127,8
DE1	05.05.2022	dish 11	veggie line	500	549					0
DE1	05.05.2022	dish 12	menu line 1	450	413					0
DE1	05.05.2022	dish 13	menu line	800	1073					0
DE1	05.05.2022	dish 14	daily special offer	450	681					0
DE1	05.05.2022	Buffet			489					0
DE1	05.05.2022					108,2	57,2	12,8	31,2	101,2
DE1	06.05.2022	dish 15	veggie line	300	251					0
DE1	06.05.2022	dish 16	menu line 1	400	351					0
DE1	06.05.2022	dish 17	menu line	600	686					0
DE1	06.05.2022	dish 18	daily special offer	300	329					0
DE1	06.05.2022	Buffet			409					0
DE1	06.05.2022					138,2	58	6,2	60	124,2

Annex 1: Example of excel list used for waste measurement