Defining Dashboards

The degree to which guidelines for designing different dashboard types in a business context are applicable in a non-business context

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Preface

I came to the Technological University of Delft for my master programme with the ideology that computer science could be used to help make the world a better place. Specifically, during my bachelors in Amsterdam, I had become intrigued by the idea that computer models & data science could be used to help decision-makers in the sector of humanitarian aid. The master programme of Engineering and Policy Analysis offered me the opportunity to strengthen my computer science skills and learn more about the world of policy- and decision-making. While taking courses I often did not realize the valuable skills I was learning, until my master thesis required me to apply everything I had previously learned. From interview skills to programming experience, from problem analysis trees to the always re-occurring slogan of *'it depends'*: the program taught me the skills and knowledge to see common patterns in complex problems, no matter the context I found myself in.

My favourite word in the English language is 'Serendipity', which means "a lucky coincidence". This word describes perfectly how I found my thesis project. After reaching out to a former fellow master student, I was connected to Marijn Markus at Capgemini. Our shared interest in both computer science and humanitarian aid quickly got us both talking enthusiastically, and with his involvement at Project ENHANCE I was able to join the perfect organisation for my research interests. I would like to thank everyone involved at Project ENHANCE for their assistance in helping me understand the organisation's ambition and offering their wonderful insights on how to reach that ambition. I specifically would like to thank Marijn Markus for his great guidance during my research and promise to never ever ever ever spill tea over my laptop again. Ever.

In addition to the people at Project ENHANCE, I would like to thank my supervisors from the TU Delft: Marijn Janssen, Ricardo Matheus and Jan Anne Annema. They found the perfect balance between offering concrete enough feedback to help me further whenever I got stuck and letting me find my own way during this process. Most importantly, they were always firm in their insistence on when, and most importantly when not, thesis should come before other aspects in life. For that I am most grateful.

I never thought my master thesis would be an easy process, knowing that with my ADHD I do better in already well-structured plans and working with other people as opposed to on my own. The corona pandemic definitely made this thesis process feel even more like a lone quest, so I want to thank everyone who made me feel like I wasn't alone during this period. To all these wonderful people who listened to my enthusiastic scattered rambles, or made me tea to carry on when I lost my motivation: you guys are awesome. Every single one of you deserves a much bigger thank-you than I can put on paper, so I will use the words of the amazing Leslie Knope:

"No One Achieves Anything Alone"

Martine Keulen
Delft, 14/06/2021

Executive Summary

Due to their usefulness on guiding decisions, data dashboards have been introduced in many day-to-day processes from sales strategies to the corona pandemic response. Having data available in an easy-to-understand format in a dashboard, is assumed to lead to better decisions on how to tackle critical issues. Designing a dashboard requires making trade-offs on many different aspects, such as level of detail versus information processing capacity. Academic research on guidelines to design dashboards so that they meet their intended purpose is lacking. Filling this research gap may help practice in designing improved dashboards.

The most commonly used principle in dashboard design is that different kinds of users will have different purposes for using dashboards and that these purposes will influence what design principles works best for a dashboard. There is hardly any literature with empirical evidence to support this principle, but it is commonly claimed and was made famous by two researchers independently of each other in the early 2000's: Few and Eckerson. Based on the dashboard's purpose they defined four different types of dashboards, with recommendations on what design works best for each type. These four types of dashboards still dominate recommendations on dashboard design nowadays, however these types have been defined in a business context only.

Business and non-business contexts differ in many different aspects: in terms of accountability, type of decisions made, how stakeholders are involved, and orientation on profit versus people. These differences may require different dashboards and thus different dashboard designs. However, there has been hardly any research on the difference between dashboards used in a business context versus in a non-business context. Even more specific, there has been no research on whether the four types of dashboards commonly used in business can be found in non-business context and whether the same dashboard design principles then apply. This makes it challenging for dashboard designers in a non-business setting to know which design recommendations from a business context can be applied to their dashboards.

The organisation Project ENHANCE encountered this challenge of limited recommendations for dashboard design in non-business context during the early phase of their dashboard development process. Project ENHANCE is collaboration between four different organisations, who together want to create a dashboard to be used in the non-business side of the food system. Each organisation, however, has a different perspective on the purpose of this dashboard, making the creation of a dashboard design even more complex. For this thesis, a case study was conducted for Project ENHANCE, to serve as a starting point for their dashboard design. As there are mainly four types of dashboards discussed in business context, the suitability of these types is explored for Project ENHANCE in this research.

This thesis thus presents the research on developing a suitable dashboard for Project ENHANCE following the guidelines from Few and Eckerson, and the recommendations that follow from this process for dashboard design in a non-business context. The main research question is phrased as:
To what degree can the guidelines from Few and Eckerson for designing different dashboard types in a business-context be applied to a non-business context?

With the following sub questions:
SQ1. What guidelines exist on designing dashboards in a business and non-business context?
SQ2. What user requirements does Project ENHANCE have for their dashboard?
SQ3. How do the user requirements from Project ENHANCE match the dashboard types defined by Few and Eckerson?
SQ4. How do representatives from Project ENHANCE evaluate the different types of dashboards?

Research Approach

As dashboards are very context dependent, it was decided to not let Project ENHANCE only evaluate already existing dashboards from other contexts, but also have them evaluate custom made dashboards for a more accurate evaluation. For the custom-made dashboards the research methodology framework chosen for this thesis is the Action Design Research (ADR) methodology, which combines the development of an IT artefact (Design Research) and the use of the IT artefact for organisational action (Action Research). This framework was chosen as ADR recognizes the importance of context evaluation of an IT artefact, similar to how dashboard design principles recognize the importance of tailoring a dashboard for its context

As artefact it was chosen not to build a completely functional dashboard, but rather mock-up dashboards, due to time limitations. A mock-up dashboard is not quite yet a prototype dashboard, it is a conceptual visual design of a dashboard, which does not yet need to be fully functional. User requirements for the mock-ups were collected during individual interviews with 11 representatives from Project ENHANCE. Interviewees were selected following recommendations from Project ENHANCE and to ensure a diverse group in terms of organisation and role. The 65 user requirements listed during the interviews did not present a united view on what the purpose of the dashboard from Project ENHANCE should be. The user requirements and varying responses on expected purpose of their dashboard, were attempted to be matched to the four archetypes of dashboards. Not all user requirements and purposes mentioned could be matched to the archetypes. From this matching process four distinct mock-up designs matching the archetypes were created.

Two mock-up dashboards were developed in Python, using the Dash library. These mock-ups represented the Analytical and Strategic type, as defined by Few and Eckerson. The Operational and Tactical type were not developed, as each mock-up required unique data and for these types there was limited data availability. The mock-ups were evaluated by 9 representatives from Project ENHANCE, who explored the mock-ups without guidance. Subsequently, the nine testers filled in a survey evaluating individual aspects of each dashboard and ranking the dashboards against each other on several aspects. This was done to research how well these archetypes of dashboards were suitable for Project ENHANCE. An explorative analysis of the respondents scores and textual comments was conducted to gain a deeper understanding of the respondents reasoning behind their evaluations.

The results of the evaluation of the custom-made mock-ups were supplemented with the results of the rankings of already existing OTSA dashboards by Project ENHANCE representatives. This ranking was conducted during the user requirements interviews.

Findings

In the literature research on other guidelines for dashboard design it was discovered that dashboards are used for more purposes than the four purposes defined by Few and Eckerson. This notion was repeated in the user requirements interviews on the expected purpose of the dashboard of Project ENHANCE. The most commonly listed purpose in the interviews could be aligned with the purpose of the Analytical dashboard archetype. However, the abstract phrased purpose of 'advocacy', which was frequently given by respondents, did not match any of the four major dashboards archetypes.

Figure 1: Screenshots of the Custom-Made Mock-Up Dashboards

In the exploratory analysis of the survey results, the two custom-made mock-up dashboards were evaluated by the respondents with exactly the same average overall score. When asked to choose between the two dashboards, the Analytical mock-up was preferred by a majority of the respondents on 4 out of 5 aspects. Their main reasoning for this preference was that they found the Analytical mock-up to contain richer information and that they appreciated the additional detailed information they could see in pop-ups. Furthermore, the comments of respondents indicated they liked the interactive functionalities of the dashboard, especially the sliders section. Overall, most of the respondents noted that the Analytical dashboard was easy to use and understand, whereas they did not always understand the Strategic one.

Based on business context literature findings, the Strategic mock-up was expected to be received more favourably, but this was not the case. The majority of the respondents did prefer the visualisations of the Strategic mock-up, commenting that the graphs were easier to understand in that mock-up and criticizing the complexity of the visualisations in the Analytical dashboard. Additionally, it was noted by several respondents that familiarity with the work of Project ENHANCE would be essential for external users to understand the Analytical mock-up.

Furthermore, when presented with four example dashboards, each of a different archetype, 7 of the 11 interviewees noted that they thought a mix of two or more archetype dashboards would be the most suitable for them. The reasoning for this was that interviewee's thought each type would be suitable for a different user group. By combining archetype dashboards, the final dashboard would be suitable for different groups of users.

Discussion
The discussion focusses on potential reasons why the Analytical mock-up was received more favourably than expected. The following reasons were gathered from the interviews and survey comments:
- The aim of Project ENHANCE, as stated at the beginning of the case study, is to create a kind of analytical dashboard. Therefore, even though the mock-up would not be suitable for respondents personally, respondents still (unconsciously) kept this aim in mind while evaluating the mock-ups.
- The Analytical mock-up was relatively easy to understand, as it had been developed from a very basic design. The mock-up thus did not accurately represent its archetype: it was easier to understand than Analytical dashboards usually are.

- The respondents who evaluated the dashboards were not representative for the expected end-users. Analysts were overrepresented in the response group and other respondents were already very familiar with the work of Project ENHANCE. Meanwhile, the expected end-users would be neither analysts nor overly unfamiliar with the work of Project ENHANCE, making it more difficult for them to understand the Analytical dashboard.

As dashboards are very context-dependent, it is difficult to generalize the results of this study to a broader context or to argue how representative the research was. For future research, the following topics are thus suggested: 1. Expand the research for Project ENHANCE by evaluating other types of mock-ups or iterating over the current types. 2. Conduct the same research in different non-business contexts to see whether observations can be reproduced. 3. Conduct more general research on the effects of using dashboards as these effects could provide valuable insights on what designs are effective.

Conclusion

In conclusion, this case study shows that the guidelines from Few and Eckerson for designing different dashboard types could only be partly applied to the non-business context of Project ENHANCE. This is due to the fact that Project ENHANCE largely aims for a different purpose of their dashboard than recognized by Few and Eckerson, as was discovered during the user requirements interviews. Furthermore, Few and Eckerson make no distinction between dashboards for internal audiences or external audiences, whereas comments in the evaluation survey demonstrated that this distinction can greatly influence dashboard design.

A new type of dashboard is proposed based on the conducted research: the Communication & Learning dashboard. This dashboard type does not offer decision-making support like the ones defined by Few and Eckerson, but presents data to educate or inform the users. The users would be part of an external audience: either the general public or a specific group which is not part of the dashboard's main organisation. This new type of dashboard can be seen as a combination between the Analytical and Strategic dashboard: it focusses on exploring data, but presents this data in an easy-to-understand visualisation like in the Strategic dashboard. From the survey evaluation results three design principles for the communication & learning dashboard are established: 1. Provide a lot of context with the data in the dashboard to meet the audience domain knowledge level. 2. Bear in mind the frequency of use by external users while designing the dashboard. 3. Include simple yet attractive visualisations to make the dashboard easy and enticing to use.

Recommendations for Dashboard Designers and Project ENHANCE

Several recommendations for dashboard designers in general and Project ENHANCE in particular can be made based on the findings of this research. When designing a dashboard, it is recommended to choose a single simple purpose for the dashboard to ensure the dashboard will be able to meet that purpose. Having multiple purposes can cause conflicting design principles. Furthermore, other purposes for using dashboards than the ones defined by Few and Eckerson should be considered as nowadays dashboards can be used for other purposes.

For Project ENHANCE, these recommendations are all essential to be applied in the further development of their dashboard. First, the realization that one dashboard can't be everything to everyone should be discussed among its member organisations as there is not yet a common agreement on the purpose and users of their dashboard. Secondly, Project ENHANCE should include communication and learning as an important factor in the formulation of the purpose of the dashboard, as these aspects were frequently mentioned in the interviews. These purposes would require a different kind of dashboard design than has been previously created, as they are not recognized by Few and Eckerson. Most importantly, the member organisations of Project ENHANCE need to agree on whether the dashboard(s) should be designed for internal or external audiences as this will greatly influence their design.

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"If the information is important, it deserves to be communicated well." – Stephen Few

1. Introduction

1.1. Research Problem Statement

Without a dashboard in the car, a driver would have no information on the internal processes of the vehicle to guide their actions. Decisions to slow down to stay under the speed limit, stop at the gas station or pull over to check the tire pressure, would have to be based on external stimuli and intuition. Due to their usefulness on guiding decisions, dashboards have been introduced in many day-to-day processes from sales strategies to the corona pandemic response. Having data available in an easy-to-understand format in a dashboard, is assumed to lead to better decisions on how to tackle critical issues. Designing a dashboard requires making trade-offs on many different aspects. For instance, providing more detailed data can help with more in-depth analyses, but can make the dashboard more difficult to understand. However, academic research on guidelines to design dashboards so that they meet their intended purpose is lacking.

1.2. Research Gap & Research Objective

For a business context there are guidelines on which situations best suit different types of dashboards to tackle different issues. Most literature in the field of Business Intelligence uses the categorization made popular by Few and Eckerson in the early 2000's. Independently of each other, they defined four different types of dashboards called Operational, Tactical, Strategic and Analytical (OTSA) (Eckerson, 2006; Few, 2006). The suitability of each of these dashboards is dependent on the kind of user and purpose of the dashboard. For each type Few and Eckerson made recommendations on what design works best. These four types of dashboards still dominate recommendations on dashboard design nowadays. However, these four types of dashboards have been defined in a business context only. Business and non-business contexts differ in many different aspects: in terms of accountability, type of decisions made, how stakeholders are involved, and orientation on profit versus people. These differences may require different dashboards and thus different dashboard designs. However, there has been hardly any research on the difference between dashboards used in a business context versus in a non-business context. Even more specific, there has been no research on whether the four types of dashboards commonly used in business can be found in non-business context and whether the same dashboard design principles then apply. Simply put: the type of dashboard which would be best suited in a business context may not be the most suited type in another context, even if the kind of user and purpose are similar. This makes it challenging for dashboard designers in a non-business setting to know which design recommendations from a business context can be applied to their dashboards. It could be those other types of dashboards, outside of the commonly used OTSA dashboards, be even more suited in a non-business context, but there is limited research on this topic. The objective of this thesis is thus to find or create guidelines for designing dashboards in a non-business context so that the dashboards can meet their intended purpose.

1.3. Research Approach & Research Questions

A single case study was conducted for the organisation Project ENHANCE. Project ENHANCE is a collaboration between the World Food Programme (WFP), the Center for Liveable Future at John Hopkins University (JHU), the Zero Hunger Lab at Tilburg University (ZHL) and the software consultancy company Capgemini. The objective of the organisation is to create a dashboard which can be used by the WFP in collaboration with local governments and organisations to improve their policy-making in the food system. The food system is the system in which all aspects of food come together: environment, people, inputs, processes, infrastructures, institutions (HLPE, 2017).

The different organisations in Project ENHANCE all have their own area of expertise and different ideas on what the envisioned dashboard should look like and be used for. As Project ENHANCE has only recently taken off, the design of the dashboard is still in the early conceptual phase. This makes the results of this study valuable for them to serve as a starting point for their dashboard design. As there are mainly four types of dashboards discussed in business context, the suitability of these types was explored for Project ENHANCE.

As dashboards are very context dependent, it was decided to not only let Project ENHANCE evaluate already existing dashboards from other contexts, but also have them evaluate custom made dashboards for a more accurate evaluation. Prototype dashboards were created and tested to see which one was chosen to be the most suitable. A prototype dashboard (henceforth referred to as a mock-up to prevent confusion with 'type of dashboard') is a conceptual design of the envisioned dashboard. Each mock-up created was a different type of dashboard, as defined by Few and Eckerson.
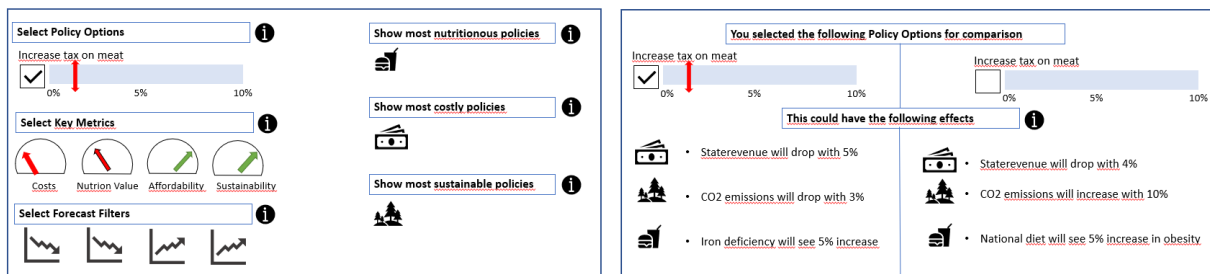
Figure 2: Examples of Mock-Up Dashboards

For the creation of the mock-up dashboards, first information on the intended users of the dashboards and their user requirements for the dashboard had to be collected. These user requirements could then be matched against each of the OTSA dashboard types, so that distinct dashboard designs could be made. These mock-up dashboards were then evaluated by representatives of Project ENHANCE. The results from these evaluations will serve as recommendations for Project ENHANCE and dashboard designers in a non-business context.

This research approach leads to the following main research question:
RQ: To what degree can the guidelines from Few and Eckerson for designing different dashboard types in a business-context be applied to a non-business context?

With the following sub questions:
SQ1. *What guidelines exist on designing dashboards in a business and non-business context?*
SQ2. *What user requirements does Project ENHANCE have for their dashboard?*
SQ3. *How do the user requirements from Project ENHANCE match the dashboard types defined by Few and Eckerson?*
SQ4. *How do representatives from Project ENHANCE evaluate the different types of dashboards?*

1.4. Research Relevance

1.4.1. Societal Relevance

A non-business context can be a public organisation or branch of government, where the primarily goal of the organisation is not to make profit. The societal relevance is in the many different contexts where dashboards are being used or may be introduced, from health care to pandemic regulations. The decisions made in these organisations greatly influence society and dashboards are increasingly being introduced in these organisations. In the context of the non-business side of the food system data availability is recognized as a major issue within this field, for which introducing dashboards could potentially be beneficial (International Food Policy Research Institute (IFPRI), 2016). However, in the most important papers on food systems issues dashboards are not even mentioned by name (Interagency Committee on Human Nutrition Research, 2016; UNICEF, 2019). With this lack of guidance on how dashboards should be designed in this context, the problem of insufficient data availability remains a hinderance in creating a better food system.

1.4.2. Academic Relevance

The expected outcome of this research is an indication on how applicable the guidelines for designing different types of dashboards in a business context are for a non-business context within the food system. These findings will make a novel academic contribution to academic research as there has been no research yet on the application of the guidelines for dashboard design by Few and Eckerson in a non-business context.

1.4.3. MSc Engineering & Policy Analysis

The grand challenge of providing enough food to all people on the planet is one that involves many more large and small challenges. However, the one challenge which influences all aspects of producing the right amount of food and ensuring it is at the right place at the right time, is ensuring the actors involved in decisions on these aspects have the necessary information available to best make these decisions. Thus, the challenge of ensuring policy-makers, involved in the national and emergency diets of the world, have access to the right information to best support their decision-making process is most essential. An advice on how they can shape this information in a dashboard may be a first step towards a more evidence-supported decision-making process in the food-system.

1.5. Thesis Structure

In the following chapters the main research question and sub-questions are answered. First a literature review on dashboards and guidelines for designing dashboards is presented in chapter 2 to answer sub-question 2. This is followed by an explanation of the used methodologies in chapter 3. The consequent chapters show the results of these described methods: The user requirements of the dashboard to answer sub-question 3, the design & development of the mock-ups, and the evaluations results of the survey to answer sub-question 4, in chapter 4, 5 and 6 respectively. These chapters are followed by a discussion on the research conducted in chapter 7 and a conclusion to the research questions in chapter 8. The final chapter 9 contains the recommendations made to dashboard designers in general and Project ENHANCE specifically.

"If we have data, let's look at data. If all we have are opinions, let's go with mine." – *Jim Barksdale*

2. Literature Review

In the following chapter the findings of the literature review are presented. The first section describes the approach and reasoning behind this review. This is followed by a section where the term dashboard and its general characteristics are defined to create a shared understanding of the concept. The next two sections discuss the guidelines for designing dashboards in a business context and in a non-business context respectively. At the end of this chapter the findings of the literature review are summarised in a conclusion section.

2.1. Literature Review Approach

This literature review was conducted to answer sub question SQ1: *What guidelines exist on designing dashboards in a business and non-business context?* For this purpose, information on the following topics was sought:

- The exact definition of a dashboard and which characteristics make up a dashboard. This was done to ensure a thorough understanding of the term 'dashboard' and its characteristics while researching the guidelines for designing dashboards.
- Guidelines on designing dashboards in a business context. Within the business context specifically the guidelines created by Few and Eckerson were explored in more detail. Additionally, alternatives guidelines were researched to see if these would be more applicable to a non-business context.
- Guidelines on designing dashboards in a non-business context. First it was researched whether the guidelines of Few and Eckerson had or could in some way be applied in a non-business context. Alternative design guidelines were also studied and as the area of the case study for Project ENHANCE is in the food system, specific attention was paid to relevant information for designing dashboards in the food system.

While researching these guidelines, not all aspects of designing a dashboard were explored. The main focus of this thesis is to look for design guidelines which help dashboards meet their intended purpose. This means that detailed visualisation aspects such as colour selection or text styles were left out of the review. For each of the two contexts it was researched for what purpose dashboards are used within that context and which guideline exists to design dashboards to meet those purposes.

Relevant academic research for this literature review was very limited. Yigitbasioglu & Velcu provide a more detailed description of this limited scope of scientific literature in their review on dashboards in business context (Yigitbasioglu and Velcu, 2012). Generally speaking, most academic sources describe the different motivations to use dashboards, stages of implementing a dashboard, or serve as a case study report on a specific dashboard. These case study reports however, usually do not include an evaluation of their dashboard or fail to address which of their findings can be generalized. Even the popular design guidelines defined by Few and Eckerson are not based on academic research, but on their experience as dashboard builders. Textbooks, online webpages, organisational reports, and other kinds of non-academic sources were thus used for this literature review to provide additional information. Although these sources may not be as reliable as academic sources, they provide valuable insights from experienced dashboard users and/or developers.

2.2. General Dashboard Definitions and Characteristics

The term 'dashboard' is used across all kinds of sources to describe many different displays of data, which makes it difficult to understand what exactly defines as a dashboard (Sarikaya *et al.*, 2019). To set a baseline for this thesis, a data dashboard, generally simply referred to as 'a dashboard', is defined as **a type of visualisation interface where data is displayed**. This visualisation interface can take many different forms, from single screen online visualisations to static reports. Ganapati defines a dashboard as capable of being either static or dynamic (Ganapati, 2009). A dynamic dashboard contains *interactive elements*, which are generally recommended for allowing the user to engage with the data and to tailor it to their own preferences (Matheus, Janssen and Maheshwari, 2020). A static visualisation display is an unchangeable snapshot of data and can generally be found in reports or briefings.

A dashboard is made up of multiple components, which are briefly described below. **The data in dashboards** is typically complex data which is drawn from multiple different sources (Bartlett and Tkacz, 2017). Data can be presented '*raw*', which means it has not been transformed in any way. Data can also be presented '*edited*', which means the original raw data has been aggregated or transformed in some other way. Data in a dashboard is sometimes a '*Key Performance Indicator*' (KPI), which is a metric that reflects a target of an organisation (Eckerson, 2006).

The design of a dashboard encompasses many different aspects. Li differentiates these aspects in two different categories: functional and visual features (Li, 2019). The *functional features* are the features of the dashboard which cover the data presentation, interaction features and other non-visual aspects. These functional features are according to Li, dependent on the purpose of the dashboard, the task the user wants to do with the dashboard, and the knowledge and personality of the user. *Visual features* refer to visual aspects of the dashboard such as colour and layout. According to Li, these can universally be guided by certain design principles, without being customized for each dashboard.

Nadj et al. define **the purpose of a dashboard** as a type of *Decision Support System* (DSS), as a DSS can be a tool to support decision makers in making decisions in complex situations (Nadj, Maedche and Schieder, 2020). However other sources state that a dashboard can have alternative purposes than to serve as a DSS. All of these possible dashboard purposes are discussed in more detail in the following sections.

2.3. Guidelines for Designing Dashboards in a Business Context

2.3.1. Guidelines from Few and Eckerson

The different types of dashboards used in a business context are generally categorized in the same fashion: based on their purpose. This classification recognizes four different types of dashboards and is widespread across the internet in sources on how to design dashboards in a business context (Tamhankar, 2019; Durcevic, 2020). This categorization was made popular by two researchers independently of each other: Few and Eckerson. Below a short description is given of how each researcher defined these types of dashboards and the design recommendations they made for these types. Following this description an overview of the four types of dashboards is presented in *Table 1* and for each type an example image is provided.

In the early 2000's Stephen Few, an experienced dashboard designer and consultant, combined his years of experience designing dashboards in the book 'Dashboard Design: The effective visual communication of data' (Few, 2006). In the book he offers several general design principles for small details of dashboards, such as limiting the dashboard to a single screen or how data should be arranged. The starting point of a dashboard design however, he argues, should be by looking at the purpose the dashboard will have. The purpose of a dashboard is the largest influencing factor on its design. He categorizes dashboards into different types based on their purpose and explains how for each type a different design is most suitable. The purposes dashboards are used for in business context are defined by Few as Operational, Strategic and Analytical.

The Operational Dashboard is defined by Few as being generally used for monitoring data in real-time. It allows supervisors to know the current status of a metric and visualizes the daily updates of operations. Generally, these dashboards focus on a short timeframe of operations. Users of these dashboards are generally operational level employees, tasked with day-to-day decisions within one department. As operational monitors must be able to quickly see if something is going wrong, a very simple design is required. Unique to the operational visual design is that anything that is wrong must immediately grab the attention of the user. For this, Few recommends the use of evaluative indicators which show in which range a metric is.

The Strategic Dashboard is used to show data essential for making decisions on the strategy of the business. In these dashboards the KPI's are generally tracked over a long timeframe. This dashboard is generally used by decision-makers on high levels within the operation, generally referred to as executive management. The data must be supplemented with contextual information, so that users can identify whether for example targets are met. Few argues that managers will not want to spend much time in the dashboard, so it must provide a quick and easy to understand overview without any required interaction.

The Analytical Dashboard is used to analyse data to find and explain trends. Users of these dashboards are usually business analysists, who should be very familiar with the context of the data to be able to observe and most importantly explain data trends. This dashboard requires a high level of interactive features so that the data can be explored. Furthermore, Few explains that the complexity of the data in this dashboard will usually require more complex data visualisations.

Based on the purpose of a dashboard, Eckerson also created a classification of three types of dashboards in the early 2000's in his report: Deploying Dashboards and Scorecards (Eckerson, 2006). Eckerson used his experience within business intelligence to create a report on the best practices for designing dashboards. Although Eckerson and Few do not comment on each other's work in their respective book and report, their classifications of dashboard types can be synergized. Eckerson defines three types of dashboards based on their purpose: Operational, Tactical and Strategic. The Operational and Strategic dashboard as defined by Eckerson correspond to the same types as defined by Few, as Eckerson defines the main purpose for an Operational dashboard as monitoring operational processes and the purpose of a Strategic dashboard as communicating strategy within an organisation.

The Tactical Dashboard, however, is defined by Eckerson as a dashboard most suited for mid-level managers. It showcases both trends, strengths and weaknesses across multiple departments. The purpose of a tactical dashboard is to optimize processes. The timeframe of the data is of a longer period than the Operational dashboard, but of a shorter timeframe than the Strategic dashboard. Eckerson, unlike Few, does not give any design principles for the dashboard he defines. Many web-based sources on dashboard design however give recommendations on its design (Durcevic, 2019, 2020). The Tactical dashboard requires data to be more aggregated than the Operational dashboard in simple graphic visualisations. Furthermore, the dashboard requires a level of interactivity so that managers can investigate key factors in process optimization.

The following table of dashboard types in business context was created based on research by Few and Eckerson (Eckerson, 2006; Few, 2006). Their research was supplemented with descriptions of these dashboards found in dashboard design blogs (Durcevic, 2020).

	Operational	*Tactical*	*Strategic*	*Analytical*
Main Users	Operational Staff	Managers	Executives	Business Analysts
Level of Seniority	Junior	Middle	Senior	Middle
Purpose	Operational Control	Process Optimization	Strategy Management	Business Analyses
Information	Details	Detailed Summary	Summary	Raw Data
Metrics & KPI's	Drivers	Drivers and Outcomes	Outcomes	Raw Data
Scope	Department	Multiple Departments	Organisation	Variable
Updates	Hourly /Daily	Daily / Weekly	Quarter / Monthly	Variable
Time Period	Routine	Medium-Term	Long-Term	Medium-Term
Time Focus	Past	Current	Future	Variable
Visualisation & Interaction	Simple display of data, immediate action clear	Simple graphical visualisations, supports interactions	Simple aggregated graphical visualisations without interaction	Support interactions with data, Complex displays

Table 1: Table of Characteristics of Dashboard Types

The following images were all selected to represent their dashboard type and were gathered from various online sources (Klipfolio, no date; Durcevic, 2020).

(a) Operational Dashboard

(b) Tactical Dashboard

(c) Strategic Dashboard
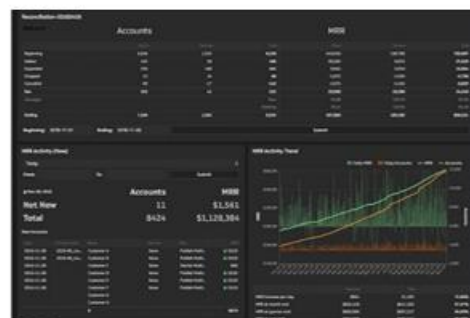
(d) Analytical Dashboard

Figure 3: Example Dashboards of the OTSA Dashboard Types

2.3.2. Alternative guidelines for designing dashboards in business context

Besides Few and Eckerson, two other academic sources were found which present somewhat alternative guidelines for designing dashboards in a business context based on their purpose.

Yigitbasioglu & Velcu define four other purposes for dashboards in their review on dashboards in businesses. These purposes are Performance Monitoring, Performance Monitoring Consistency (Analysis), Communication, and Planning (Yigitbasioglu and Velcu, 2012). These purposes correspond to some degree to the ones identified by Few and Eckerson, however Yigitbasioglu & Velcu do not go as far to say that each of these distinct purposes leads to a different 'type' of dashboard. Furthermore, they nor do give guidelines on how their categorization lead to specific design principles like Few nor do they make any mention of dashboards in a non-business context.

Staron et al. created a dashboard selection model for the business context of the Volvo Car Group and used seven different axes to categorize dashboards on (Staron, Niesel and Meding, 2015). These axes are: type of reporting, data acquisition method, type of stakeholders, method of delivery, frequency of updates, aim of the information, and length of the data processing flow (*see figure below*). They then used this model to match user's preference for dashboards against different dashboards. Staron et al however also make no mention of how their categorization can lead to finding appropriate design principles. Nevertheless, they also identify another purpose for dashboards on the axis of aim. This axis ranges from providing Information to providing Decision Support. Decision Support is recognized by Few and Eckerson as an underlying purpose of Operational, Tactical and Strategic dashboards. However, they do not explicitly mention providing Information as a purpose of dashboards.

Figure 4: The Dashboard Selection Model (Staron, Niesel and Meding, 2015)

2.4. Guidelines for Designing Dashboards in a Non-Business Context

2.4.1. Alternative guidelines for designing dashboards in a non-business context

No source could be found in which explicitly the guidelines of Few and Eckerson were discussed for their suitability in a non-business context. Even more so, it was difficult to find any general guidelines on designing dashboards in non-business context. As some sources did not explicitly differentiate between business and non-business context, the relevant findings of those sources are discussed below.

First, the question whether a dashboard is actually needed should be asked according to panel discussions at the Technology Salon, summarised in a blog by Linda Raftree (Raftree, 2015). This notion is echoed in research by Bartlett & Tkacz in their work on dashboards in governance. They state that dashboards are not inherently the best suited tool for each problem or question (Bartlett and Tkacz, 2017). Furthermore, the critical role of the users in the dashboard design process is highlighted across multiple sources (Raftree, 2015; Bartlett and Tkacz, 2017; Matheus, Janssen and Maheshwari, 2020). This role goes beyond simply stating their preference for dashboard display type 1 of type 2, but actively including user requirements from the beginning of the design process. Additionally, the intended use of the dashboard, user's knowledge of the organisation and user's resources are all important aspects to consider when creating a dashboard. Matheus et al. adds to this by stating the importance of customized views of dashboards for user groups for gaining insights (Matheus, Janssen and Maheshwari, 2020).

More recently Sarikaya et al. looked at the broad scope of dashboards examples publicly available and created a new type of classification of dashboards in both business and non-business context (Sarikaya *et al.*, 2019). They identified 15 distinguishing factors in 4 different categories, ultimately characterizing 7 different clusters of dashboards. Although the previously discussed types of Strategic, Tactical and Operational are recognized as purposes of dashboards, they dismiss the analytical type and instead introduce the Motivation & Learning type of dashboard. This type of dashboard is defined as not soliciting decision-making on any temporal scale and in their identification these dashboards are always used to provide communication to the public.

Goal	Cluster	# Examples	Purpose				Audience			Visual Features					Data Semantics		
			Strategic	Tactical	Operational	Learning	Audience	Vis Literacy	Domain Expertise	Construction	Interactivity	Modify Data/World	Highlighting	Multipage	Alerting+Notification	Benchmarks	Updateable
Decision-Making	1 Strategic Decision-Making	16	Y	Y	-	N	O	-	-	-	Y	N	N	Y	-	-	Y
	5 Operational Decision-Making	14	N	Y	Y	N	O	-	-	-	Y	N	N	Y	-	Y	Y
Awareness	3 Static Operational	10	N	N	Y	N	O	L	-	-	-	N	N	N	-	Y	Y
	4 Static Organizational	8	-	-	N	N	O	M	-	N	N	N	-	N	N	-	Y
Motivation and Learning	2 Quantified Self	7	N	N	Y	N	I	H	N	N	Y	N	-	Y	-	-	Y
	6 Communication	13	-	-	-	Y	P	M	N	N	-	N	-	-	N	N	Y
	7 Dashboards Evolved	15	-	-	-	-	P	H	-	-	-	-	-	-	-	-	Y

Table 1: The dominant characteristics observed for each cluster of coded dashboards. A factor is considered dominant if it occurs at least 50% over the prior probability, otherwise it is marked with a dash (-). **Y** indicates present or supported, **N** entails the opposite. **P** identifies the general public, **O** represents organizational audiences, while **I** indicates dashboards designed for individual consumption. **L**, **M**, and **H** indicate low, medium, and high visualization literacy required to understand the dashboard, respectively.

Figure 5: The Classification of Dashboard Types (Sarikaya et al., 2019)

Sarikaya et al. also state the importance of the goal of the dashboard as the driving factor for the visual design and functional features, which can be seen in how this is the main distinction between the different clusters in the figure above. Although Sarikaya et al. use a different phrase, this appears to be the same kind of categorization as done by Few and Eckerson. Sarikaya et al. also recognize that design principles efficient for one type of dashboard, may not be efficient for another type of dashboard. However, they offer no recommendation on design principles for the types of dashboards they have studied, only observations on the visualisations that those dashboards had.

2.4.2. Guidelines for Designing Dashboards in the Food Systems

Although the search term "Food Systems Dashboard" yields around 52.000 results on Google Scholar, most papers refer to dashboards in a passing reference and not as a major topic. Further investigation found that asides from the term 'dashboard' several other terms are used to roughly describe the same, among others Decision-making Support Tool, Platform, Visualisation Tool. Yet even papers on these topics combined with the phrase 'food systems' yield few results which actually discuss the use of these objects in the food systems, let alone their development. Even in a report from the Global Panel on Agriculture and Food System for Nutrition on how improved metrics and data are essential for in the future, any of the terms used to refer to a dashboard (dashboard, visualisation, tool, platform) is missing (Webb, 2015).

The most relevant example of a dashboard in the food system which could be found, is presented by Fanzo et al. in their paper called 'The Food Systems Dashboard' (Fanzo *et al.*, 2020). The tool is designed to display data on global, regional and national food systems. The beta version of the dashboard was launched in June 2020 and it was created by a team from Johns Hopkins University, GAIN, Harvard University, the University of Michigan and Michigan State University, in collaboration with the iTech Mission organisation. The Food System Dashboard brings together data on over 140 indicators from many different sources. Additionally, the website behind the dashboard explains that the dashboard was

developed for a large group of users. This becomes clear in the design of the dashboard, which has an overwhelming number of data sources and limited guidance on how the dashboard can be used. So far only one instance could be found of an user of the dashboard evaluating its usefulness, and this was a researcher rather than a policy-maker (Duncombe, 2021).

Manorat et al. consider dashboards in the food system under the larger umbrella of data visualization tools (DVT's), which also includes scorecards, indices and profiles (Manorat, Becker and Flory, 2019). They found and analysed 22 DVTs and supplemented their analysis with a literature review of data visualisations. Although they do not make the distinction between dashboards and other data visualisation tools, their findings can be assumed to be applicable for dashboards. Their major criticism of the existing data visualisation tools in the nutrient field is the lack of purpose supporting these tools. Manorat et al. refer to this phenomenon as a 'built-it-and-they-will-come' approach and note that this approach does not seem to work. *"DVTs with a focused theory of change seem more poised to achieve their goals based on our initial consultations." – (Manorat, Becker and Flory, 2019).*Their main recommendations to those developing DVTs are to have a clear theory of change about the key decisions and users of the DVT, including more actionable indicators and ensuring the DVT's format aligns with the user's requirements.

2.5. Conclusion on literature review

The term dashboard is used to describe many different data visualisation formats across all kind of sources, but the topic of dashboards in general is very limitedly discussed in academic sources. Guidelines on designing dashboards in a business context, mostly follow the categorization of four types of dashboards made popular by Few and Eckerson. They identified Operational, Tactical, Strategic and Analytical type of dashboards and offer distinct design guidelines for each type of dashboards. Alternative guidelines for designing dashboards in a business context are difficult to find, as other papers do recognize other possible purposes of dashboards but offer no design guidelines for those type of dashboards. There has been no research conducted in which the OTSA dashboard types have been discussed in a non-business context. General research on dashboards in a non-business context as a whole is very limited, even more so on design guidelines. A most recent study on the subject identifies another possible purpose for dashboards of learning and communication, but offers no guidelines on the design that would suit this purpose. Guidelines for designing dashboards in the Food System remain elusive, but the importance of aligning the format of the dashboard with the user requirements in given as an important recommendation.

In conclusion, limited academic research exists on guidelines for designing dashboards in a both business and non-business context. Research indicates that user requirements are important to take into consideration when designing dashboards and that the purpose of a dashboard greatly influences its design. Dashboards may have other purposes than the ones identified by Few and Eckerson. Ultimately, it has become evident from this literature review that it has not been researched whether the guidelines from Few and Eckerson for designing different dashboard types in a business-context can be applied to a non-business context.

"There is no such thing as information overload. There is only bad design." – Edward Tufte

3. Research Methodology

This chapter contains a detailed description of the chosen methodologies to investigate the dashboard design guidelines of Few and Eckerson in a non-business context. The literature review in chapter 2 has shown that there is limited academic research on this topic, so an exploratory research methodology was deemed necessary. First the reasoning behind the chosen case study of Project ENHANCE and the chosen framework of Active Design Research are presented. Then for each phase of the Active Design Research framework the used methods in that phase are described in more detail in the subsequent sections.

Although literature research has shown many aspects make up a successful dashboard such as implementation and company culture, for this thesis only the aspect of dashboard design was researched. This means that aspects such as ensuring the dashboard will be used by the proposed target group (an aspect of implementation) or which actors should be involved in setting-up the dashboard (an aspect of creation) were not extensively studied.

3.1. Case Study

As main research method for this thesis a qualitative research method was proposed: the case study. A case study is a detailed exploration of a particular case and is defined by Yin as a research approach which can be used as part of a larger evaluation to provide insights on a complex problem (Yin, 2003). The reason this method was chosen over for instance a literature focussed method is that the literature review in chapter 2 has shown that academic research on design guidelines for dashboards in a non-business context is limited. Therefore, a case study, as an exploratory research approach, was selected to be the most suitable method. Flyvbjerg highlights the context dependency of the case study as one of its major criticisms, but argues that this is also a great advantages as it allows for the creation of detailed expert knowledge (Flyvbjerg, 2006). No other case study has been conducted on this topic, so findings of other case studies cannot be used for comparison. Although a single case study may thus not be very suitable to research general dashboard design guidelines across the whole non-business context, it can serve as a detailed starting point to find guidelines which potentially could be generalized. Due to time limitations of this thesis only one case study was conducted instead of multiple.

The case study was conducted for Project ENHANCE, a collaborative organisation of four different institutions. The main objective of Project ENHANCE is to create a dashboard which can be used by actors and policy-makers in the food-system to improve their policy-making. Project ENHANCE thus qualifies as operating in a non-business context. Furthermore, as they are in the starting phase of creating their envisioned dashboard, design recommendations from this thesis will be useful for them as a starting point. A disadvantage of this chosen case study is that the chosen organisation has multiple differing views on the purpose and expected user of their dashboard. This makes it more difficult to generalize findings for the organisation as a whole. Nevertheless, the results of this thesis can be used by Project ENHANCE to launch a discussion in the organisation to better align their views.

The different organisations in Project ENHANCE all have their own area of expertise and different ideas on what the envisioned dashboard should look like and be used for. On the next page is a short description of each organisation in the project, based on information collected during several meetings with Project ENHANCE representatives.

❖ The World Food Programme (WFP) is the world's largest humanitarian agency with a presence in over 80 countries and a strong engagement with food systems. The Systems Analysis for Nutrition Team is the department of the WFP involved in Project ENHANCE. This team has over 4 years of experience in more than 30 countries focused on situation analysis, strong understanding and capacity to apply analytics for decision making by actors across food, social protection and health systems. For this purpose, they use the Cost of the Diet software, which optimizes for a given prize a constrained diet which can meet different nutritional requirements. The WFP has several Country Offices across the world, from which they work together with governments and NGO's. Their main goal for the dashboard is to ensure everyone will use the models they have created and gain insights from the analysis from it.

❖ The Zero Hunger Lab at Tilburg University (ZHL) is a research institution that has created the Cost of the Diet software used by the WFP. They have created multiple software solutions to contribute towards eradicating hunger. One of them, the multi-variate model Optimus, was created to optimize food supply chains. It's insights have contributed towards reducing operational costs of the World Food Programme in Iraq by 12%, without compromising on other important aspects such as nutritional value (Fleuren and Heijne, 2020). The ZHL want to see a dashboard which will make people follow the recommendations from their software models.

❖ The Center for a Liveable Future at John Hopkins University (JHU) is an interdisciplinary academic center dedicated to building healthy, just, equitable, and sustainable food systems that function within planetary boundaries. They not only prioritize science and research, but also the translation of scientific evidence into informed policy development and action for change. They are focussed on the policy side of the story where they look at how to make the models of the ZHL understandable for all policy-makers. They want to see a dashboard with clear actionable advice in it.

❖ The fourth organisation Capgemini is a software consulting company involved in creating digital solutions for their partners. They are more focussed on the technical aspects of the dashboards and are involved with the hosting and back-end of the dashboard platform. However, their expertise on the creation of dashboards mean they are also looking at the dashboard from a design perspective in terms of functionality and usability.

Representatives from each organisation were involved in the case study, so that all different views were heard in this research. Within this case study a research framework was used to structure the research process, which is discussed in the next section.

3.2. Research Framework of Methodology

To research the guidelines from Few and Eckerson in this case study two options were considered. The first was to ask representatives from Project ENHANCE on their opinion on four already existing OTSA dashboards. However, research in chapter 2 has shown that dashboards are very context dependent which could make the results of the first option less valid. Thus, it was decided that for a more accurate evaluation custom dashboards would also be designed for Project ENHANCE. Throughout the whole design process of developing a dashboard the guidelines from Few and Eckerson's would then be followed so that their guidelines would be more thorough evaluated. The evaluation of already existing OTSA dashboards was considered a small additional part of the research, with the main focus on the creation and evaluation of the custom-made dashboards.

The framework chosen to support the custom-made dashboards part of the research is the Action Design Research methodology (ADR). This methodology combines the development of an IT artefact (Design Research) and the use of the IT artefact for organisational action (Action Research) (Sein *et al.*, 2011; Lee, Hillegersberg and Kumar, 2016; Petersson and Lundberg, 2016). ADR was chosen as the methodology recognizes the importance of context evaluation of an IT artefact, similar to how dashboard design principles mention the importance of tailoring a dashboard for its context. This method was furthermore chosen over other methods such as the V-Process model, as ADR has as its final stage the generalization of design principles from the research results. This matches the overall objective of this thesis to find or create design principles for dashboards in a non-business context.

The ADR methodology consists of four phases:
1) Problem Formulation: In this phase the problem is identified. This is done by establishing research questions and exploring the status quo with the expected users of the artefact.
2) Building, Intervention, and Evaluation (BIE): In this phase the artefact is built, used by the organisation for which it was developed and evaluated by the users.
3) Reflection and Learning: In this phase the results of the intervention and evaluation are analysed.
4) Formalization of Learning: In this phase the outcomes of phase 3 are used to derive general design principles.

Although the ADR framework believes in an iterative process over the four phases to come to a final design, due to time limitations only one cycle was conducted in this thesis. As the main goal of this thesis is to discover the applicability of guidelines in a non-business context, one iterative cycle was considered to be enough. For the purpose of designing the most perfect dashboard for Project ENHANCE, multiple cycles would be recommended. The phases of the ADR framework as they were used in this thesis are presented in the figure below.
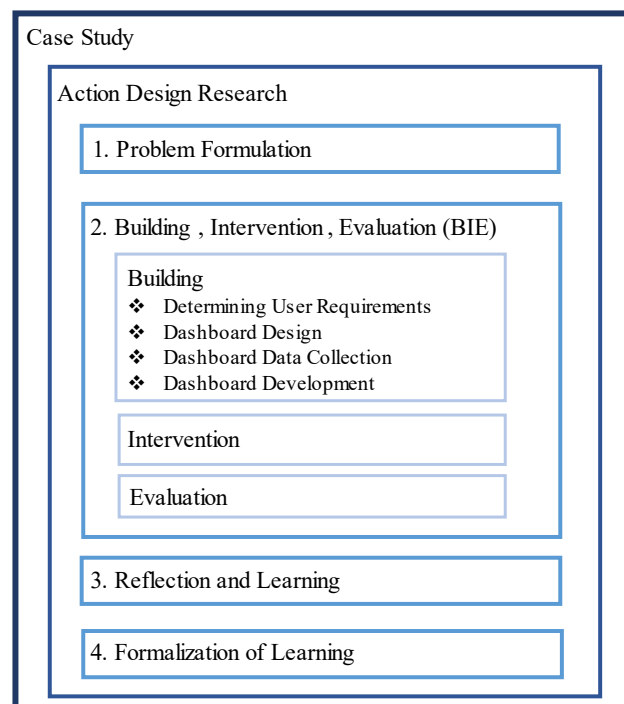
Figure 6: Overview of Research Methodology

The first phase of the ADR framework was conducted by establishing the problem faced by Project ENHANCE. This was done during informal meetings with representatives of Project ENHANCE. The problem was identified as the question of what design their dashboard should be.

The second phase of the ADR framework contains two tasks before the building part of the phase can begin. The first task of defining a knowledge-creation target was already done by Project ENHANCE, as they chose a dashboard. For this knowledge-creation-target then an artefact had to be chosen to be created. It was decided to not built a completely functional dashboard as artefact, but rather a mock-up due to time limitations. A mock-up dashboard is not quite yet a prototype dashboard, it is a conceptual visual design of a dashboard, which does not yet need to be fully functional (*The What, Why, and How of Mockups - Designmodo*, no date). Mock-up dashboards are commonly used in academic research to gain insights on user preferences, without requiring complete functionality. The advantage of using mock-ups is that they require less time in creation, but a disadvantage is that the users who test the mock-ups may base their opinion on not-yet functioning aspects or less than perfect visualisations. This disadvantage was taken into consideration during the creation of the evaluation survey and interpreting the results.

The second task in this phase consists of selecting the form of the BIE phase. The second phase can have the form of either being IT dominant or organisation dominant. The difference is whether the opinion of the creators (IT) is only involved in the design or if the opinion of the user (organisation) is also consulted. As dashboard design principles have shown that end-users should be involved in the creation of the dashboard design, for the BIE phase the Organizational dominant was chosen as it includes the end-users in the creation of the alpha version of the artefact.

The building stage of the second phase in ADR is not specifically tailored for designing a dashboard and thus an approach on how this process would be shaped had to be chosen. In Chapter 2 several components were listed which make up a dashboard. There are quite a few papers on researchers explaining their design of a dashboard and measuring the effect of their design, however a paper which details how the design process of a dashboard can be most effective remains elusive. The methods used in this thesis was thus based on examples by other researchers and online recommendations made by professionals in the business of designing dashboards. The methods used in the building stage and other phases of the ADR Framework are explained in the following sections.

3.3. Methods used in Building Phase

The process of building the mock-up dashboards in this thesis consisted of four steps: determining user requirements, dashboard design, data collection and dashboard development. Each of these steps are described in the following sections.

3.3.1. Determining Dashboard Requirements

To discover the user requirements, a group of representatives from Project ENHANCE and additional expected users of the dashboard were interviewed. The choice to interview them (as opposed to for instance a survey) was made as an interview can be more easily customized to each individual respondent. The respondents were expected to have different fields of expertise and backgrounds, considering how Project ENHANCE is made up already of several distinct organisations. This required the interview method to be customizable.

Interview Respondents Selection

Within each organisation an initial group of interviewees was selected based on their involvement in Project ENHANCE or role in their respective organisation. This initial group of representatives were interviewed first. During each interview they were asked to list other people who would be suitable to interview for this purpose. Selection of interviews was further limited by time constraints. Since the expected user is still a broad relatively undefined group of people, using representatives allowed for determining user requirements within the limited timeframe.

In total 11 people were interviewed, listed in the table below. Four interviews were conducted with the analysts from the System Nutrition Team of the WFP and four with representatives of the country offices of the WFP. The WFP already has a substantial stronghold in Ethiopia and Indonesia with a lot of connections to local NGO's and the government. Due to the WFP stronghold there, it was decided to focus on the country offices colleagues in these countries. Two more interviews were conducted with representatives from the Zero Hunger Lab. The eleventh interview was conducted with a representative from JHU, who has previously worked at the WFP

Although the group of interviewees does not give an equal distribution among all participating organisations, the division was determined fair by representatives of Project ENHANCE. As the WFP is the main expected user of the dashboard, the larger representation of this group was deemed important. From JHU and ZHL no other colleagues were actively involved in Project ENHANCE nor expected to be able to represent the end-users. The same was argued for Capgemini, whose representatives stated they could offer no valuable user requirements to the interview process and were thus excluded.

Organisation	Role in Organisation
World Food Programme – System Analysis Team	Nutritional Consultant
World Food Programme – System Analysis Team	Nutritional Analyst
World Food Programme – System Analysis Team	Nutritional Analyst
World Food Programme – System Analysis Team	Nutritional Analyst
Zero Hunger Lab – Tilburg University	Co-Director
Zero Hunger Lab – Tilburg University	PhD Student
World Food Programme – Country Office, Ethiopia	Nutrition Partnerships and FNG focal
World Food Programme – Country Office, Ethiopia	Nutrition Team Leader
World Food Programme – East-Africa Country Office Coordination, Nairobi	Regional Head of Program
World Food Programme – Country Office, Indonesia	Head of Nutrition
John Hopkins University – Centre for a liveable Future	Director

Table 2: Interview Respondents

Potential interviewees were emailed with a brief explanation of the research conducted and with the request for an interview. Each interviewee was ensured anonymity of their answers in the interviews and joined the interview process voluntarily.

Interview Protocol Formulation

The user requirements were collected during interviews using a semi-structured interview protocol. This semi-structured protocol ensured all important aspects about the user requirements would be covered, while still allowing for flexibility in adapting the protocol to each individual's background and experience. The interview protocol was created based on online recommendations by dashboard builders and revised based on feedback by supervisors (Hughes, 2010; DiRobbio, 2017; Nguyen, 2019). The interview protocol is attached in Appendix A. The protocol begins with a section on the interviewee's familiarity with dashboards to establish a shared understanding of the definition of 'dashboard', as it can be so broadly defined. In the second section the context in which the dashboard would be used is discussed, together with the expected purpose of the dashboard and the expected users. Then the specific user requirements are questioned, divided in the common cornerstones of dashboard design: data, functional features and visual features. If the interviewees were not expected end-users of the dashboard, they were asked to state their opinions on behalf of the expected users.

Following these sections, the interviewees were asked to evaluate four already existing OTSA dashboards. This part was added to the protocol to observe initial evaluations of how suitable the four OTSA dashboards would be for Project ENHANCE. This section was placed at the end of the interview to ensure respondents would state their own unbiased opinions in the first section rather than basing their opinion off example dashboards. Due to the restriction of only conducting interviews online, the four OTSA types were shown in an order rather than all together for comparison. See Appendix B for the four slides with OTSA example dashboards. The four dashboards were always shown in the same order and were selected from online sources. There was no source where all four dashboards' types could be found in the same layout style. Each dashboard thus has a distinguished style and respondents were asked to be explicit if their opinion was based on the visual colour or layout aspects.

In total 11 interviews were conducted. Although not all interviews strictly followed the complete protocol, the findings were all determined to be useful enough to be included in this thesis. That is to say, not all respondents answered all questions in the interview protocol but the answers they did give were included in the requirements. Interviewees were interviewed via online platforms in the period of January and February 2021. The notes from the interviews were send to the respondents for approval before being analysed.

To analyse the interviews for user requirements a qualitative content analysis was conducted. This method was chosen as it can be used to find patterns in content, and the objective was to group the user requirements together per topic relevant for designing the mock-ups. As the themes interesting for analysis were predetermined, the choice was made to use concept-driven coding with a pre-made set of codes. For this purpose, note-taking space was included in the interview protocol, which means the interview notes were already be categorized into certain groups.

Below is an image of the hierarchical framing of the coding concepts, based on the interview protocol topics. Based on the interview notes this coding protocol was revised to include also system requirements in addition to user requirements. System requirements were defined to be those requirements of the dashboard which were mostly irrelevant for the creation of the mock-up, but nevertheless relevant for the creation of the dashboard in a later process.
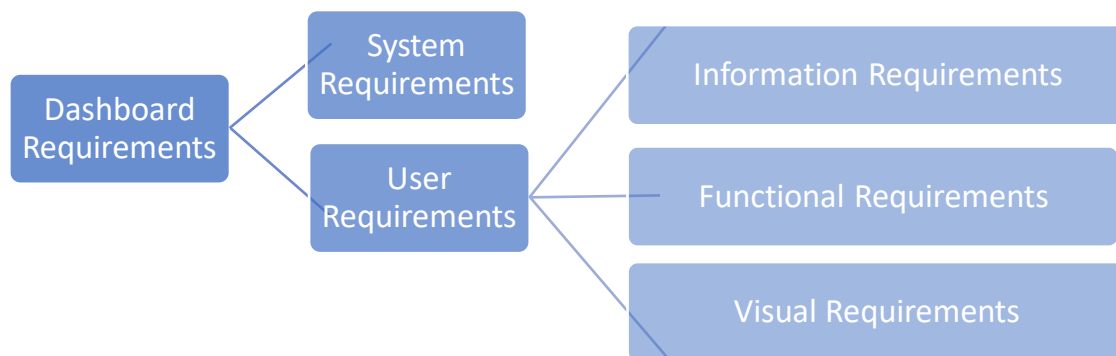
Figure 7: Coding Protocol of Interviews

The interview notes were coded manually, as there were only 11 interviews and most of the notes were categorized already. The notes were numbered per line or multiple lines if they were part of the same answer. The requirements were collected in one overview following the analysis, with each requirement showing which respondent made this requirement. The notes were divided over four categories: System Requirements, Information Requirements, Functional Requirements, Visual Requirements. Following this division, the Information requirements were split into Information and Data, with the Data requirements covering the format of the data and Information requirements covering the content of the data. See Appendix C for the complete overview of all requirements notes analysis.

In the interviews respondents were asked to state their user requirements in general for their ideal dashboard, not per dashboard type. This was done so that interviewees would not be pushed already towards a certain type of dashboard. As the mock-ups would be created to match the OTSA types, the complete set of user requirements had to be further analysed to see which requirements matched each OTSA type. This was done by first selecting the purpose and expected end-user of each OTSA dashboard for Project ENHANCE. These purposes were chosen from the collection of purposes given by representatives of Project ENHANCE during the interviews. Following this process, user requirements were matched with the most suitable OTSA mock-up. This process is described in more detail in Chapter 4.

3.3.2. Dashboard Mock-Ups' Design, Data and Development

Following the decision made during the interview phase to focus on the WFP Country Offices of Ethiopia & Indonesia, it followed that the mock-ups for Project ENHANCE would be created specifically for only these countries. The advantage of making a mock-up dashboard for the two countries was hypothesized that it could be compared what general framework is useful for the dashboard and which aspects are context specific per country. The following sections describe the methods of how the mock-ups designs were created, how the data for the mock-ups was collected and how the mock-up dashboards were developed. The results of this process are presented in chapter 5.

Dashboard Design

The conceptual design of the mock-ups was created based on the user requirements and design principles on the four OTSA dashboard types found in literature. The designs were created by first selecting a purpose & expected user for each OTSA mock-up, followed by matching user requirements to each mock-up. Following this matching process initial design sketches were made. The initial design sketches were then consulted with a key representative of Project ENHANCE to ensure suitability of the mock-ups for the organisations. The approved designs then served as starting points to the data collection process.

Dashboard Data Collection

Per mock-up dashboard a separate set of data had to be collected. Some of this data was publicly available, other datasets were provided by Project ENHANCE' organisations. By creating a mock-up dashboard limited time was spend on ensuring data accuracy. If the requested data was not available in an appropriate format for instance, mock-up data was be created. The advantage of this was that the mock-ups could be created relatively quickly, but a clear disadvantage was a less realistic mock-up.

Dashboard Development

The mock-up dashboards were developed in Python. The choice to create the mock-ups with a programming language, as opposed to a visual-only mock-up was that the functionality in a mock-up was expected to greatly influence user's evaluation of the mock-up. The choice to program the dashboards in Python was then made as it is an opensource available programming language, ensuring that the mock-ups could be used and built-upon further. A disadvantage of this choice was that getting certain functionalities actual functioning took a lot of time. Both dashboards were created to 'visually' appear similar in terms of colour scheme, letter type and overall layout of sections and controls. This was done to ensure those details would not influence the preference of evaluators for one dashboard over the other, but that preference would be based on dashboard type.

3.4. Methods used in Intervention Phase

The Intervention part of the BIE-phase is defined by Petersson and Lundberg to be any kind of activity whereby the artefact is used in the target environment (Petersson and Lundberg, 2016). The using of the artefact can be seen as a kind of testing of the artefact. Since the mock-up dashboards were limited in their functionality and volume of content, they could not be properly 'used' yet in the target environment. Thus, the Intervention phase in this thesis was limited to simply having selected users from the target environment explore the mock-up dashboards. This made the evaluation of the mock-ups less accurate, but was deemed accurate enough to serve as a starting point for presenting designing guidelines. Respondents were able to make use of several functionalities in each of the mock-ups such as filter options, sliders and buttons. However, as the individual evaluation of each dashboard was considered less important than the comparison between the two dashboards, no specific functionalities or tasks were specified for the users to focus on in their exploration. The purpose of the exploration was for the respondents to get a good impression of the dashboards, not to test the functionalities. The invitation for users to explore the mock-ups was done by sending selected respondents an email with an URL from which respondents were able to access the mock-ups in their own browser window. The mock-ups were hosted on an external server with help from Capgemini.

3.5. Methods used in Evaluation Phase

Choice for Evaluation Survey

To evaluate the custom-made mock-ups there are several different options which were considered. According to Petersson and Lundberg in the ADR framework it is recommended to have evaluations occur spontaneously in the targeted organization (Petersson and Lundberg, 2016). However, as mentioned previously due to the limited functionality of the mock-up's users would not be actual able to 'use' the dashboards in the target environment. Additionally, this artefact is created for a combined group of organizations which limits the possibility of spontaneous evaluations taking place as the organisations themselves are not even in the same place. The evaluation methods of Petersson and Lundberg included questionnaires, interviews and observations made during the user tests. As the main objective of this thesis is to compare the evaluations of the different dashboards, multiple evaluators were desired for the evaluation phase so that personal preferences would not skew the evaluation results. Expecting multiple respondents made an interview method less desirable for evaluations, due to time constraints for this research. Another alternative method of making observations during the user tests was considered in two ways. The first way would require either a live presence during the user testing or a recording of how the users tested the mock-ups. This way would require a quite complicated set-up of screen-sharing, accessing and recording due to the geographical distance between participants. A second way to make observations during user testing would be to create built-in measurements of how many times certain functionalities of the mock-ups were used during the user tests. This too would require quite a complicated set-up of data storing and sharing in the mock-ups. Since the expected additional value of these methods did not measure up against the expected time needed to create these set-ups, it was decided not to make observations during user testing. Instead, an evaluation questionnaire was chosen to be the most suitable evaluation method for this research. The questionnaire would allow for a systematic comparison between the evaluations of the two mock-ups and would be the fastest method to deploy. Additionally, as most respondents noted they had quite busy schedules, a method which they could schedule themselves was preferred by representatives of Project ENHANCE.

Evaluation Survey Creation

Evaluation of dashboards can almost be considered a research field on its own grounds, with the number of existing surveys available online plenty. However, most evaluation criteria used in questionnaires are not suitable for all different types of dashboards and are not necessarily good for each dashboard's purpose. For instance Karami et al. define 7 categories of evaluation criteria of which both knowledge discovery, interaction options and alerting can be very dependent on the purpose of the dashboard (Karami, Langarizadeh and Fatehi, 2017). Thus, for this thesis a new survey was created. For a complete overview of the survey's questions and their origin see Appendix E.

As the goal of the evaluation survey was to compare the mock-ups to each other, each mock-up was first evaluated individually in the survey and then in a few questions respondents were asked to choose between the two dashboards. For the individual evaluations a collection of statements was presented on a Likert-scale with open-ended questions where respondents could provide comments. The choice-questions between mock-ups were presented as multiple-choice questions where respondents could pick between the dashboard types or select the 'Other' option. For each choice-question respondents could also make comments to explain their choices. For the Likert-scale statements on the individual dashboards two surveys were chosen as most suitable to serve as the basis for creating a new survey. The survey designed by Matheus et al. for the purpose of evaluating several IT tools was chosen to be adapted for this thesis as it was created specifically to evaluate IT tools and the questions included in it covered all aspects considered important in this thesis such as user acceptance and user usability (Matheus, Jansen and Praditya, 2019). All questions related to how well the dashboard works were removed and all other questions were made more hypothetical towards the future, due to the mock-ups limited functionality. The second survey chosen to serve as a basis was created by Li. They created a survey for the purpose of evaluating a mock-up dashboard created for a company (Li, 2019). This survey was chosen as Li synergized many of the most commonly used surveys to one that best fit evaluating a mock-up they had created. As Li made quite a long survey, it was decided to scrape a lot of the questions to ensure respondents would be more likely to complete the survey. The open-ended questions were left optional as to not discourage respondents from completing the survey.

Selection of Survey Respondents

The survey was sent to the same group of Project ENHANCE members who had previously participated in the interview phase, as they were already familiar with the research and had expressed interested in participating. This group was extended upon with a few respondents who had expressed interest in evaluating the dashboards but had been unable to be interviewed. For the software to send the survey Google Forms was chosen as it is free, useful for long text answers and easy to build as opposed to for instance SurveyMonkey and Qualtrics. The survey was sent to 16 respondents alongside a link from which respondents could access the mock-ups. 9 respondents completed the survey in the allocated timeframe.

Evaluation Survey Data Cleaning

The Google Form containing the evaluation survey was linked to a Google Sheet in which the data of the survey was collected. In this sheet the column header names were changed to a short descriptive abbreviation, as opposed to the long question text itself. For example, the question on User Acceptance Goals of the Analytical mock-up would receive the column header name of A_UA_Goals. Additionally, the questions were numbered in the order they were presented in the survey. The data was then transferred to excel, where the data was pivoted to a long format. Additional columns were added, which are coloured grey in the image below.

The column respondent_id was added with an integer for each respondent. The column Weight was added for easy calculations purposes and all cells contain the value 1. The NumericValue column was added for the Likert-scale questions where each response on the Likert-scale corresponded to a numeric value. The answer 'Strongly disagree' was given a score of 1 and the answer 'Strongly agree' was given a score of 5, with all other Likert-questions options scored on the same scale. The column Question_Type was added to make filtering easier during the data visualisation process and contains one of the following possible values: Likert, Choice, Text. The column Question_Category was added for visualisation purposes and contained the category of the questions: (User Acceptance, Facilitating Conditions, etc).

The column Question_Text was added for visualisation purposes and contained the text of the question asked. The column TextValue_Edited was used for the preference choice-questions at the end, where respondents could select either 'The Analytical Dashboard', 'The Strategic Dashboard' or 'Other'. As Google Survey only saved the text explanation made by respondents to 'Other', here the value 'Other' was added. Since the choice-questions and all comment-questions did not correspond to the Likert-scale, these questions were given the numeric value of 0.

	A	B	C	D	E	F	G	H	I	J
1	Respondent_ID	TimeStamp	Organisation	Role	Weigh	Question_ID	TextValue	TextValue_Edited	NumericValue	Question_Typ
133	2	23-4-2021 16:2	Zero Hunger Lab	Analyst	1	Pref_Data_Choice	I find it hard to say, as I am	Other	0	Choice
134	2	23-4-2021 16:2	Zero Hunger Lab	Analyst	1	Pref_Data_Comments			0	Text
135	2	23-4-2021 16:2	Zero Hunger Lab	Analyst	1	Pref_Useful_Choice	The Analytical Dashboard	Analytical	0	Choice
136	2	23-4-2021 16:2	Zero Hunger Lab	Analyst	1	Pref_Useful_Comments	From the perspective of o	From the perspective of o	0	Text
137	2	23-4-2021 16:2	Zero Hunger Lab	Analyst	1	Pref_ENHANCE_Choice	I think, in the end, a comb	Other	0	Choice

Figure 8: Demonstration of transformed columns in evaluation survey data

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Analysis of Custom-Made Dashboards Evaluations

Due to the small number of survey respondents, statistical analysis of the survey results was not possible. Thus, an exploratory analysis of the results was conducted to observe the occurrence of any trends or patterns. This analysis was supplemented by an in-depth analysis of the comments made by respondents in the survey. Interpretation of the results was done with an advisor from Project ENHANCE, who provided context for the respondents' comments.

      In the table below an overview can be found of the organisations and roles of the 9 respondents. It was chosen to first analyse the evaluation survey results per role of the respondents. These pre-defined roles were based on the definition of Few and Eckerson on the most suitable user group per OTSA dashboard type. These roles were operational level, management level, executive level, analyst level. This divided analysis per role was chosen, as it was expected based on literature findings that the role of the respondent could influence their evaluations of the mock-ups. For instance, the analysts were expected to evaluate the Analytical mock-up very positive, whereas other roles could be less enthusiastic about this mock-up. To ensure these potential differences per role would not be missed in a total results analysis, first analyses per role were conducted.

	Roles				
	O	M	E	A	Total
WFP-Country	1	1			2
WFP-SA				2	2
ZHL			1	2	3
Capgemini	1				1
JHU			1		1
Other					0
Total Respondents	**2**	**1**	**2**	**4**	**9**

Table 3: Overview of all survey respondents

Three respondents did not select any of the pre-defined roles, so their roles were changed to a pre-defined role as used by Few and Eckerson. This was done to ensure their results could be analysed from a role-based perspective. The role of Respondent #3 (Timestamp 30-4-2021 13:05) was transformed from 'other: mid-level management' to the pre-defined value of 'management level', as it closely matches the description used by Few of who belongs in the 'management level'-category. The role of Respondent #5 (Timestamp 5-5-2021 04:37:32) was transformed from 'other: Partnerships & Research' to the pre-defined value of 'operational level' as it closely matches the description used by Few on who belongs in the 'operational level'-category. The role of Respondent #7 (Timestamp 5-5-2021 21:00:10) was transformed from 'other: Software & Solution architect' to the pre-defined value of 'operational level' as it closely matches the description used by Few on who belongs in the 'operational level'-category.

From all organisations which make up Project ENHANCE, at least one respondent replied. None of the respondents reported a different organisation than the pre-defined five options. Out of the four different pre-determined roles, the analysts were the most represented with four respondents. Two more respondents filled in the survey after the deadline for completing the survey had passed and were thus excluded from the analysis. Both of the respondents were not given any leniency as their respective combinations of roles and organisation were already represented in group of respondents.

Following the exploratory analyses of the survey results per role, the total results of all respondents combined were investigated. This investigation was done to see if any general trends could be observed across the group as a whole.

Analysis of Pre-Made Dashboards Evaluations

Respondents were asked to state their preference on example OTSA dashboards by ranking them during the interviews. The results of these rankings were visualised in Excel by giving each OTSA dashboard a score for each rank they received. If a dashboard was given first rank it received a score of 4, second place got a score of 3 and so on. In addition to the ranking, the comments made by respondents during this phase of the interview were investigated to gain a better understanding of their evaluations. See Appendix D for the complete overview of all ranking notes.

3.6. Methods used in Reflection and Formalization of Learning Phases

Following the evaluation of the survey results, the phase of Reflection & Learning of the ADR framework could commence. In this phase a reflection was made on the possible reasons behind the most striking results from the evaluation survey and other influencing factors on the research. The results of this phase are presented in the discussion in chapter 7.

In the final phase 'Formalization of Learning' the outcomes of the discussion were used to derive general design principles. This phase is documented in chapter 8 and chapter 9, containing the conclusions and recommendations of this thesis respectively.

"Which audience are you making the dashboard for is the real question, like how choosing a language depends on who you need to talk to." – Respondent 3B

4. Dashboard User Requirements

In the following chapter the results from first step of the building phase are presented to answer sub-question *SQ2: 'What user requirements does Project ENHANCE have for their dashboard'.* The notes from the interviews are summarised as user requirements for the mock-up dashboards. The first section contains background information on the interview respondents. This is followed by the second section describing the various possible purposes and users of the dashboards mentioned during the interviews. The notes from the interviews are then presented as user requirements divided into different categories: Information & Data, Functional features, Visual features and System. The complete overview of the respondents answers on these topics are attached in Appendix C. The next section is where sub-question SQ3 is answered: *How do the user requirements from Project ENHANCE match the dashboard types defined by Few and Eckerson?* To answer this question for each OTSA mock-up a purpose and expected user is selected from the requirements made by Project ENHANCE and the user requirements from section 2 are matched with the mock-ups. The final section contains a conclusion on the user requirements of Project ENHANCE.

4.1. Interview Respondents

In total 11 interviews were conducted. Below an overview of the respondents is given, with each interviewee assigned a number and letter. The number indicates the organisational group the interviewee belonged to and the letter was added to distinguish the individual.

Respondent	Organisation	Role in Organisation
1A	World Food Programme –System Analysis Team	Nutritional Consultant
1B	World Food Programme – System Analysis Team	Nutritional Analyst
1C	World Food Programme – System Analysis Team	Nutritional Analyst
1D	World Food Programme – System Analysis Team	Nutritional Analyst
2A	Zero Hunger Lab – Tilburg University	Co-Director
2B	Zero Hunger Lab – Tilburg University	PhD Student
3A	World Food Programme – Country Office, Ethiopia	Nutrition Partnerships and FNG focal
3B	World Food Programme – Country Office, Ethiopia	Nutrition Team Leader
3C	World Food Programme – East-Africa Country Office Coordination, Nairobi	Regional Head of Program
3D	World Food Programme – Country Office, Indonesia	Head of Nutrition
4A	John Hopkins University – Centre for a liveable Future	Director

Table 4: Interview Respondents for User Requirements Analysis

4.2. Interview Results on User Requirements

The results from the interviews are sorted into categories which correlate to the dashboard aspects' table seen in the literature chapter. They are presented in the same order as the table. The aspects of user and purpose of the dashboard are presented together, as most interviewees mentioned these aspects together in an interconnected way. Following these aspects, the other requirements on Information, Data, Functional and Visual features are presented. These are followed by the System requirements.

4.2.1. Users & Purpose

The different backgrounds of the respondents were reflected in the interviews by a diverse view on the purpose and expected user of the dashboard. Below the different purposes & users are presented.

One of the most common mentioned purposes was that the dashboard of Project ENHANCE could be used by the analysts of the WFP System Analyses team. The members of the WFP analyst team which were interviewed mainly expected the dashboard to be used by themselves. They currently use software (called Cost of the Diet) to conduct analysis for governments and NGO's. This software does not have a very user-friendly interface and their analysis takes quite a long time, due to limited capabilities to run the software with various parameters. They would like the envisioned dashboard to be designed in such a way that it will allow them to do their work more efficiently. Respondent 1A noted that: "*If the dashboard does not have to constantly mechanically be updated then it would relieve the burden of the system analysis team.*".

However, all interviewees from this group also noted that they envisioned (at least) two purposes and different user groups of the dashboards. Besides themselves they also imagined a user who would be working at either country offices of the WFP, local governments or NGO's. The purpose the interviewee's envisioned of this user group using the dashboard ranged from better insights to support policy-making, to creating more agreement on data between different people. One analyst respondent noted however that they wouldn't know which problem would be solved by this second user group using the dashboard.

The respondents from the ZHL also mainly listed the analysts from the WFP as the main user, but also could think of how the dashboard could be used for other purposes. In addition to showing solutions to policy-makers it could also be used to gain insight by letting people play around with it. Respondent 4A of the ZHL made it clear that the purpose of the dashboard should be to show information and be used for advocacy. The rest of their response on this topic highlighted the importance of the context in which this dashboard could be employed. In order for the dashboard to be effective this respondent argued that the dashboard should be used by the ministry of agriculture, where the decision-making power is much greater than at for instance the WFP country offices.

The respondents from the WFP Country Office gave several purposes that a dashboard could have if they were the intended user, none of which were mentioned by the other respondents. These purposes were: updating donors on projects progress to justify their spending of money, tracking and monitoring of projects, and increase data transparency and data accountability. The only purpose mentioned that had been previously stated by another respondent was to use the dashboard as an advocacy tool to convince governments of the importance of analysis of the WFP.

During the interviews with the WFP Country Office' representatives it was discovered that in the Ethiopia Country Office dashboards are already being used to monitor their projects. Respondents also noted that a key challenge with the Food System is it goes across different organisations and different ministries. It is difficult to work across those different sections, as there is lots of data spread over those sections. This makes it difficult determining what is relevant for policy-makers who are non-technical so that they can understand and make decisions based on the data.

4.2.2. Information & Data Requirements

The dashboard should contain Information on…

#	Requirement	Respondents
I1	Prices of food, both regional and national	1A-14, 1C-27, 1D-15
I2	Affordability of diet	1D-15, 2A-14, 3C-20
I3	Aggregated nutrient score of how nutritious the diet is	1C-27, 1D-15, 3C-20
I4	Nutritional consistency of food	1A-16, 1B -22, 1D-13, 2A-13
I5	Nutritional needs of different age and sex groups	1C-26, 1D-13
I6	Supplementation and fortification	3D-14
I7	Type of diet: vegetarian, vegan, etc	1B-24
I8	Cultural information on diets	1C-26
I9	Typology of the food system in the country	1D-13
I10	Environment aspects of food: greenhouse gasses, water use, land use, footprint	1B-25, 1C-26, 1D-13, 2A-13, 3C-14
I11	Environmental impact of diet	1C-27, 1D-15, 2A-14, 3C-20
I12	Food production data	1C-26
I13	Food use, food loss, food waste	1C-26
I14	Infrastructure	1B-26, 1C-26
I15	Trade: import and export of food	1C-26, 3C-11
I16	Education, health of demographic, general utility access	1B-27
I17	WFP Country Office Projects: Location, Partners, Main Findings, Status	3A-16/17

Table 5: Information Requirements

The requirements were all derived from comments made during the user requirements interviews. Information requirements I1-I13 are all directly related to aspects of the Food System. Information requirements I14-I16 are still relevant for the Food System, but can be seen as distinct aspects. I17 is directly related to the WFP Country Offices operational processes. The data requirements covered either the detail level of the data (D1-D2), the timeframe on which the dashboards data should focus (D3-D4), or the update frequency of the data (D5-D8). Respondents gave different and often conflicting data requirements.

The data should…

#	Requirement	Respondent
D1	Be as granular as possible	1A-17, 3C-23
D2	Separated by gender and age groups	3D-15
D3	Retrospective	1C-29
D4	Show the future	2A-15, 2B-12, 3C-21, 4A-10
D5	Be updated every month	1B-17, 1C-31, 3B-13, 3D-17
D6	Be updated every day	2A-16, 3A-18, 3B-12
D7	Be updated every quarter	2B-13, 3D-17
D8	Be updated every year	3C-22

Table 6: Data Requirements

4.2.3. Functional Requirements

The dashboard should include the functional option....

#	Requirement	Respondent
F1	To add a new food	1B-22
F2	To calculate the affordability of a diet	1B-23, 1D-16
F3	That if you select a diet to see similar diets given certain parameters	2B-10
F4	To select policy levers such as subsidies	3C-12
F5	To optimize the diet based on certain parameters or see multiple suggestions	1D-15, 1A-18, 1B-28, 1C-32, 2A-18, 3C-25
F6	To compare regions	1A-15
F7	To compare different diets	2A-20
F8	To select different scenarios and see their effect, for instance a flood	1A-20
F9	To correlate the diet with different data	1B-29
F10	Create a basket for a household with different household members, that meets criteria for all those members	1D-17
F11	To adjust parameters and situations	3C-24
F12	To compare countries	4A-11

Table 7: Functional Requirements

Apart from F5 which was mentioned six times, one other functional requirement was mentioned twice (F2) and all other functional requirements were only listed once.

4.2.4. Visual Requirements

#	Requirement	Respondent
V1	See trade-offs between different objectives: cost, environment, nutritional	2B-9, 3C-13, 2A-2, 2B-14
V2	See on both national level and regional level	3D-13
V3	See greatest contributor in diet in diet in terms of cost, water footprint, greenhouse gas footprint	1A-19
V4	See if they are meeting their SDG goal	3D-18
V5	Very easy to understand	1A-3, 3A-20, 3D-20
V6	Include drawings, figures, icons	3A-21, 3D-21
V7	Standard format for each country	1A-3
V8	Plate or spiderweb to see optimalization	1B-31, 2B-16
V9	Map to see situational analysis	1C-4
V10	No pie charts	1C-35
V11	No maps	2A-24
V12	A button which says start optimizing	2B-16

Table 8: Visual Requirements

For the visual requirements the most listed requirement was to see trade-offs between different objectives. Respondent 3C noted that: "*It is a very different perspective if you aim for the best food system or for the most nutritious decision, so you need to see the trade-offs.*". Another requirement which was mentioned quite frequently was that the dashboard should be easy to understand.

4.2.5. System Requirements

#	Requirement	Respondent(s)
S1	The dashboard should be dynamic	1A - 13
S2	The dashboard should have two interfaces: one to see results in and one to calculate results in	1C -22, 3C-19
S3	The dashboard should be online	1B – 16, 1C -23, 2A -11, 3A -15
S4	The dashboard should be offline	1D -11
S5	The dashboard should be interactive	2A – 10, 3A-15
S6	The dashboard should be light on internet use	3A-19, 3C-29, 3D-11
S7	The dashboard should have a short response time	2A-28
S8	The dashboard should have the option to download data	1B-8, 1C -34, 1D-12, 3D-12
S9	The dashboard should have the option to print the graphs	3C-20
S10	The dashboard should be open source	1C-18
S11	The dashboard should have a tutorial	1C-21
S12	The dashboard will need someone to look at data consistency	3D-6
S13	The dashboard should have consistent data	3D-16
S14	The dashboard should have a feature to filter for different audiences	3A-12
S15	The dashboard should have keyboard shortcuts instead of mouse clicking	1D-19
S16	The dashboard should have the option to input your own data and a check for input errors	2B-15

Table 9: System Requirements

As this research focuses on the design of the dashboard, the system requirements were mostly disregarded during the rest of the building phase. As the majority of respondents required an online web based, dynamic, interactive dashboard: this was chosen to be the system requirements shaping the rest of the design. This means requirements S1, S3 and S5 were met in the designs of all mock-ups.

4.3. Matching of User Requirements to Dashboard Types

In this section it is investigated how the user requirements from Project ENHANCE match the Operational, Tactical, Strategic and Analytical (OTSA) dashboard types defined by Few and Eckerson.

On the purpose of the dashboard, it became clear from the interviews the members of Project ENHANCE envision different purposes and user groups for the dashboard. Almost all respondents expected two different kinds of users: analysts and people who work in the WFP Country offices/governments/NGOs. This already goes against the notion of Few and Eckerson that dashboards should be designed for a single user group. The purpose that the dashboard would be used to give people working at the WFP-CO/Governments and NGO's better insight was consistently phrased so vaguely that it could match any of the OTSA dashboards. The same goes for the purpose of creating agreement on data between different people, increasing data transparency and data accountability. None of these purposes are also listed by Eckerson and Few as a purpose of their OTSA dashboards. Furthermore, the listed purposes of showing information and advocacy could not be matched to any of the OTSA types.

Nevertheless, in the collection of purposes & users mentioned during the interviews several could be matched to Few's and Eckerson's OTSA types.

❖ Operational: The purpose mentioned by a respondent of the WFP Country Offices that the dashboard could be used to monitor WFP Country Office projects matches the Operational type.

❖ Tactical: The purpose of the dashboard being used to gain an understanding of the current situation in a country and to make policy decisions on a short timeframe matches the Tactical type of dashboard.

❖ Strategic: The purpose mentioned for the dashboard to support policy-making at a governmental level aligns with the purpose defined for the Strategic dashboard, as does the purpose to update donors on projects progress to justify their spending of money.

❖ Analytical: One of the most common purposes listed was that the dashboard would have as its purpose to use the CoD software, which matches the Analytical dashboard. The expected user group of analysts listed with this purpose also matches the Analytical dashboard.

These purposes, which were all a match for the OTSA types, were chosen as the purposes of the mock-up dashboards with their corresponding user groups.

Following this selection, it was then analysed how the different user requirements matched the OTSA types. Some of the frequent mentioned requirements could match multiple or all of the OTSA dashboards. For example, the data requirement for data to show the future is more Strategic but can also be Analytical. Another example is that the user requirement for easy visualisation matches both the Operational, Tactical and Strategic dashboard to some degree and that the visual user requirement to see trade-offs between objectives could also be a match for each OTSA type.

Due to this ambiguity of the user requirements matching the OTSA types, it was decided to add user requirements to mock-ups based on how well they matched the already decided purpose of the mock-up as well as the corresponding OTSA type. A detailed list of each mock-up's requirements can be found in Appendix F. An overview table of the four mock-ups and their most important requirements can be found in the next chapter as it served as the starting point of the design process.

4.4. Conclusion on User Requirements

In conclusion, the results of the interviews to determine the user requirements of the mock-ups confirm the previously supplied information that the organisations and individuals within Project ENHANCE have quite differing ideas about what the ENHANCE dashboard should be like. The most common listed purpose was for the dashboard to provide insights from using the CoD software and to be used as an advocacy tool. Many possible purposes of the dashboards were phrased so vaguely that they could match all OTSA dashboard types as defined by Few and Eckerson, or did not match the types at all such as the purposes of providing information and advocacy. Four purposes were named which matched the OTSA types and were thus chosen to be the purposes of the mock-up dashboards. Most of the user requirements on the aspects of information, visual and functional features could not directly be matched to an OTSA type so the matching was done by looking at the specific purpose of each mock-up.

"Insisting on cute displays when other means would work better is counterproductive, even if everyone seems to be in love with them. This love is fickle." – Stephen Few, 2006

5. Dashboard Mock-Ups

This chapter contains a detailed description of second, third and fourth step in the building phase of the ADR Framework: the design, data collection and development process of the mock-ups. First the initial designs for each of the four OTSA-types are presented, followed by a more detailed design for the two mock-ups which were actually developed. The second section discusses the collected data and the code used to develop the mock-ups. Then screenshots of the mock-ups are presented accompanied by descriptions of the mock-ups. In the final section the mock-ups are validated by comparing them against the characteristics of the OTSA-type dashboard they are supposed to represent.

5.1. Dashboard Design

5.1.1. Mock-Ups Designs

To create a design for the four types of mock-up dashboards for each mock-up a purpose and corresponding user had to be defined. This process was described in chapter 4. After the assignment of a purpose and user group to each mock-up, user requirements were listed for each mock-up. A complete overview of the most important requirements of the mock-ups is presented in table format below.

	Operational	*Tactical*	*Strategic*	*Analytical*
Main User	WFP Country Offices	Country Governments	Country Governments and WFP Donors	Nutritional Analysis Team
Purpose	Monitoring of WFP Country Offices Projects	Understanding current situation in a country and seeing trade-offs for policy options	Show updates on SDG progress and WFP Projects Contribution	Explore CoD software
Information	Details on Projects	Details on countries, regions and policy-options	Summary on Country Progress and WFP Projects	Raw Data from CoD software
Updates	Daily/Monthly	Monthly/Quarterly	Quarterly/Yearly	Not applicable
Visualisation & Interaction	Simple display Changes over time visible; Immediate action clear	Easy to understand graphics; Supports comparison options	Easy to understand Shows progress clearly	Supports data interactions More technical display

Table 10: Overview of Mock-Up Requirements

During the development phase of the dashboards, it was realized that the Operational and Tactical mock-ups could not be developed to an acceptable level. Due to difficulties in collecting appropriate data and time constrictions these two designs were not further developed and excluded from being evaluated. In the text below the design of the Strategic and Analytical mock-up dashboards are explained in more detail, accompanied with sketches on their initial design.

Strategic Mock-Up Design

The purpose of the Strategic dashboard is to give updates on WFP projects for governments and most importantly donors combined with showing progress on the SDG goals of that country. The time period of data updates would be quarterly to yearly. The content ideas of the dashboard are to show a list of sustainable development goals for that country and to show the country's performance versus this goal. Additionally, it would show the country's performance versus other countries and show the WFP projects that contribute to the specific SDG goal. This dashboard is strategic as it shows the progress of a country and what is being done to support meeting the goals. As the users are unfamiliar with dashboards, the visualisations should be easy to understand. The initial design sketch of the Strategic mock-up can be seen in the figure below.
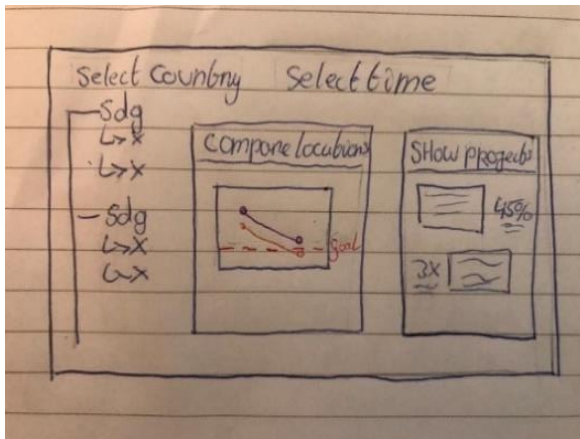
Figure 9: Initial Design Sketch of Strategic Mock-Up

Initially, the Strategic Mock-Up would contain a selection panel on the left side in which the relevant SDG could be selected. Next to this tree the progress of the selected country against this SDG would be visualised in a graph. Per selected SDG the relevant WFP projects would be visualised on the right side of the screen.

Following advice from a representative from Project ENHANCE and external advisors, the design was updated to include a table at the top of the screen. In this table all of the relevant SDG's would be displayed so that at a glance immediately the country's progress would be clear.

Analytical Mock-Up Design

The initial design of the Analytical mock-up can be seen in the image below. The purpose of the Analytical dashboard would be to explore the CoD software. The user is the Nutritional Analysis Team and the update period of the data depends on the available data of the software. For content ideas of the dashboard the python version of the CoD software from Zero Hunger Lab was used as a foundation for the design. As the CoD software is a linear optimization model with mathematical equations, the process behind setting these parameters and optimization was displayed in the initial design. Per requests of the Nutritional Analysis Team, this dashboard would include export and import options for data. Compared to the Strategic mock-up, this dashboard would show a lot more data and tables.

Following a consultation with a representative of the ZHL who works with the CoD software, it was decided against showing the optimization model behind the CoD software as this would be too complex to visualise within one screen. Instead, the design of the Analytical mock-up was changed so that it would mainly include tables and more complex data visualisations. A larger settings panel including sliders was also added to the improved design.
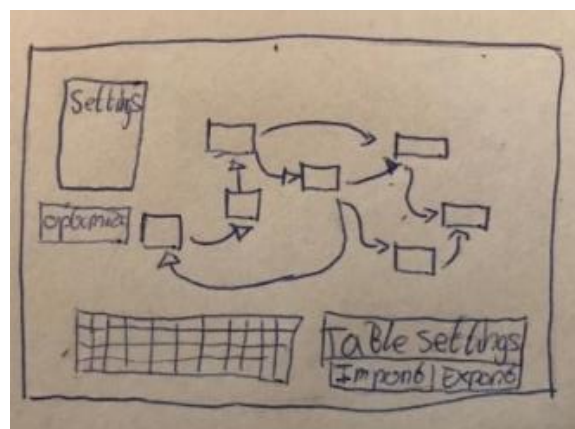
Figure 10: Initial Design Sketch of Analytical Mock-up

5.2. Dashboard Development

5.2.1. Data

Each mock-up was created using different data sources, for which in this section a general description can be found. The full list of data sources used are in Appendix G.

For the Strategic dashboard data on the WFP projects in Indonesia and Ethiopia was sought, but ultimately partly made up based on existing examples due to limited information availability. Data on the SDGs progress in each of these countries was used from several online databases on the SDGs.

For the Analytical dashboard data on the population in both Ethiopia & Indonesia was collected from online population databases. The ZHL further provided a mock-up data collection to be used in the dashboard, which contained data on prices of food products, nutritional composition of food products and the nutrition requirements of individuals. The data from the ZHL was edited to be reduced in size.

5.2.2. Scripts

The dashboards were programmed in Python using Dash, a library which is especially built for the purpose of creating dashboards. The scripts can be found at https://github.com/Mkeulen/dashboard-enhance. In addition to the python scripts a customized CSS file was created to make the dashboards appear user-friendly and aesthetically pleasing. The mock-ups were hosted on https://enhance-tryout-app.herokuapp.com/.

5.3. Final version of Mock-Ups

The final mock-up dashboard was created as one single website where each dashboard is a tab page. The mock-up always opens on the Analytical dashboard and contains a disclaimer to alert testers to the fact that part of the data is made up.

5.3.1. The Analytical Mock-Up Dashboard

On the next page the screenshot of the Analytical mock-up can be seen. In the image the Analytical mock-up dashboard can be seen as it appears when users first open the dashboard. In the top left section called 'Population Settings' users can select from a dropdown menu between the countries of Ethiopia and Indonesia. Then, users can choose whether or not to optimize the diet for the entire population of the country, a specific household or an individual person. Below these selection options are two buttons which are not working but are clickable: import data & export data. The actual functionalities were not included in the mock-up due to technical constraints.

The first row of the dashboard also contains a table with the daily diet requirements of the population of the selected country. This table is made up of the columns: Person description, number of people, and the requirements for energy (kcal), protein (g) and fat (g) per person type.

The second row of the dashboard contains the diet constraints box on the left. Here the optimized diet can be constrained by choosing the diet type from omnivore, vegetarian and vegan which updates the table on the right to only show the constrained products per diet type. Below the dropdown are sliders to select the range in which the optimized diet may fall. Users can then choose whether the optimized diet should stay close to the provided reference diet and whether a single or multiple results should be presented. None of the functionalities above actually influence the optimized diet that will be shown as this would require too complex mathematical equations. Above all else, the purpose of this mock-up was not to create the best functioning mock-up; it needed to be just functioning enough for users to get an idea of what it might look like.
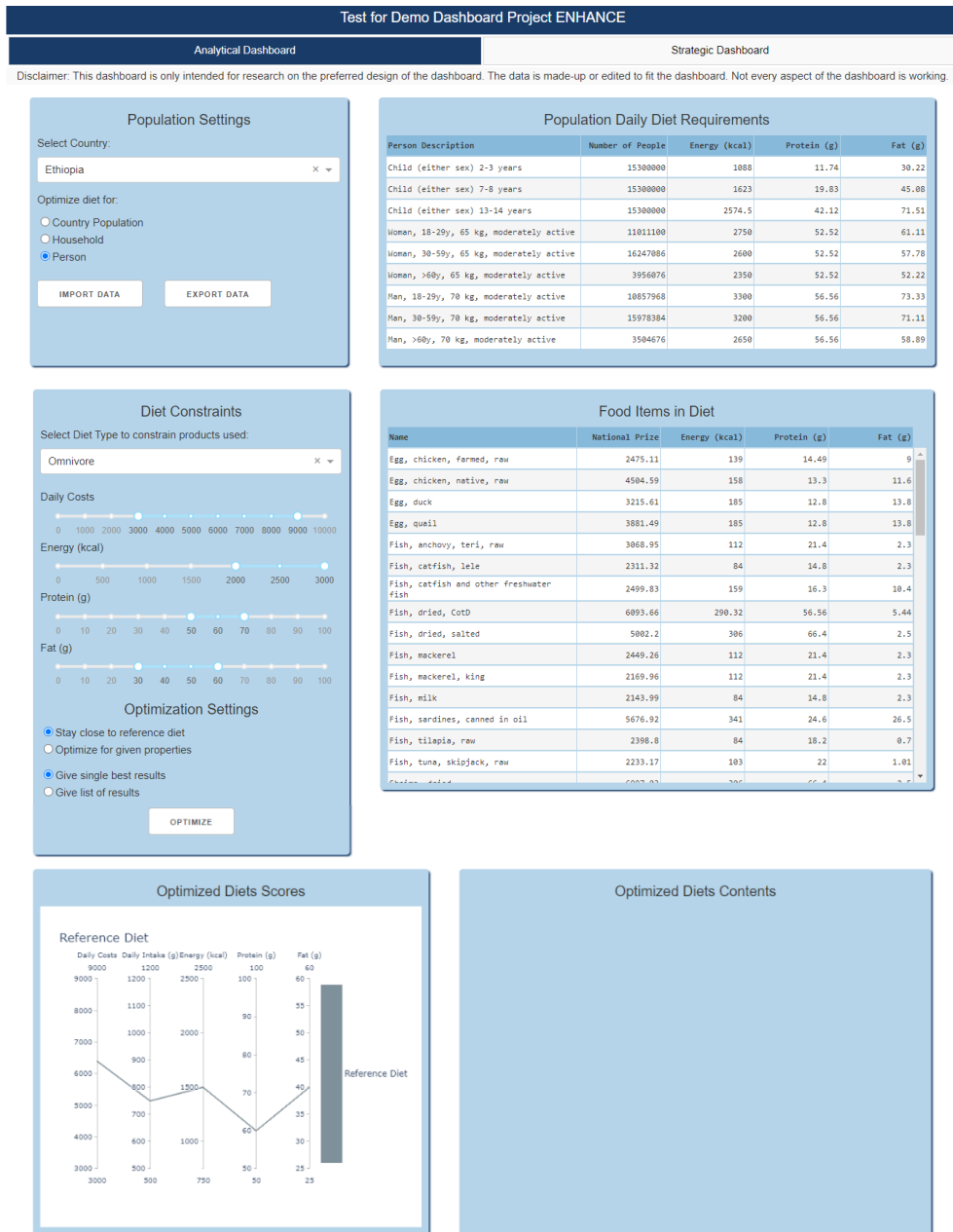
Figure 11: Screenshot of the Analytical mock-up

The table on the right of the diet constraints shows the food items which are available to be included in the optimized diet. For each product the national prize is shown along with the amount of energy, protein, and fat in each product. The third row of the dashboard shows the results once the 'Optimize'-button is clicked. Initially it only shows the reference diet in the figure left and shows nothing in the figure right. Clicking the button leads to the data visualisations which can be observed in the following figure.
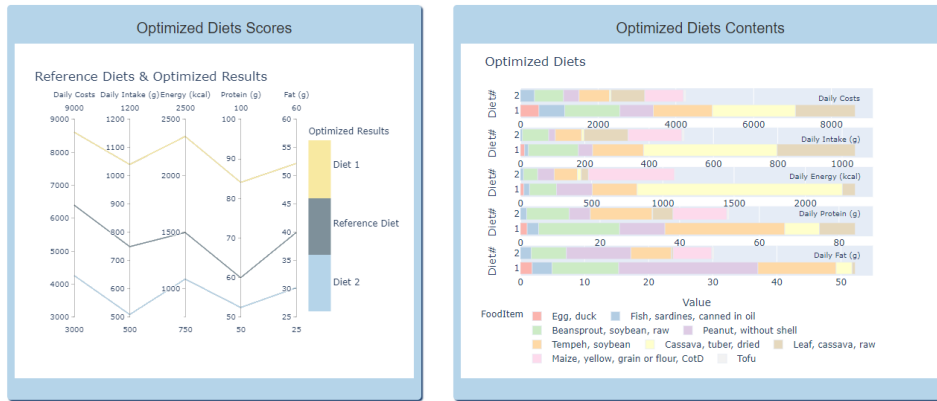
Figure 12: Screenshot of the Analytical mock-up after clicking 'Optimize'

The section labelled 'optimized diet scores' show how two fictional diets perform on several axes such as daily intake, daily costs and how it meets the requirements of energy, protein and fat. The second section shows how each diet is made up from different products and how each of those products contributes to the overall value a diet has for each of the axes in the left figure.

The following requirements were (partly) met by the Analytical mock-up:

- I1 Prices of food, both regional and national
- I2 Affordability of diet
- I3 Aggregated nutrient score of how nutritious the diet is
- I4 Nutritional consistency of food
- I5 Nutritional needs of different age and sex groups
- I7 Type of diet: vegetarian, vegan, etc
- D1 Be as granular as possible
- D2 Separated by gender and age groups
- F2 To calculate the affordability of a diet
- F3 That if you select a diet to see similar diets given certain parameters
- F5 To optimize the diet based on certain parameters or see multiple suggestions
- F7 To compare different diets
- F9 To correlate the diet with different data
- F10 Create a basket for a household with different household members, that meets criteria for all those members
- F11 To adjust parameters and situations
- V1 See trade-offs between different objectives: cost, environment, nutritional
- V3 See greatest contributor in diet in diet in terms of cost, water footprint, greenhouse gas footprint
- V7 Standard format for each country
- V10 No pie charts
- V11 No maps
- V12 A button which says start optimizing

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5.3.2. The Strategic Mock-Up Dashboard

The Strategic mock-up contains two distinct rows. The top row contains a section called 'dashboard settings' which contains the same dropdown seen in the Analytical mock-up to select a country. Below this dropdown is a list of radio-items from which one indicator can be selected. The indicators are used to track a country's performance on the Sustainable Development Goal 2: 'Zero Hunger'. Selecting an indicator updates the second row of the dashboard.
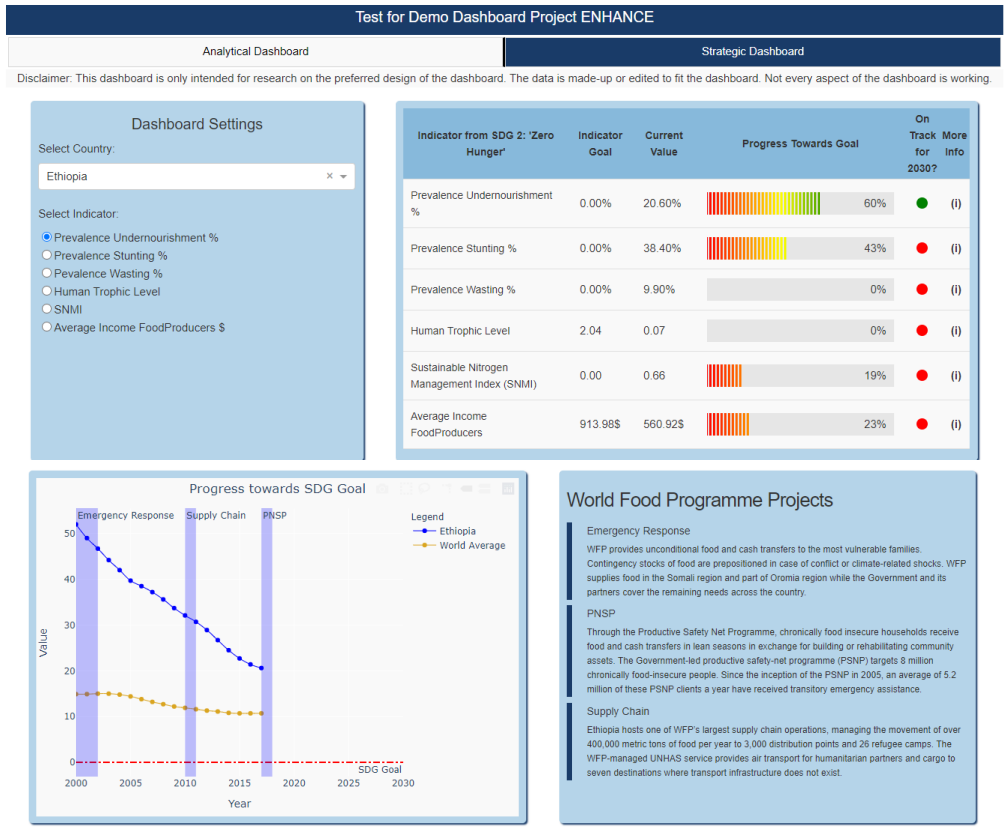
Figure 13: Screenshot of the Strategic mock-up

The second row shows on the left a graph displaying the progress a country has made in achieving the indicator's goal along with a comparison against the world's average for that indicator. The projects the WFP has undertaken to make progress on this indicator are displayed in the graph for the period in which the projects took place alongside a description of the projects on the right side of the graph.

The top row also contains a table displaying for each indicator its goal, current value, progress towards the goal and whether or not the country is on track to achieve the goal by 2030. Hovering over the 'more information'-icon displays more information on the indicator itself.

The following requirements were (partly) met by the Strategic mock-up:
- I17   WFP Country Office Projects: Location, Partners, Main Findings, Status
- D3   Retrospective
- D4   Show the future
- F12   To compare countries
- V4   See if they are meeting their SDG goal
- V5   Very easy to understand
- V6   Include drawings, figures, icons
- V7   Standard format for each country
- V10   No pie charts
- V11   No maps

5.4. Validation of Mock-Ups

To ensure the mock-ups were an accurate reflection of the OTSA dashboard type they were meant to represent, the mock-ups were validated by comparing them against the previous defined characteristics of the OTSA dashboards (see chapter 2).

5.4.1. Validation of the Strategic Mock-Up

In the table below the cells of the Strategic dashboard are coloured green if the Strategic mock-up was determined to be an accurate representation of that aspect. For instance, the mock-up was designed to be used by executives and thus that cell is coloured green. A cell containing an aspect is coloured red if the aspect was not displayed in such a way in the mock-up that it reflected well on its intended archetype.

	Operational	*Tactical*	*Strategic*	*Analytical*
Main Users	Operational Staff	Managers	Executives	Business Analysts
Level of Seniority	Junior	Middle	Senior	Middle
Purpose	Operational Control	Process Optimization	Strategy Management	Business Analyses
Information	Details	Detailed Summary	Summary	Raw Data
Metrics & KPI's	Drivers	Drivers and Outcomes	Outcomes	Raw Data
Scope	Department	Multiple Departments	Organisation	Variable
Updates	Daily / Hourly	Weekly / Daily	Quarter / Monthly	Variable
Time Period	Routine	Medium-Term	Long-Term	Medium-Term
Time Focus	Past	Current	Future	Variable
Visualisation & Interaction	Simple display of data, immediate action clear	Simple graphical visualisations, supports interactions	Simple aggregated graphical visualisations without interaction	Support interactions with data, Complex displays

Table 11: Validation of the Strategic Mock-Up

The Strategic mock-up was validated to be an accurate reflection of its intended archetype, as it matched all of its characteristics with the exception of the aspect of Updates and Scope. The aspect of Updates could not be accurately displayed in the mock-up as it will not be updated. The aspect of Scope was determined to not also be completely following the archetype, as the dashboard includes information not only on the WFP as a whole but also on a country as a whole. Furthermore, the Strategic mock-up focussed on both the past and the future by displaying historical progress of the country as well as expected progress to meet the SDGs.

5.4.2. Validation of the Analytical Mock-Up

The Analytical mock-up was also validated to be an accurate reflection of its intended archetype, as it displayed almost all aspects as would be expected in an Analytical dashboard.

	Operational	*Tactical*	*Strategic*	*Analytical*
Main Users	Operational Staff	Managers	Executives	Business Analysts
Level of Seniority	Junior	Middle	Senior	Middle
Purpose	Operational Control	Process Optimization	Strategy Management	Business Analyses
Information	Details	Detailed Summary	Summary	Raw Data
Metrics & KPI's	Drivers	Drivers and Outcomes	Outcomes	Raw Data
Scope	Department	Multiple Departments	Organisation	Variable
Updates	Daily / Hourly	Weekly / Daily	Quarter / Monthly	Variable
Time Period	Routine	Medium-Term	Long-Term	Medium-Term
Time Focus	Past	Current	Future	Variable
Visualisation & Interaction	Simple display of data, immediate action clear	Simple graphical visualisations, supports interactions	Simple aggregated graphical visualisations without interaction	Support interactions with data, Complex displays

Table 12: Validation of the Analytical Mock-Up

The aspects which were determined not to have been displayed or included correctly were the aspects of Updates, Time Period and Time Focus. Similar to the Strategic mock-up, the Analytical mock-up will not be updated. Furthermore, due to its analytical nature there is no time sensitive data included in the dashboard. This makes both the aspects of Time Period and Time Focus irrelevant.

"If the statistics are boring, then you've got the wrong numbers" – Tufte, 1983

6. Dashboards Evaluations Results

Following the intervention and evaluation phases in which respondents explored and evaluated the mock-ups, this chapter presents the results of the evaluation of the custom-made dashboards as well as the small evaluation of the pre-made dashboards. The first section contains a descriptive summary of evaluation survey respondents and results, followed by an exploratory in-depth analysis on the survey results divided per role of the respondents as well as the total results. The second section contains a small exploratory analysis of the rankings of the pre-made dashboards. Findings of both sections are summarised in the final conclusion section.

6.1. Evaluation of Custom-Made Dashboards

6.1.1. Evaluation Survey Data Descriptive Summary

The survey was sent to 16 respondents, of which 9 answered within the allocated timeframe of two weeks. Two of the respondents were from the World Food Programme Country Offices, one at the operational level and one at the management level. From the World Food Programme System Analysis Team two analysts filled in the survey. Two more analysts from the Zero Hunger Lab completed the survey as well as an executive from that organisation. From Capgemini and John Hopkins University only one respondent filled in the survey, one working at the operational level and the other at the executive level. In the table below an overview can be found of the organisations and roles of the respondents.

	Roles				
	O	M	E	A	Total
WFP-Country	1	1			2
WFP-SA				2	2
ZHL			1	2	3
Capgemini	1				1
JHU			1		1
Other					0
Total Respondents	**2**	**1**	**2**	**4**	**9**

Figure 14: Overview of all Survey Respondents

Per respondent there were 69 rows of data: 29 rows for the individual evaluations of the Analytical mock-up, 29 rows for the Strategic mock-up, 10 rows for the section of the survey where respondents were asked to choose between the two mock-ups and 1 row for any final comments. In total this gave 621 rows of data in the Excel file. The complete overview of the survey questions can be found in Appendix E. The data of the Likert-questions and choice-questions was visualised using the software Tableau so that it could be investigated easier. The text comments were explored in Excel.

6.1.2. Evaluation Survey Results Analysis per Role

To ensure potential differences per role would not be missed in a total results analysis, first analyses per role were conducted. The following sections present these analyses for the Operational respondents, Management respondent, Executive respondents and Analyst respondents, in that respective order.

Survey Results by Operational Respondents

The survey was answered by two respondents who were determined to fall in the 'operational' category: Respondent #5 and Respondent #7. Respondent #5 listed the World Food Programme – Country Office as their organisation. Respondent #7 listed Capgemini as their organisation.

In the image below it can be seen that neither of the Operational respondents ever chose the Analytical mock-up and only once chose the Strategic mock-up for the choice-questions at the end of the survey. The respondents selected the 'Other'-option in all other choice-questions.
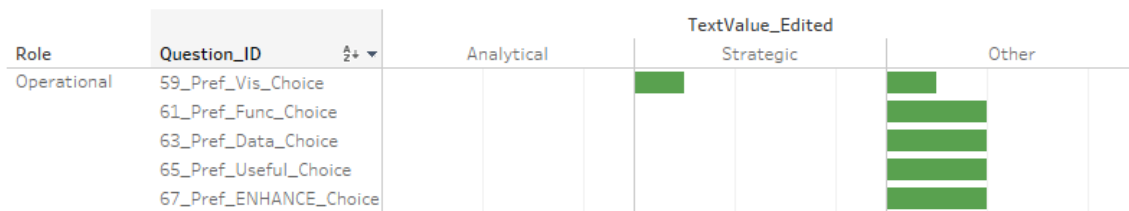
Figure 15: Operational Respondents Results on Choice-Questions

Respondent 5 chose the Strategic mock-up for the visualisation choice-question, with the following comment: *"Maybe the simplicity and minimal layering of the dashboard makes it easy to understand faster while the analytical one takes some time, which is understandable since it contains may different parameters"*. Resp7 stated that *"In the strategic dashboard the visualisations are less overwhelming: less info to display and includes some intuitive colour-coding"*.

Resp5 listed 'Both' as reasoning behind choosing the 'Other'-option for all the following four choice-questions, indicating that they could not make a choice between the two mock-ups. Resp5 gave as further reasoning in one of the comments: *"The difference is in the audience each one is relevant to. Analytical might be more useful to programme designers and implementers while the later* (Strategic) *to Management"*.

Respondent 7 argued in his comments to the choice-questions that the choice between the two dashboards depends on your role for the choice-questions on visualisation, data and usefulness for Project ENHANCE. For the functional question Resp7 noted that both dashboards have pros and cons, but did not specify what they were. For the choice-question on personal usefulness Resp7 noted that neither dashboard would be useful to them.

To understand the choices made by the Operational respondents when asked to choose between the two mock-ups, their evaluations of the individual mock-ups was further analysed. By summarising their scores on the Likert-questions per dashboard, an average evaluation score of each mock-up could be determined. These scores are presented on the right.

	Analytical	Strategic
Resp5	4,16	4,84
Resp7	2,95	3,63
Operational Average	3,55	4,24

Figure 16: Average Evaluation Scores by the Operational Respondents

Both respondents scored the Strategic mock-up on average about 0.7 point higher than the Analytical mock-up. This differs from their answers to the choice questions, in which no overall preference for either one of the dashboards could be observed. To understand these higher average evaluation scores of the Strategic mock-up, the scores per Likert-question were visualised in the following image.

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Evaluation Score
- Strongly Disagree
- Somewhat Disagree
- Neither Agree/Disagree
- Somewhat Agree
- Strongly Agree

Category	Statement	Analytical Mock-Up (Avg. Evaluation Score)	Strategic Mock-Up (Avg. Evaluation Score)
User Acceptance	The dashboard would help me to achieve my goals	50% 3,5 50%	50% 50% 4
	The dashboard would be useful to me	50% 4 50%	50% 50% 4
	The dashboard would help me to make better decisions	50% 4 50%	50% 50% 4
	I am generally satisfied with the dashboard	50% 4 50%	50% 50% 4
Facilitating Conditions	I have the knowledge necessary to use the dashboard	50% 4 50%	50% 50% 4,5
	The dashboard does not require high level technical knowledge	2 100%	50% 50% 4,5
System Quality	My interaction with the dashboard was satisfying	50% 3,5 50%	50% 50% 4,5
	My interaction with the dashboard is clear and understandable	50% 3 50%	50% 50% 4,5
Data Quality	The data in the dashboard can be easily interpreted (easy to understand)	50% 3 50%	50% 50% 4,5
	The dashboard contains useful data metrics	50% 4 50%	50% 50% 4,5
	The dashboard contains data at a sufficient level of detail	50% 4 50%	100% 4
	The dashboard focusses on a useful time-frame	50% 3 50%	100% 4
Functional Features	The dashboard provides all the functionalities I am interested in	100% 4	100% 4
	The dashboard is easy to use	100% 4	50% 50% 4,5
Visual Features	The dashboard has a clear visualisation	100% 4	50% 50% 4,5
	The visualisation provided by the dashboard makes better interpretation of the data	50% 3,5 50%	50% 50% 4
	I am satisfied with how the data is visualized in the dashboard	50% 3,5 50%	50% 50% 4,5
Intention to Use	I would use the dashboard frequently	50% 3,5 50%	50% 50% 4
	The dashboard would be accepted by my colleagues	3 100%	50% 50% 4

% of Respondents (0% 20% 40% 60% 80% 100%)

Figure 17: Evaluation Scores by the Operational Respondents

The higher average evaluation scores of the Strategic mock-up were found to be due to the following reasons. The lowest average evaluation score was a 2 for the Analytical mock-up on the statement that the dashboard does not require high technical knowledge. The highest average score given to any aspect of the Operational dashboard is a 4, which is the lowest average score given to any aspect of the Strategic dashboard. None of the aspects of the Strategic dashboard received an average score lower than a 4, with ten aspects of the Analytical dashboard receiving at most a 3,5 or lower average score.

Several comments made by the Operational respondents gave useful insights to their evaluations. The aspect of User Acceptance for the Analytical mock-up was evaluated positively by Resp5 who commented that "*It is a quick but efficient tool for programme implementers and designers to use targeting specific populations*". However, both respondents were critical of how difficult the Analytical mock-up was. Resp5 commented on the aspect of Facilitating Conditions that: "*While some bits are easy to read and interpret, other items such as "optimizing diets" may require specific training on Cost of the Diet software*". Resp7 also noted difficulty understanding the mock-up: "*Interpretation of the results is hard. Am I looking a person, household or nation avg when comparing diets?*".

For the Strategic mock-up, Resp5 made the comment that "*The user interface is easier to understand compared to the analytical one*" on the Visual Likert-question. Respondent 7 made no comments for the questions on the Strategic mock-up.

Survey Results by Management Respondents

The survey was answered by one respondent who was determined to fall in the 'Management category: Respondent #3. They listed the World Food Programme – Country Office as their organisation.

In the image below it can be seen that the Management respondent chose the Analytical mock-up three times and selected the Strategic mock-up twice for the choice-questions. They never selected the 'Other'-option.
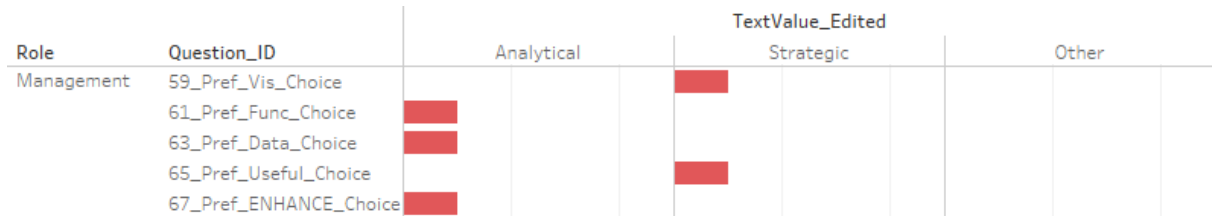
Figure 18: Management Respondents Results on Choice-Questions

Respondent 3 chose the Strategic dashboard for the Visualisation choice-question and for their Personal Usefulness choice-question. For these questions they made the comments that: "*Dashboard information should be aligned with audiences for easy digest and use for decision maker to act*" (Visualisation) and "*Note that Indonesia does not implement the program like in other places, no food aid component, no traditional school feeding programme, in principle, WFP Indonesia is supporting to government priorities. Perhaps it would be good if this dashboard is integrated to exist government dashboard*" (Personal Usefulness). From these comments no reasoning could be found for their choices.

Resp3 evaluated the Analytical mock-up on average slightly higher than the Strategic mock-up. This aligns with their answers to the choice questions, in which a small preference for the Analytical dashboard could be observed. To understand the reasoning behind these evaluations, the scores per Likert-question were visualised in the following image.

	Analytical	Strategic
Resp3	3,89	3,53
Management Average	3,89	3,53

Figure 19: Average Evaluation Scores by the Management Respondent

Figure 20: Evaluation Scores by the Management Respondent

Only the Analytical mock-up ever received a high score of 5 on the question whether the Analytical mock-up would be useful to Resp3. The Strategic mock-up only received a 4 on this question. This is in contradiction with the choice-question on which dashboard would be most useful to them, as Resp3 there chose the Strategic mock-up. Furthermore, the Strategic mock-up was evaluated with more low scores of 3 than the Analytical mock-up. The Analytical mock-up was not given a 3 on any aspect for which the Strategic mock-up also did not receive a 3. On the aspects of achieving goals, requiring high technical knowledge, satisfying interaction, containing useful data, focussing on useful time-frame and having clear visualisations the Strategic mock-up scored lower.

Resp3 left limited comments to explain their evaluation scores, but some insights could be derived from them. For the Analytical mock-up most of the comments listed possible improvements such as: "*Indicator may go bit down to sub-national, like a case in Indonesia, it is a huge country and disparities is a big gap*" on the aspect of Visualisation. On the aspect of Functional Features Resp3 noted that "Y*es it looks easy to use and understand.*"

For the Strategic mock-up the respondent only made one comment: *"Dashboard should be consulted to government stakeholders since they are managing national dashboard"*. It was assumed that since the comments made by Resp3 for both mock-ups included many mentions of Indonesia, this respondent came from that particular country office of the WFP.

The survey was answered by two Executive respondents. Respondent #6 listed John Hopkins University as their organisation. The other respondent, #8, selected the Zero Hunger Lab as their organisation.

In the image below it can be seen that the Executive respondents never selected the 'Other'-option. Both respondents chose the Strategic dashboard for the visualisation question, but preferred the Analytical dashboard for the functionality and data question. On the question which dashboard would be most useful to them personally and for Project ENHANCE, they were equally divided.
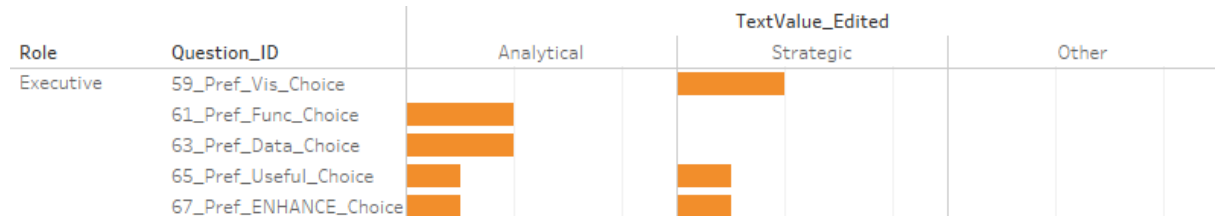
Figure 21: Executive Respondents Results on Choice-Questions

To understand the reasoning behind their choices for these questions, the comments the Executive respondents made for these choice-questions were investigated. Only Resp8 made two comments for these questions, whereas Resp6 left all these open-ended comment-questions blank. Respondent 8 gave as their reasoning for choosing the Strategic mock-up for the Visualisation choice-question: *"More condensed information"*. For the question on functionality, Resp8 chose the Analytical mock-up with the comment that the mock-up "*Gives more feeling of 'control'*".

Resp6 gave an average higher score to the Strategic dashboard of 0.16 point, whereas Resp8 gave an average higher score to the Analytical dashboard of 0.05 point. As the average score given to the Analytical dashboard by Resp8 was barely higher than the Strategic dashboard, the overall average Executive evaluation score is very slightly in favour of the Strategic dashboard.

	Analytical	**Strategic**
Resp6	3,68	3,84
Resp8	4,58	4,53
Executive Average	4,13	4,18

Figure 22: Average Evaluation Scores by the Executive Respondents

This matches their answers to the choice questions, in which no clear overall preference for either one of the dashboards could be observed. To further explore these average scores, the scores per Likert-question were visualised in the following image.

Category	Statement	Analytical Mock-Up (Avg. Evaluation Score)	Strategic Mock-Up (Avg. Evaluation Score)
User Acceptance	The dashboard would help me to achieve my goals	4	4,5
	The dashboard would be useful to me	4,5	4
	The dashboard would help me to make better decisions	4,5	3,5
	I am generally satisfied with the dashboard	4	4
Facilitating Conditions	I have the knowledge necessary to use the dashboard	4,5	4,5
	The dashboard does not require high level technical knowledge	4,5	4,5
System Quality	My interaction with the dashboard was satisfying	4,5	4,5
	My interaction with the dashboard is clear and understandable	4	4,5
Data Quality	The data in the dashboard can be easily interpreted (easy to understand)	4	4
	The dashboard contains useful data metrics	4	4,5
	The dashboard contains data at a sufficient level of detail	4	4
	The dashboard focusses on a useful time-frame	4,5	4,5
Functional Features	The dashboard provides all the functionalities I am interested in	4	4,5
	The dashboard is easy to use	4,5	5
Visual Features	The dashboard has a clear visualisation	4	4
	The visualisation provided by the dashboard makes better interpretation of the data	4	3,5
	I am satisfied with how the data is visualized in the dashboard	4	4
Intention to Use	I would use the dashboard frequently	3	3,5
	The dashboard would be accepted by my colleagues	4	4

Evaluation Score legend: Strongly Disagree, Somewhat Disagree, Neither Agree/Disagree, Somewhat Agree, Strongly Agree

Figure 23: Evaluation Scores by the Executive Respondents

From a glance, the evaluations of the two mock-ups appears to be relatively similar in terms of overall high and low scores given. The lowest average evaluation score is a 3 for the Analytical mock-up on the statement that they would use the dashboard frequently. In contrast with the respondents' favour for the Strategic mock-up, the next three lowest scores average scores were given to the Strategic mock-up for the aspects of using the dashboard frequently, the visualisation aids interpretation of the data and whether the dashboard would help make better decisions. The highest average score of 5 is only given once to the Strategic mock-up on whether the dashboard is easy to use. Inconsistently, the respondents gave higher average scores to the visual features section of the Analytical mock-up than the Strategic mock-up. Even though they both selected the Strategic mock-up for the Visualisation choice-question.

Resp6 left all open-ended questions blank and Resp8 made only a few comments for the Strategic mock-up which offered not clear insights. However, on the Facilitating Conditions of the Analytical mock-up Resp8 commented that: "*It looks really user-friendly. And of course, you need to know a lot before successfully using the dashboard.*" This is a contradiction of their positive score to the statement that the dashboard does not require high technical knowledge. On the Visual Features of the Analytical mock-up, they made the following comment "*Is clear, I guess...*', which does not come across as a very enthusiastic statement. This matches the lower average scores given to the statements on the visual aspects of the Analytical mock-up, but gives no explanation as to why these scores were lower.

Survey Results by Analyst Respondents

The survey was answered by four respondents who selected the Analyst role as their main position. Two of those listed the World Food Programme – Nutrition System Analysis Team as their organisation: respondent #1 and #4. Respondent #2 and respondent #9 listed the Zero Hunger Lab as their organisation.

In the image below it can be seen that the Analyst respondents chose the Analytical mock-up with a clear majority. Only three times a different option was selected, with once a preference for the Strategic mock-up on the Visualisation choice-question. Two times the 'Other'-option was selected, on the aspects of data and which dashboard would be most useful to Project ENHANCE.
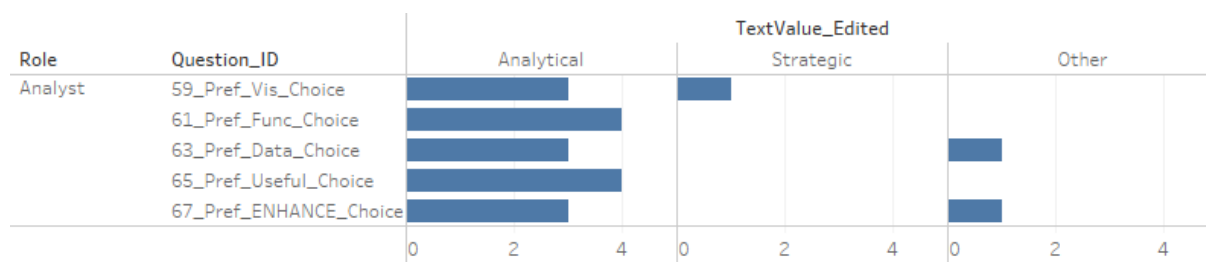
Figure 24: Analyst Respondents Results on Choice-Questions

To understand the reasoning behind the choices the Analyst respondents made, their comments for these questions were further investigated. Resp4 gave no comments and Resp9 gave only one comment. This comment was made to explain their choice to the visualisation question, where they selected the Strategic dashboard. "*In the strategic dashboard the visualisations are less overwhelming: less info to display and includes some intuitive colour-coding*". Resp1 also only made one comment, to defend their choice on the visualisation question; where they chose the Analytical dashboard. "*There is generally richer information in the analytical dashboard*".

The two times the 'Other'-option was selected was done by Respondent 2, who provided comments with their choice. On the aspect of Data, they noted that "*I find it hard to say, as I am not the intended user. I would say that both are important, but in their own way. One of them focuses on diets and compares them, whereas the other shows overall progress (and you cannot compare policies).*" This sentiment of the dashboards being of equal importance was repeated in their comment on which dashboard would be most useful to Project ENHANCE. *"I think, in the end, a combination of both will be useful (compare diets and evaluate its influence on progress, does it match the strategic goals you have?). Maybe on different tabs, like you did."*

Three out of four Analyst respondents evaluated the Analytical mock-up with higher average scores. Resp2 rated the Strategic mock-up slightly higher with 0,11 point. The highest average score given to any dashboard was a 4,16 by Resp1 to the Analytical dashboard and by Resp2 to the Strategic dashboard. The lowest average score given was a 2,89 by Resp9 to the Strategic dashboard. The overall average evaluation score was also slightly in favour of the Analytical mock-up.

	Analytical	Strategic
Resp1	4,16	4,05
Resp2	4,05	4,16
Resp4	3,68	3,21
Resp9	3,53	2,89
Analysts Average	3,86	3,58

Figure 25: Average Evaluation Scores by the Analyst Respondents

These average evaluation scores match the answers made by the Analyst respondents to the choice questions, but the average evaluation score of the Analysts was expected to be more in favour of the Analytical mock-up. To further explore these average scores, the scores per Likert-question were visualised in the following image.

Figure 26: Evaluation Scores by the Analyst Respondents

The highest average score given by the Analyst respondents is a 5 for the statement that they would have the necessary knowledge to use the Analytical mock-up. This is followed by a 4,75 for the statement that the Analytical mock-up is easy to use and that the Strategic mock-up does not require high technical knowledge. The statement that the Analytical mock-up would be accepted by their colleagues is also evaluated with a high score of 4,5. Interestingly, the Analysts gave an average score of 2,75 for their satisfaction on how the data is visualised in the Analytical mock-up. The following lowest average scores are all 3's given to the Analytical mock-up for the aspects of timeframe of the data, providing all functionalities and whether the visualisation aids in the interpretation of the data. Considering the strong preference for the Analytical mock-up by the Analyst respondents to all the choice questions, the lowest average scores that were given to the Analytical mock-up are in sharp contrast.

The Analyst respondents made many positive comments to the Analytical mock-ups but also offered many possible points of improvements. All of the improvements are discussed in chapter 9. An example of the positive comments is the comment made by Resp2 on the aspect of Facilitating Conditions for the Analytical dashboard: *"Personally, I found the diet constraints part very intuitive. Secondly, I think that the user should be familiar with the idea behind CoD/ENHANCE to also use the dashboard but from a technical perspective it feels intuitive."*

6.1.3. Evaluation Survey Analysis Total Results

This section contains an analysis on the total results of the survey. This analysis was done to observe how the dashboards were evaluated by all organisations of Project ENHANCE together as well as to better see the differences between roles. As the different roles of the respondents were not equally divided over the different organisations, the differences between organisations were not further explored.

Results on Choice Questions between Dashboards

In the image below it can be observed that the Operational respondents selected the 'Other'-option more than any other roles. Furthermore, the Analyst respondents chose the Strategic dashboard far less than the Management respondent and Executive respondents.
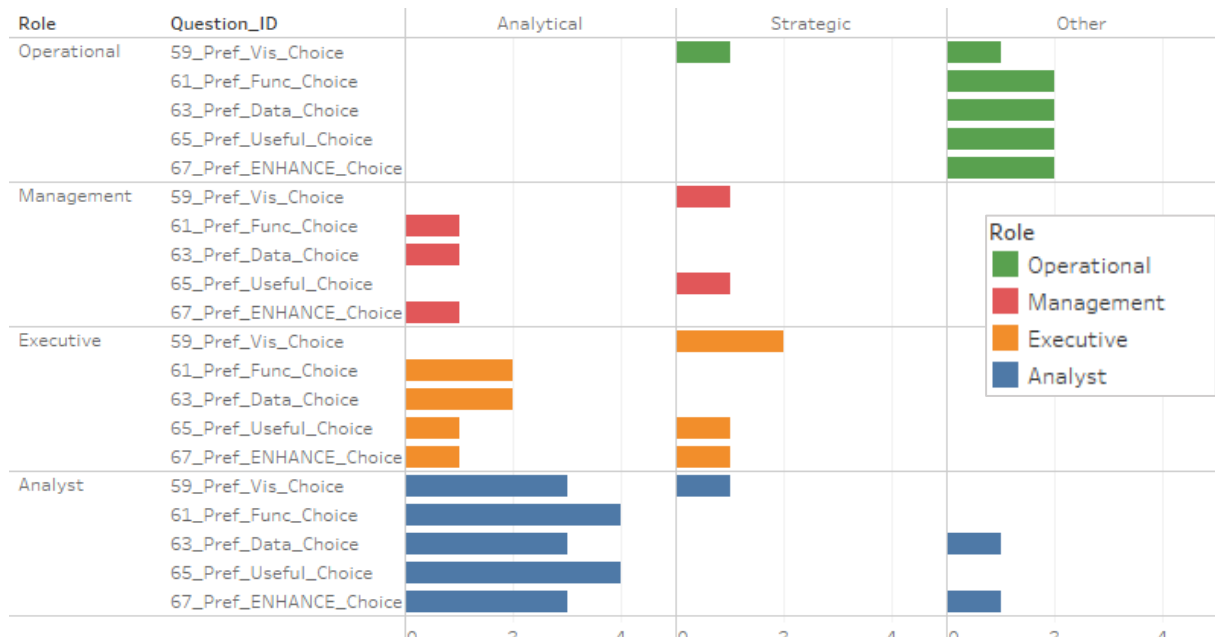
Figure 27: Total Results of Choice-Questions Per Role

In total, on four out of the five choice questions, the Analytical mock-up was chosen as the best option by a majority of five or more of the respondents. The question on the Functionality aspect saw the highest preference for the Analytical mock-up, with seven out of nine respondents preferring it over the Strategic mock-up.
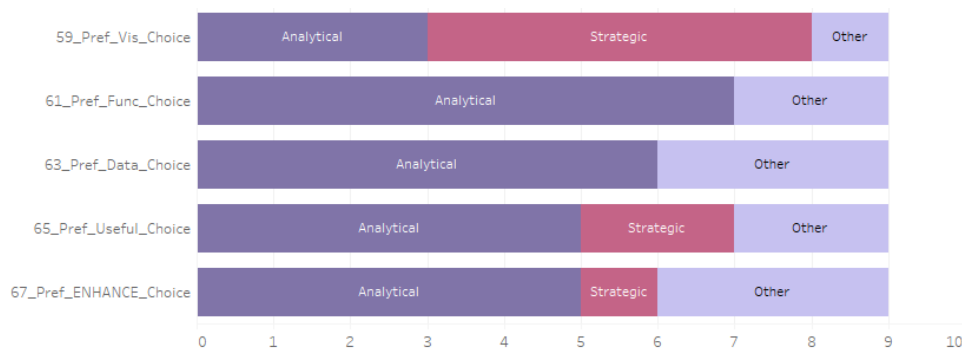
Figure 28: Combined Results on Choice-Questions

The exception to the overall preference for Analytical was the question on the Visual aspect. Here, the Strategic mock-up was chosen by five out of 9 respondents. The Strategic mock-up was never chosen as the best option for the aspects of Functionality and Data. Furthermore, only two respondents thought the Strategic mock-up would be the most useful for them personally and only one thought the Strategic

mock-up would be the most useful for Project ENHANCE. Only three respondents ever selected the option Other when asked to choose between the two dashboards.

Total Average Evaluations of Custom-Made Dashboards

In the following figure the average scores per evaluation of each mock-up can be seen. These are the average scores per role of all the Likert-questions per mock-up and the total average evaluation score.

	Analytical	Strategic
Operational	3,55	4,24
Management	3,89	3,53
Executive	4,13	4,18
Analysts	3,86	3,58
Total	3,85	3,85

Figure 29: Total Average Evaluation Scores

Interestingly, both mock-ups are in total evaluated with the exact same average score of 3.85. This does not align with the results of the choice-questions, in which a strong preference for the Analytical mock-up was observed. When comparing the average evaluation scores per role, it can be seen that the Operational respondents gave the Strategic mock-up the overall highest average score of 4,24 and the overall lowest score was given by the Management respondent to the Strategic mock-up with 3,53. Both the Operational respondents and the Executive respondents rated the Strategic mock-up higher than the Analytical mock-up (although with a very minimal difference for the Executive respondents). The Management respondent and the Analysts gave a higher average score to the Analytical mock-up.

On the next page the total average evaluation scores per Likert-question are presented to see which aspects of the mock-ups were extremely positively or negatively evaluated. The following observations were made when investigating the overall average scores per Likert-question.

The Analytical mock-up has as its highest scores a 4,56 for the statement that users have the knowledge to use the dashboard, followed by a 4,44 for that the Analytical dashboard is easy to use. These positive evaluations were reflected in comments of the respondents, but several of them also noted that the Analytical mock-up could still be difficult to use for some people. For instance, Resp2 commented on the aspect of Facilitating Conditions for the Analytical dashboard that "*Personally, I found the diet constraints part very intuitive. Secondly, I think that the user should be familiar with the idea behind CoD/ENHANCE to also use the dashboard but from a technical perspective it feels intuitive*." Additionally, Resp5 commented that *"While some bits are easy to read and interpret, other items such as "optimizing diets" may require specific training on Cost of the Diet software"*.

The lowest score for the Analytical mock-up is a 3,33 for the statement that users were satisfied with the visualisations of the Analytical dashboard. Respondents were quite divided on this statement, which was reflected in the diverging comments made on this topic. Resp5 made the positive comment that "*I appreciated the detailed information that is included in the pop-ups as user hovers over specific areas on the charts and the fact that it is interactive"*. Whereas Resp2 commented that "*For me the Optimized Diets Scores is more difficult to easily understand. I do not really like the different axis with different scales as it implies that all features are equally important.*".

The Strategic mock-up has as its highest scores a 4,44 for the statement that it does not require high technical knowledge, followed by a 4,22 on three aspects: two on System Quality statements on interaction and one for the dashboard being easy to use. Although there were less comments made for the Strategic mock-up, Resp5 did make the comment that *"The user interface is easier to understand compared to the analytical one"*. The lowest scores which can be observed is a 3,11 for the statement that users would use the Strategic dashboard frequently.

Category	Statement	Analytical Mock-Up Avg. Evaluation Score	Strategic Mock-Up Avg. Evaluation Score
User Acceptance	The dashboard would help me to achieve my goals	3,89	3,78
	The dashboard would be useful to me	4,22	3,89
	The dashboard would help me to make better decisions	4,00	3,67
	I am generally satisfied with the dashboard	4,00	3,67
Facilitating Conditions	I have the knowledge necessary to use the dashboard	4,56	4,11
	The dashboard does not require high level technical knowledge	3,67	4,44
System Quality	My interaction with the dashboard was satisfying	4,11	4,22
	My interaction with the dashboard is clear and understandable	3,89	4,22
Data Quality	The data in the dashboard can be easily interpreted (easy to understand)	3,89	3,78
	The dashboard contains useful data metrics	3,78	4,11
	The dashboard contains data at a sufficient level of detail	3,89	3,78
	The dashboard focusses on a useful time-frame	3,44	3,78
Functional Features	The dashboard provides all the functionalities I am interested in	3,56	3,78
	The dashboard is easy to use	4,44	4,22
Visual Features	The dashboard has a clear visualisation	3,78	3,67
	The visualisation provided by the dashboard makes better interpretation of the data	3,44	3,56
	I am satisfied with how the data is visualized in the dashboard	3,33	3,78
Intention to Use	I would use the dashboard frequently	3,44	3,11
	The dashboard would be accepted by my colleagues	3,89	3,67

Evaluation Score legend: Strongly Disagree, Somewhat Disagree, Neither Agree/Disagree, Somewhat Agree, Strongly Agree
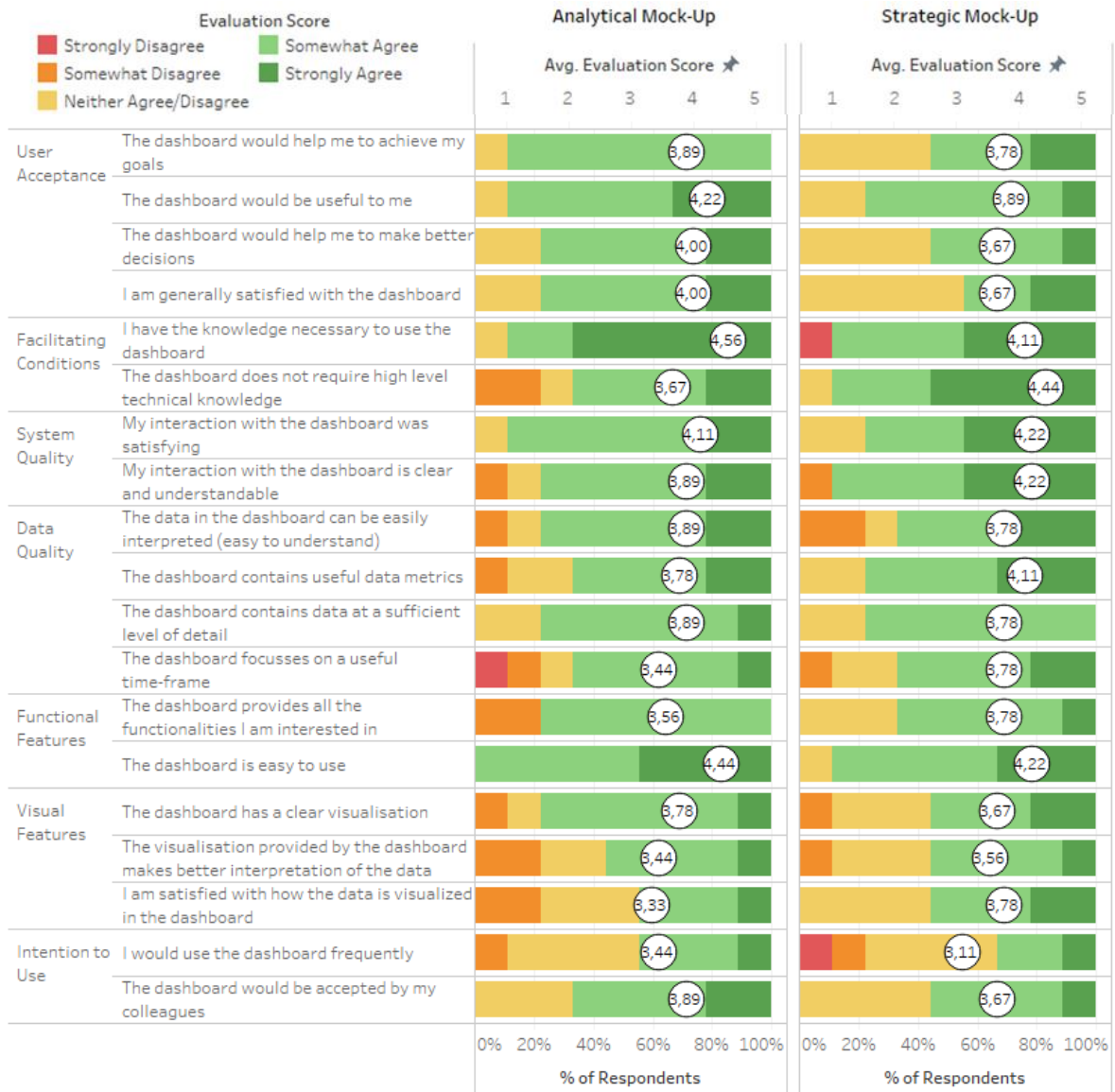
% of Respondents (0% – 100%)

Figure 30: Evaluation Scores of All Respondents

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6.2. Evaluations of Pre-Made Dashboards

In addition to the evaluation of the custom-made dashboards, another small evaluation was conducted to serve as supplemental information. During the user requirements interviews respondents were asked to rank four pre-made OTSA dashboards, which followed the guidelines from Few and Eckerson. See Appendix B for these pre-made dashboards. The interview results of the ranking of the four OTSA dashboards are presented in the figure below. See Appendix D for explanation behinds respondents ranking. Respondents 3A, 3B, and 4A did not want to rank the four types but noted that each one of the pre-made dashboards would be suitable for a different user.
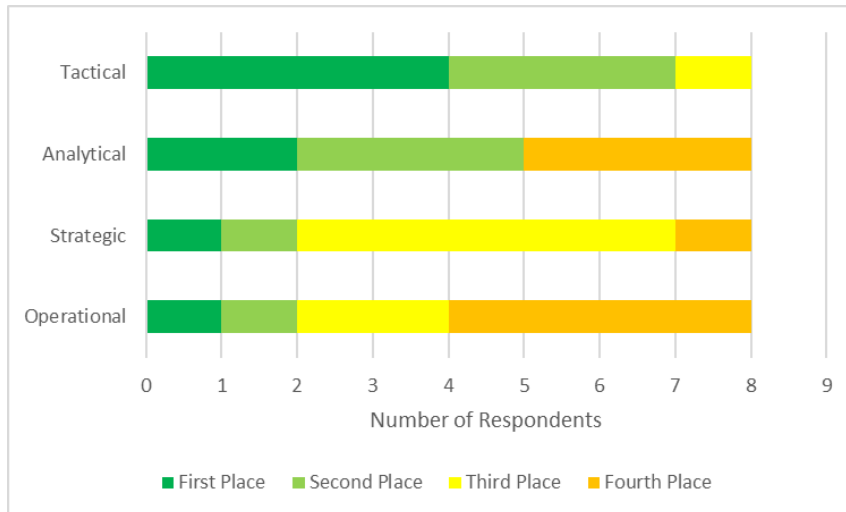

Figure 31: Ranking Results of Pre-Made OTSA Dashboards

The interviewee's showed a clear preference for the Tactical dashboard, with seven of the eight interviewee's listing it in the first or second place. Respondent 3D noted that in the Tactical dashboard it would be easier to understand the progress and respondent 1B noted that they preferred the Tactical dashboard visually.

The second place was taken by the Analytical dashboard; however, respondents were divided on its ranking with three interviewees' ranking the Analytical dashboard in the last spot. Respondent 1A and Respondent 1D, both from the WFP-SA, argued that they expected an Analytical dashboard to be used by analysts. Respondent 1A noted that: "*Analytical is attractive to me for my role, but would only be appropriate for internal use*". Respondent 1D expended on that, claiming that the dashboard did not have to be as visually friendly as for instance the Operational pre-made dashboard was. The pre-made Strategic dashboard was not as well received, with most respondents ranking it in third place. Respondent 2A argued that a Strategic dashboard would be too high level for Project ENHANCE, but both respondent 3B and 1B actually thought a Strategic dashboard would be good as everyone would be able to understand it.

Furthermore, 7 of the 11 interviewees noted that they thought a mix of two or more archetype dashboards would be the most suitable for them. The reasoning for this was that interviewee's thought each type would be suitable for a different user group. By combining archetype dashboards, the final dashboard would be suitable for different groups of users.

6.3. Conclusion on Evaluations of Dashboards

This chapter presented the results of the evaluations of the custom-made and pre-made dashboards to answer sub-question SQ4: *How do representatives from Project ENHANCE evaluate the different types of dashboards?*

In the exploratory analysis of the survey results per role, some differences between the different respondent groups could be observed. The Operational respondents gave no clear preference for either of the mock-up in the choice-questions, but evaluated the Analytical mock-up overall lower than the Strategic mock-up. Their lowest evaluation score criticized the high technical knowledge required for the Analytical mock-up. The Management respondent however evaluated the Strategic mock-up less favourably. They rated the Strategic mock-up lower for the statement that it did not require high technical knowledge. The Executive respondents showed only a slight preference for the Strategic mock-up in their evaluation scores and noted they preferred the Analytical mock-up for its functionality. The Analysts were clearly in favour of the Analytical mock-up in the choice-questions, but were rather critical of the Analytical mock-up in its individual evaluation. Especially the visualisations of the Analytical mock-up were criticized.

Overall, the two custom-made mock-up dashboards were evaluated by the respondents with exactly the same average score. When asked to choose between the two dashboards, the Analytical mock-up was preferred by a majority of the respondents on 4 out of 5 aspects. Their main reasoning for this preference was that they found the Analytical mock-up to contain richer information and that they appreciated the additional detailed information they could see in pop-ups. Furthermore, the comments of respondents indicated they liked the interactive functionalities of the dashboard, especially the sliders section. Overall, most of the respondents noted that the Analytical dashboard was easy to use and understand, whereas they did not always understand the Strategic one. However, it was noted by several respondents that familiarity with the work of Project ENHANCE would be essential for users to understand the Analytical mock-up. The majority of the respondents did prefer the visualisations of the Strategic mock-up, commenting that the graphs were easier to understand in that mock-up and criticizing the complexity of the visualisations in the Analytical dashboard. The Strategic mock-up was also positively evaluated for the statement that the mock-up did not require a high level of technical knowledge.

In the evaluation of the pre-made dashboards, 7 of the 11 interviewees noted that they thought a mix of two or more archetype dashboards would be the most suitable for Project ENHANCE. Respondents favoured the Tactical dashboard as they expected it to be easy to understand. They were divided on the suitability of the Analytical dashboard, with one interviewee commenting that it would perhaps only be suitable for internal use.

"There is a fine line between dashboard design and dashboard consumption" - Jonathan Taylor

7. Discussion

In this chapter the results of the reflection and learning phase of the ADR framework are described. The first section contains a reflection on the results in which the most striking findings are further discussed. This is followed by a section in which the limitations of this research are presented. The final section contains suggestions for future research topics.

7.1. Reflection on Results

7.1.1. Equal Total Average Scores for Individual Evaluations of Mock-Ups

Interestingly, both mock-ups were evaluated overall with the exact same average score of 3.85. This was unexpected as it did not align with the preferences given in the choice-questions. Although this result cannot be considered statistically significant due to the small number of respondents, it is still interesting to consider why the total average evaluation scores for each mock-up were equal. This could be because the test setting is not an accurate reflection of real-life evaluations, where the dashboards could be used multiple times. Overall, it shows the importance of not just individually evaluating each mock-up but also giving respondents the option of comparing them.

7.1.2. Relatively Low Evaluation Scores by Analysts for Analytical Mock-Up

Although a more distinct higher average score for the Analytical mock-up was expected based on the Analyst preferences in the-choice questions, the Analyst respondents evaluated the mock-up on average lower than both the Management and Executive respondents. To understand the reasoning behind these (relatively) low evaluations, the comments made by the Analyst respondents were further explored. For the aspects of Data Quality and Functional Features, the respondents made not so much negative remarks on the Analytical mock-up as rather mentioned a lot of possible areas for improvements. The improvements suggested were mostly quite technical and are discussed in Chapter 9. On the aspect of Visual Features Resp2 made the comment that *"For me the Optimized Diets Scores is more difficult to easily understand. I do not really like the different axis with different scales as it implies that all features are equally important."* When looking at the context of the Analyst respondents, it can be suggested that due to their experience their critical evaluations of the Analytical mock-up and yet preference for the Analytical mock-up in the choice-questions makes sense. As the respondents appear to be more familiar with this type of dashboard based on their many technical improvement suggestions, it makes sense that they would be more critical of the individual aspects. Overall, though, they would still prefer the Analytical mock-up as it has the purpose most relevant for their role.

7.1.3. Overall Preferred Visualisation of the Strategic Mock-Up in Choice-Questions

In the choice questions, eight out of nine respondents preferred the Strategic mock-up for its visualisations which was expected. In accordance with the design principles from Few, the Strategic mock-up was attempted to be given the easiest visual aspects (Few, 2006). Respondent 5 noted that: *"Maybe the simplicity and minimal layering of the dashboard makes it easy to understand faster while the analytical one takes some time, which is understandable since it contains may different parameters"*. This indicates that the aim of the visual design of the Strategic mock-up was successful.

7.1.4. Overall Preference for Analytical Mock-Up in Choice-Questions

On four out of the five choice questions, the Analytical mock-up was chosen as the best option by five or more of the nine respondents. Overall, it was expected the Strategic mock-up would be chosen more favourably, but this was not the case. Possible explanations for why the Analytical mock-up was chosen more favourably could be that the group of respondents was made up by almost a majority of analysts (four out of nine). As the Analysts respondents almost always selected the Analytical mock-up for the choice-questions, the scale could be relatively easily tipped in favour of the Analytical mock-up.

However, other respondents than the Analysts also chose the Analytical mock-up quite often for the choice-questions. This goes against expectations and could possibly be explained by the following reasons. First, the respondents of the survey might not have been the right kind of end-users. Most of them understood the context and details of the Analytical mock-up, making them evaluate it more positively, whereas the real end-users would probably not know the context of the information in the dashboard. Secondly, the Analytical mock-up could have been too easy to understand as the CoD software was reduced in its complexity to be able to quickly create a mock-up. And finally, the overall aim of Project ENHANCE stated at the beginning of this case study was to create a kind of Analytical dashboard which would contain the CoD software. It thus makes senses that members of Project ENHANCE would support this aim in evaluating the mock-ups, even it for their own role such a dashboard would not necessarily be useful.

7.2. Limitations
7.2.1. Choice of Methodology Framework

The methodology framework of Action Design Research was useful in this thesis as it recognized the importance of context for evaluating IT artefacts, which allowed for the evaluation process to be tailored for this specific context. However, the ADR framework highlights the importance of conducting multiple iterations in the BIE stage. This was not possible due to time constrictions of this thesis. Although the research conducted in this thesis can be seen as the first iteration, the ADR framework is more suitable for research projects for which more time is available or in which the stages take less time by for instance creating less complex mock-ups.

7.2.2. Interview User Requirements

The user requirements for the mock-ups were determined during individual interviews with involved members of Project ENHANCE. This proved to be very valuable for gaining an understanding of the ambitions of Project ENHANCE and the different views on how a dashboard could aid in those ambitions. Limitations of the interviews were that not as many end-users were interviewed to provide user requirements. Furthermore, interviewees were only asked to list requirements for their 'ultimate' dashboards but were not asked for their opinion on the user requirements others had listed. This could have given more insights into how the organisation of Project ENHANCE as a whole thought about other user requirements.

7.2.3. Mock-Up Design & Development

The mock-ups created for this thesis had multiple limitations, which are described in this section. First, the choice to create mock-ups instead of fully functioning dashboards allowed for this thesis to be completed within the given timeframe. However, mock-ups may not reflect as accurately on how a fully functioning dashboard will be evaluated. Users who test the mock-ups may base their opinion on not-yet functioning aspects or less than perfect visualisations.

Secondly, the choice was made in this thesis to not create mock-ups for all four OTSA-types. This was partly due to limited availability of data for the Operational and Tactical mock-up. The other reason was that the Analytical and Strategic mock-ups were seen as most essential to be evaluated. Nevertheless, the survey results would have given a more complete picture if all four different types had been evaluated. Additionally, the mock-ups that were created might not have corresponded as well to

the OTSA-type as they were meant to reflect. The Analytical mock-up may have been made too easy, as it was reduced in complexity in both functionality and data used.

Finally, the most suitable dashboard for any given purpose may very well be a combination of OTSA-types or an entirely different solution. Eckerson has added this notion to the second version of his well-known book on dashboards, explaining that the purpose of the OTSA-types is to aid a developer in understanding the different types which are possible to create (Eckerson, 2010).

7.2.4. Evaluation Survey and Analysis

The significance of the results of the evaluation survey was limited by the small number of respondents, which in turn meant only a small number of respondents per role and per organisation. Additionally, not enough respondents were from the Country Offices of Indonesia and Ethiopia to compare differences between countries. Respondents could also have been biased if they were part of the interview group of respondents and via that already knew about the different types of dashboards.

In the average evaluation scores per role some results matched the expectations, whereas others did not. Additionally, when compared to the scores of other roles some groups of respondents gave relative higher or lower scores. A detailed reasoning for these occurrences has mostly already been provided in chapter 6, but one overarching explanation has not yet been discussed. At the start of the survey respondents could select one of the four predefined roles or respondents could select the 'other'-option and state their own role. The respondents who did not chose on of the pre-defined roles had their role changed to one of the four pre-defined roles, in accordance with Few's description of those roles. This role transformation could have significantly influenced the outcome of the analyses results as these were the results of the only two operational and only one management respondent.

Furthermore, the survey may not have included the correct individual evaluation Likert-questions on which the choice-questions are answered. Perhaps there are other aspects on which answers to the choice-questions were based which were not included in the Likert-questions. Finally, the survey question on 'whether the dashboard required a high level of technical knowledge' included the word 'not', which respondents may have skipped over as all other questions did not contain a contradiction.

Finally, the analysis of the survey results could have been interpreted with bias. The lack of comments to the text-questions also made the results more difficult to interpret. More respondents gave comments for the Analytical mock-up then for the Strategic one. This was probably due to the order in the survey, as the questions on the Analytical mock-up always came first and respondents grew tired of providing comments.

7.2.5. Role of the Designer

One of the critical limitations of this thesis is that the collection of user requirements, the design of the mock-ups and the exploratory analysis of the evaluation results were all done by the same person. This meant that the same potential bias could influence all aspects. As dashboards are so context dependent, it is essential for a designer of a dashboard to have a thorough understanding of the context in which the dashboard will operate. The deep involvement of a dashboard designer in the project is their biggest strength, but can also be their biggest weakness. The familiarity with the context can cause the designer to develop a dashboard which is not understandable by others less familiar with the same context (Taylor, 2021). It is thus important for dashboard designers to keep a balance between dashboard design and dashboard consumption. For this purpose, multiple feedback sessions with external supervisors were conducted.

7.3. Future research

For the future the following three topics for future research subjects are suggested. First, the research for Project ENHANCE specifically could be continued by testing the created mock-ups with more respondents. This could make the results of the evaluations statistically significant. The research could also be continued by creating other types of mock-ups such as Tactical or Operational, or by revising the current mock-ups for a second iteration of evaluations.

Secondly, in a different non-business context the same research project could be conducted to see if similar observations on preferences for dashboard types can be seen. The research project could also be conducted in a business-context to test if Few and Eckerson's guidelines can even be observed in the context in which they are expected to work. In order for the same research project to be repeated in other contexts, it must be researched how the context-dependency of dashboards can be filtered to discover general applicable findings. For this a standardized way to evaluate dashboards and mock-ups would be useful. If a standardized evaluation exists and is used by more researchers, more research on other aspects of dashboards can be researched so that design principles and other guidelines can be lifted from context-specific findings

Thirdly, the effects of using dashboards have been limitedly researched. Almost no dashboards have been evaluated in how effective they were in achieving their purpose, which really hinders knowing what works and what doesn't. More general research on the effects of using dashboards is necessary as these effects could provide valuable insights on what designs are effective.

"It isn't accidental that when we begin to understand something we say, "I see." Not "I hear" or "I smell", but "I see." Vision dominates our sensory landscape" – Stephen Few

8. Conclusion

This chapter focusses on formalizing the learnings discovered in the previous chapter, as we enter the final phase of the ADR framework. First the main research question is answered by concluding to what degree the guidelines from Few and Eckerson for designing different dashboard types in a business-context can be applied to a non-business context. The aspects of different dashboard types, purposes of dashboards and dashboard audience are taken into consideration for this section. The second section contains a proposal for a new type of dashboard. For this new type of dashboard two design principles are presented.

8.1. The Application of Few and Eckerson's Guidelines to a Non-Business Context

In conclusion, this case study shows that the guidelines from Few and Eckerson for designing different dashboard types could only be partly applied to the non-business context of Project ENHANCE. The guideline from Few and Eckerson to distinguish between dashboard designs based on the dashboard purpose is considered a useful guideline in both business and non-business context. The influence the purpose and user of a dashboard has on its design could also be found in the research of this case study. In the interviews to determine the user requirements, interviewees noted how each different kind of user would require a different type of dashboard in terms of information, functionality and design. This notion was repeated in the survey results were respondents noted that the role of the user would influence their opinion on the different type of dashboards. Respondent 5 commented that: "*The difference is in the audience each one is relevant to. Analytical might be more useful to programme designers and implementers while the later (Strategic) to Management.*"

However, the guidelines of Few and Eckerson only recognize four purposes for dashboards whereas other possible purposes are observed in both literature and the research findings. In a non-business context other purposes for dashboards are observed in the research by Sarikaya et al (Sarikaya *et al.*, 2019). This finding was repeated in the interviews for the user requirements, where interviewees for example stated a dashboard could have the purpose of advocacy or informing. The other potential purposes for the dashboard Project ENHANCE desires make the guidelines of Few and Eckerson less suitable to be applied. Furthermore, Few and Eckerson make no distinction between dashboards for internal audiences or external audiences. Comments in the evaluation survey demonstrated that this distinction can greatly influence dashboard design, with respondents commenting how the mock-ups may be too difficult to understand for external users. A major difference between dashboards in business & non-business is the audience of the dashboards. The guidelines from Few and Eckerson are meant for dashboards designed for internal use in businesses, whereas in a non-business context the dashboards may be designed for external use. Based on comments in the evaluation survey it is concluded that a dashboard which is used for external communication purposes in a non-business context could require a different type of dashboard design than is recognized by Few and Eckerson.

8.2. Proposal for a New Type of Dashboard: Communication & Learning

A new type of dashboard is proposed based on observations made in literature, interviews with Project ENHANCE representatives, and the evaluations of custom-made and pre-made dashboards. This type is proposed to be called: the Communication & Learning dashboard. This dashboard type does not offer decision-making support like the dashboard types defined by Few and Eckerson, but presents data to educate or inform the users. The users would be an external audience: either the general public or a specific group which is not part of the dashboard's main organisation. This purpose and user group of this dashboard type matches the aim of Project ENHANCE.

The Communication & Learning dashboard is proposed to be a combination between the Analytical and Strategic dashboard, as defined by Few and Eckerson. It focusses on exploring data like the Analytical dashboard, but presents this data in an easy-to-understand visualisation like in the Strategic dashboard. This proposed combination is based on the comments of the evaluation survey. Respondents appreciated the functionalities of the Analytical mock-up, but preferred the Strategic mock-up for its visualisations.

Three additional design principles for the Communication & Learning dashboard are established based on the comments in the evaluation survey:

1. Provide a lot of context with the data in the dashboard to meet the audience domain knowledge level. The aspect of facilitating conditions (the knowledge a user must have to use dashboard) should be separated in two aspects: technical knowledge (how to use a dashboard / general computer skills) and domain knowledge (understanding the information in the dashboard). This distinction is relevant for dashboard design, but not that commonly used. The comments made in the evaluation survey reflect this finding, with respondents often making a difference between knowledge on how to use a dashboard in general and knowledge necessary to use and understand a specific dashboard. This became most evident in the comment made by Resp8 on the Facilitating Conditions of the Analytical mock-up: *"It looks really user-friendly. And of course, you need to know a lot before successfully using the dashboard."* A dashboard can be easy to use (low in required technical knowledge) and still very difficult to understand (high in required domain knowledge). For an internal audience in a business context a basic level of context knowledge for the information presented in a dashboard can be expected. However, an external audience can possess no context knowledge about the information in the dashboard. This means an external audience may require a lot of context with the data in the dashboard. context more detailed context information in the dashboard.

2. Bear in mind the frequency of use by external users while designing the dashboard. Considering the investments necessary to build a dashboard both in terms of time and resources, it can be assumed for internal audiences that the frequency to use a dashboard will be more than once. An external audience however, may only use the dashboard once. This could require the dashboard to be designed so that the audience can either immediately understand the dashboard (no learning curve necessary) or is designed to be a one-time walkthrough experience.

3. Include simple yet attractive visualisations to make the dashboard easy and enticing to use. Although not everyone in an internal audience may have a high desire to use a dashboard, aspects such as company culture and management may help with raising this desire in a business context. For an external audience in a non-business context however, the best way to raise this desire use a dashboard lies within the visualisations of the dashboard itself. Few mentions that the guiding principle in dashboard design in a business context should always be simplicity to ensure people will not be irritated or distracted by them (Few, 2006). This is quite different from design principles in for instance serious games/gamified learning, where the whole principle is to make visualisations pretty and appealing to raise the desire of people to use the games. Thus, the desire an audience has to use your dashboard should be considered in your dashboard design to ensure the appropriate balance between visual seduction and visual irritation is found.

"In God we trust. All others must bring data." – W. Edwards Deming

9. Recommendations

In the following chapter two recommendations are made to dashboard designers in general and one in specific to Project ENHANCE. The first two recommendations are written to help dashboard designers and others involved in the creation of dashboards, to understand two major principles which give them a better starting point for their dashboard design process. The final recommendation is made to Project ENHANCE and explains how these two principles should be applied to the rest of their design process.

9.1. One dashboard can't be everything to everyone

When designing a dashboard, it is recommended to choose a single simple purpose for the dashboard to ensure the dashboard will be able to meet that single purpose. Despite the repeated notion by dashboard designers to aim for simplicity, dashboards often fail due to the sheer volume of information condensed in them (Allio, 2012). This goes against the very strength attributed to dashboards: to have the most important information arranged on a single screen so it can be monitored at a glance (Few, 2006). But it is not only important to limit the amount of information and visual cutesy gimmicks in a dashboard to ensure it is easy to understand.

What is in a dashboard should be there for a single common purpose so that multiple purposes do not cause conflicting design principles. As has been written about extensively by Few, different purposes of using a dashboard require different design principles (Few, 2006). James et al. continue on this idea by differentiating between 'pull' and 'push' users in their research on effective dashboard design (Janes, Sillitti and Succi, 2013). The pull user wants to pull a specific piece of information from the dashboard and therefor the dashboard should be easy to use for him. The push user needs information pushed at him and it must therefore capture his attention, no interaction should be necessary to understand the data. If a dashboard was designed for both 'pull' and 'push' users, these design principles would contradict each other, causing both kind of users to end up disliking the dashboard. The pull users would become irritated by the notifications, whereas the push users would become agitated by the time it takes them to find information in the dashboard.

The 'Food Systems Dashboard' is a great example of a dashboard hindered by its complexity (Fanzo *et al.*, 2020). The website behind the dashboard explains that the dashboard was developed for a large group of users. This becomes evident in the design of the dashboard as it has an overwhelming number of data indicators and no clear guidance on how the dashboard should be used. Although creating multiple dashboards within the same organisation may seem like a waste of resources, it would be an even bigger waste to create a massive dashboard for everyone that no one will end up using. As is wonderfully summarised in a dashboard design blog: *"One dashboard can't be everything to everyone"* (Raftree, 2015).

9.2. Consider other dashboard purposes than defined by Few and Eckerson

Although dashboards may have been used for only the four purposes defined by Few and Eckerson in the early 2000's, nowadays dashboards can be used for many more other purposes. Even Eckerson himself mentions the possibility of dashboards being used for other purposes in the second version of his well-known book on dashboards (Eckerson, 2010). He still considers his pre-defined dashboard types to be a good starting point for designing a dashboard. Seeing however that so many examples and guidelines online still follow these outdated pre-defined types, it is recommended that dashboard designers consider other purposes immediately at the beginning of their design process. Otherwise, they may become so accustomed to the pre-defined types that they can no longer have an open-mind for any other dashboard purposes or alternative designs. Seeing how the purpose of the dashboard is a major influencing factor on its design, the purpose should be well defined.

9.3. Further development of dashboard for Project ENHANCE

For Project ENHANCE, the recommendations made in the previous sections are all essential to be applied in the further development of their dashboard. First the realization that one dashboard can't be everything to everyone should be discussed among the member organisations of Project ENHANCE. The multiple purposes and kinds of users listed during the user requirements interviews have shown that there is not yet a common agreement among the organisations on these aspects. It is up to them to decide for which purpose and audience they want to design a dashboard. Project ENHANCE may come to the realization that multiple dashboards are necessary. If so, they should start with designing each of these dashboards individually. That way no compromises would have to be made on the design principles of the dashboards which may conflict with each other. It would be easier to later consider how multiple dashboards can be combined, than it is to split an already existing design in multiple new dashboards.

When considering the purpose of their dashboard, Project ENHANCE should look beyond the four OTSA-types purposes as defined by Few and Eckerson. They should consider communication kind of purposes such as advocacy and informing as these purposes were often named during the user requirements interviews. These purposes would require a different kind of dashboard design than has been created for the custom-made mock-up dashboards. Most importantly, the member organisations of Project ENHANCE need to agree on whether their dashboard(s) should be designed for internal or external audiences as this will greatly influence the dashboards' design.

Once an agreement has been made by the member organisations of Project ENHANCE on the purpose, audience and user of their dashboard(s), more research should be conducted to determine the user requirements of the end-user group. As has been observed during the user requirements interviews, different kinds of users have different user requirements. These user requirements will be essential in creating the initial designs of Project ENHANCE dashboard(s). For this purpose, end-users should be interviewed and asked for the reasoning behind their user requirements. The why behind the user requirements offers the most valuable insights for creating a dashboard design. End-users could be asked to sketch their own initial design ideas or a designer/developer could create these initial sketches. To prevent time, spend on programming mock-ups which will be drastically changed later, these initial sketches should already go through a round of feedback with a group of expected end-users.

If the dashboard(s) that Project ENHANCE choses to pursue further match in some aspects the developed mock-ups of this thesis, the comments made in the evaluation survey on how to improve the mock-ups can be used for further development. In the tables below, the comments considered to be the most useful are listed per mock-up for which they were given. The comments are listed per dashboard aspect and with each respondent number.

Improvements for the Analytical Mock-Up

Aspect	#	Comment
User Acceptance	2	As I am not the intended user, I do not know whether users will be satisfied with it. So, I have answered it based on my perspective. I would say that the layout looks clear and I like it that the top part is dedicated to input/data, whereas in the middle you can play around with the constraints before you (re)-optimize. Finally, at the bottom you can review the the diets you have optimized. Maybe in a final version you could even indicate which optimized diets you want to remember such that in your output table you only have the most interesting diets left. Another idea is to give a different color to each part of the process. For example, make the data/input have a blue background, the constraints part green and the Optimized Diets part yellow. This can help to have a strong indicator which part of the process you are currently working on (input related or output centered).
	3	Age division within population should be cleared (cut off point)
	5	It is a quick but efficient tool for programme implementers and designers to use targeting specific populations. Given there is market data available in a given programme setting where access is an issue and as a result malnutrition is high, I could use this tool to design an intervention around increasing access to nutritious foods in a timely manner
	9	It's definitely a good starting point and I like the overall interaction. To start using it for analyses we'll need to cover a bit more of the CotD functionality but looks like many of the building blocks are already there :)
Facilitating Conditions	2	Personally, I found the diet constraints part very intuitive. Secondly, I think that the user should be familiar with the idea behind CotD/ENHANCE to also use the dashboard but from a technical perspective it feels intuitive.
	3	dashboard should be used for many stakeholders and keep simple for better understanding
	5	While some bits are easy to read and interpret, other items such as "optimizing diets" may require specific training on Cost of the Diet software
System Quality	9	So far so good! Would suggest two areas where can still improve (also thinking about the future direction/usage). 1: it looks like we'll be showing a lot of tabular data (prices, demographics, etc.) and these will likely end up having 100s of rows - would suggest to implement some basic sorting/filtering functionality in the table (ag-grid is fantastic for this if you're using React/JS). 2: I found it a bit difficult to read the two visuals at the bottom; moving forward we'll likely have way more KPIs / nutrients to show so maybe worth looking at some additional visualization options so that people are not overloaded with information!
Data Quality	3	For Indonesia, WFP operate differently, no food aid component. my suggestion is to define the conventional WFP approach and WFP works in middle income country
	4	Would recommend to have tooltips that appear when mouse hovers over different elements of the dashboard. They can explain those and provide some background on the metrics.
	8	The details I can't judge but not sure whether energy-protein-fat is sufficient (probably also important vitamins, etc)
	9	We'll need some more attributes to fully cover the level of detail (locations, dates, additional nutrients, etc.) but the building blocks are there
currently the scope is also on CotD, not yet on climate/sustainability/health/etc. data so that could be interesting to start bringing in (but maybe not as clear yet as the cost/nutrition data)

	1	"1 The information on the nutrients is not sufficient for the moment, as it is only energy, fat and protein, would have to be expanded to include micronutrients, so also allow for parameters for optmization to be changed for micronutrients. 2 Allowing diets and data to be visualized for an individuals or to select individuals and then calculate diets 3 Data on environmental footprint of diets would"
	2	Maybe the option to have a kind of sort function as within excel to use for the Population Daily Diet Requirements or for the Food Items in Diet.
	5	I assume it would just be a matter of adding nutrients as protein & fats are included, hence I would suggest to add "public health priority" micronutrients contextualized for each country setting. For instance when user selects Ethiopia, micronutrients such as iron, zinc, vitamin A...should also show up on the reporting
	7	more easily switch between person, household regarding the diet suggestions would be nice, zooming in from national to person level and vise versa to see effects. Parreto vs Nash equilibrium if any ;)
Functional Features	4	I think it is missing climate and land use data.
	1	Would be good to be able to select the data that one is interested to visualize, e.g. if I am only interested at looking at the population daily requirements of iron and calcium to be able to select different micronutrients.
	3	it should be tested first and make this as living dashboard which could follow and adjust to recent conditions.
	5	For contexts such as Ethiopia that have a diverse geographical topologies, weather conditions, consumption habits....I would suggest to include a sub-national layer on the dashboard to inform programming at a more detailed level
	8	Suggestion to make it work together with the current algorithm(s). Then we will find out.
	9	"One low-hanging fruit is to include selection boxes in the first table - allowing users to create a house-hold or select an individual from the list of demographics
Visual Features	1	The optimized diet scores, I think it might be nice to had just the point on the slider, rather than the lines connecting each point (which could get messy)
	3	colorful appearance and using more graph or attractive icon
	4	"The visualization of the Optimized Diets Score should not use a line visualization between the different categories, as it suggests a trend between the categories, but they are actually independent. It's not clear to me what the difference between the two horizontal bars is for each category on the optimized diets graph.
	5	The user interface could be a little more aesthetically pleasing and when user interacts with it changing parameters, the changes could be highlighted in a more obvious, bold manner
	9	"In Optimus we use a lot of scatter plots where users can choose the KPIs on the axes; you're always looking at most at 2 KPIs in that case, but people are finding it very easy to navigate In general I think we'd benefit from having lots of different visualizations (catering to different business questions), so could be worth considering splitting up the diet creation dashboard from the diet evaluation/comparison dashboard!"

Table 13: Improvements for the Analytical Mock-Up

Aspect	#	Comment
User Acceptance	5	This is a very powerful tool for informing a wide range of stakeholders to tackle malnutrition especially for Management in terms of resource allocation where resources are usually tight and limited. It is a one-stop shop to show all aspects of activities happening linked to the different types issues in a given context, although the impact on the progress cannot be solely allocated to the specific programmes WFP is implementing as there are other interventions by other partners, it does support the narrative and provides a more informed pathway for decision-making.
Facilitating Conditions	2	The small explanations (More info (i) and WFP Projects) will be very helpful for users which do not often use this software or are first time users. This makes it easier to explain the tool to others.
System Quality	9	I don't really understand what kind of data is being displayed, but I like the idea of comparing KPIs over time and with targets and values of other countries
Data Quality	1	Subregional level data might also be required, not for overall goals like reaching SDG, but for other indicators
	1	Adding more information, more indicators, more visualizations
	3	dashboard should be consulted to government stakeholders since they are managing national dashboard
	8	Leave it to the specialists
	4	On the visualization of the progress of different indicators - what do the bars mean? Is that the time frame where each project was implemented? Would be clearer to highlight how they relate to the time/value dimensions
	5	Similar to the analytical dashboard, I would suggest the addition of a layer with sub-national data especially for contexts where there are diverse conditions affecting malnutrition levels
	2	To maybe also include some forecasts/predictions with respects to the progress.
Functional Features	5	I would suggest, depending of data availability and research in a given context, to include a layer for main causes (financial, in-access due to remoteness, lack of nutrition knowledge...) of the specific types of malnutrition. In that way, resource allocation is also based on evidence

Table 14: Improvements for the Strategic Mock-Up

Quote References

Chapter 1: "If the information is important, it deserves to be communicated well." Source: (Few, 2006)

Chapter 2: ""If we have data, let's look at data. If all we have are opinions, let's go with mine." Source: https://www.goodreads.com/quotes/655987-if-we-have-data-let-s-look-at-data-if-all

Chapter 3: "There is no such thing as information overload. There is only bad design." Source: https://www.azquotes.com/quote/674278

Chapter 4: "Which audience are you making the dashboard for is the real question, like how choosing a language depends on who you need to talk to." Source: Interview notes of Respondent 3B

Chapter 5: "Insisting on cute displays when other means would work better is counterproductive, even if everyone seems to be in love with them. This love is fickle." Source: (Few, 2006)

Chapter 6: "If the statistics are boring, then you've got the wrong numbers." Source: https://www.goodreads.com/quotes/582717-if-the-statistics-are-boring-then-you-ve-got-the-wrong

Chapter 7: "There is a fine line between dashboard design and dashboard consumption." Source: (Taylor, 2021)

Chapter 8: "It isn't accidental that when we begin to understand something we say, "I see." Not "I hear" or "I smell", but "I see." Vision dominates our sensory landscape" Source: (Few, 2006)

Chapter 9: "In God we trust. All others must bring data." Source: https://www.ibm.com/blogs/nordic-msp/in-god-we-trust-all-others-must-bring-data/

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Appendix A: Interview Protocol

Notes: The following interview protocol does not have to be strictly followed in this order and to this level of detail. Rather these are points that should/could be discussed. If time is limited, priority is indicated for what sections should be covered. Interviewee's can later add to their short answers, when they receive the notes for revision.

ID	Topic	Info / Description	Notes
Part 1: Introduction (5 min)			
1.1	Introduce Research	• The aim of Project ENHANCE is to create a platform were different actors in the food system can find information (data) on their food system • A collaboration between WFP, JHU, ZHL & Capgemini; I am a graduate intern at Capgemini • My master thesis is about dashboards. I am researching for PJE what the design of the dashboard could be and how a dashboard would help.	

1.2	Motivation for interview	• Explain that I will be interviewing different groups: people at WFP, JHU & ZHL: both users & experts
		    o *Name explicitly colleagues of them if interviewed:*
		 • The goal is to draw from the expertise of the interviewee
		    o *Beforehand: look up interviewee on LinkedIn to be specific about their expertise*	

1.3	Expectations management	• Explain the interview will take around approx. 1 hour; • If desired, I will keep you informed and recognize you in the project • Depending on involvement, access to mock-up for them, provide feedback, testing	
1.4	Consent	• Ask for permission to type notes, will send them afterwards for them to revise • For specific quotes: explicit permission will be asked when drafting the paper	
Part 2: Interviewee Background & Familiarity with Dashboards (5 min)			
2.1	Interviewee	• Name • What organization do you work for? • Can you briefly tell me your role and responsibility in the organization?	
2.2	Familiarity with Dashboards	• How would you define a 'dashboard'? • Are you familiar with dashboards? *If interviewee's are unfamiliar with dashboards, briefly explain it is a visual display of data and information.*	

Part 3: Context of Use & Purpose of dashboard (15 min)			
3.1	Context of Use (personal)	• What is your role in the organisation? • What are the top goals and priorities in your role? *If interviewee is not an expected user of the dashboard skip:* • What are the issues in your role that you think a dashboard could solve? • How would you use a dashboard to solve these issues?	
3.2	Purpose of dashboard	• What do you think should be the purpose of the dashboard? • Will this dashboard replace reporting that currently exists? • What are the most important tasks you or other users need to perform with this dashboard? • What decisions would be made based on this dashboard? • Why is having a dashboard important? • What should be the name of the dashboard?	
3.3	Users	• Who will be the user of the dashboard? • Who should have access to the dashboard? • How frequently would a user visit the dashboard? • How many users will this dashboard have? • How technically experienced will the users be?	
Part 4: User Requirements (15 min)			
4.0	Overall	• In what form would you prefer to see the dashboard?	
4.1	Data	• What kind of information should be in the dashboard? • How would you want to see this information? • What kind of metrics / KPI's should be in the dashboard? • What kind of data should be in the dashboard? • Would a user want to compare some data with other data? • What are the top 3 things you will measure in the dashboard? • For what time period should the dashboard focus on? • How often should the data be updated?	

4.2	Functional Features	- What tasks would you want to be able to do with the dashboard? - Which task would be the most important one? - What should this dashboard offer in order to be effective?
4.3	Visual Features	- What type of visualisation do you think the dashboard should have? - What are the critical must-see or must-do items?

Part 5: Dashboard Type Comparison (15 min)

5.0	Introduce	- In a business context there are different types of dashboards distinguished, based on their purpose and design. - I will present you these four types and ask for your opinion on them after showing them
5.1	Show dashboards	*As via a screen it will be impossible to show them all four at the same time, I will show them in order.*
5.2	Compare dashboards	- Which one of these do you think would be the most suitable to use? - Why do you think that? - How would you rank these dashboards based on their suitability?

Part 6: Closing of Interview (5 min)

6.1	Next steps	- Is there anyone else I should to talk to? - Any questions or other comments for me?
6.2	Sign off	- Thanking for their input - Repeat issues of confidentiality - Agreeing on (potential) follow up / contact

Appendix B: Slides of Pre-Made OTSA Dashboards

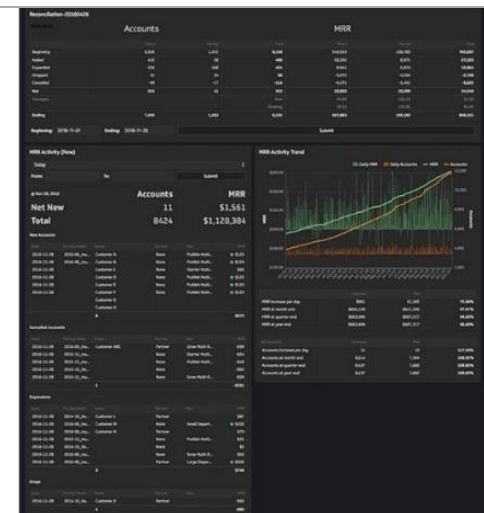Operational: Generally used for monitoring data in real-time. Displays daily updates of operations

Strategic: Used to make long-term strategies Displays long-term changes

Tactical: Used to create strategies in short or medium time frame Displays short-term changes

Analytical
Used to analyse data and explain trends
Displays data in a more raw way

Appendix C: User Requirements Interview Notes

Purpose Analysis

Resp#	Line Number & Notes
Category: Current Issue	
1A	4 Right now information is not easily available nor digestible.
	5 So the speed at which information is available is too slow, then countries cannot use it especially for a lot of last-minute requests.
	6 There is a lot of demand for data.
1B	4 The purpose of the dashboard would be to gather data as a main issue is that there is lots of data that we do not know.
1C	1 The issues would be different for the different user types.
	2 For the practitioners: more nuanced and granular looking; they want to find specific points to improve and different scenarios to change that situation.
	3 For policy-makers (high-level shapers): look for a more strategic direction, a more top line overview. Their issues are the top-level questions.
	11 The problem is a lot of disagreement and lack of technical means.
1D	1 Information easier to obtain and calculate easier. A dashboard can simplify that work.
	2 Time is limited for analysis.
	3 A sunk cost type of thing, then someone has already done a lot of calculations and I can use their work.
2B	1 If you want to evaluate different options in the CoD then the program needs to constantly rerun. Would be nice to see some precomputed outcome so that you cannot overload the system.
3C	1 It is difficult to provide in dashboards the right information at the right time.
	2 There is a gap between data geeks and users, especially in political communication and advocacy.
	3 For example: there is a lot of biometric information about the beneficiaries of the WFP programs. But this data is in need of good filtering for the data that is relevant for decision-makers.
	4 There are issues with communicating information upwards in the organisation.
	5 A key challenge with the Food System is it goes across different organisations & different ministries. It is difficult to work across those different sections. So lots of data spread over those sections, difficult determining what is relevant for policy-makers who are non-technical so that they can understand and make decisions.
	8 Right now at the WFP we have a proliferation of dashboards. The DOTS system in WFP.
	9 We can get all kinds of data but you miss the context 'What does it mean?' and the follow-up actions which come from that data.
3D	2 Food system is quite big, so need to properly define what exactly the problem is. We need to define the requirements per country.
	3 When you develop dashboard information should link between ministries. But coordination horizontally is difficult. Each ministry is defining their own dashboard.
	4 How this dashboard will be integrated will be the biggest challenge.
	5 Also updating the dashboard regularly right now is already an issue.

	Category: Expected Purpose
1A	1 It depends on the scope of the dashboard and how easy it would be to use, how much a dashboard could help. 2 It if could calculate the CoD very easily and connect it with environmental impact, then every country office of the WFP could use it. 7 If the dashboard does not have to constantly mechanically be updated then it would relieve the burden of the system analysis team. 8 It would also allow for a quicker exchange between analysists and country offices/governments who can use the data to revise policy or update budgets. 9 The purpose of the dashboard would be to allow the revision of estimates on a regular basis as opposed to static reports. 10 And more importantly the dashboard would allow data to be more digestible and easily available to users to broaden the reach of a variety of users
1B	1 The dashboard could automate my work of modelling and selecting and changing parameters and indicators. 4 The purpose of the dashboard would be to gather data as a main issue is that there is lots of data that we do not know. 5 It would also be to access data for people and compare different aspects of the data such as environmental factors and nutrition to support decision making. 6 It can also be used to share data with different partners.
1C	5 A joint platform of reference data to draw from. 8 One would be to make our lives easier with calculating and modelling. 9 Two would be to foster agreement on these scenarios as there is so much different literature out there: standardized results would help. 10 Three would be that it isn't so technical to be able to play around with different diets and scenarios, so that data scientists aren't needed that much anymore.
1D	4 I think it would have a double purpose. 5 The first to be a better improved version of the Cost of Diet software. There are lots of bugs now in the software. 6 The second I hope that we can do things with the dashboard now not possible with CoD, for example optimize on environmental impact.
2A	1 Very helpful to give people good insights. Output of optimization processes are relatively complex and you want to show them simple KPI's and how the answer is built up (user friendly insights). 3 The purpose is on one hand to show the solutions and on the other to be able to play around and give insights. 21 Should have high functionality for policy-advisors & nutritional people to come to a good solution. Give decision-making support to its users. 22 Users shouldn't be afraid of algorithms and dashboards can help with that.
2B	2 I see the dashboard as having two versions. For the first concept an initial dashboard would be to interest partners. I don't know what the final vision of the dashboard is. For the real end-users other aspects may be more important.
3A	1 For one: our main purpose is to update our donors with project progress that they have paid for. We get data form the field level in excel and it would be manually calculated for example how many beneficiaries were reached and how much food was distributed. A dashboard which summarised those figures to present to donors would make that work easier. 2 Then 2: track and monitor the progress of our projects: are we on target for this month for example. Multinational Enterprise purpose. 3 More efficient for our work processes. You create a workflow from field level to HQ level where things are reported in a more timely manner, it is an upgrade but right now things are also reported on time. It would increase transparency, you can see data being fed at the field level and if we

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	face reporting gaps identify them right away and fix them. The fields level is a real rural field level, the fields monitors don't always have access to the internet. Collect data sometime on paper, then go back to office for the internet access so that creates a time lag. 5 A dashboard would help with creating this holistic workflow with all the stakeholders in the process, then you have transparency. Then the field monitors can see the importance of timely and accurately data reporting, then they can also see the skills gap they have themselves by seeing the whole of the process in the dashboard. There is no two-way feedback from HQ to field, if you can make it a loop process from HQ back to field. Then you have more accountability and you have more transparency, so they take on their responsibility more and are more eager about these technological tools. 8 It would be (helpful), the pitch in Ethiopia for the government was done by WFP; We needed to convince them to conduct this analysis, the dashboard could be used as an advocacy. We can back up our projects with evidence, somewhat like a marketing tool to convince the governments.
3B	4 To make the CoD software dashboard available for everyone: ministries, donors etc. 5 Ministries: Don't know exactly how ministries would use it. The ministries requested it though, they are the owners of the data and want to see it analyzed. Any project they are designing or making decisions on they can use it. 7 Donors: Donors want to see justification for how they spend their money. So lots of detailed data, as the more data is shown the more their spending is justified. Data on who has been helped, with how much money and which exact product.
3C	10 Hard for me to answer because I don't know the CoD software that well. 27 There is a real policy focus the last twenty years on the production sector to grow, with under investments in social sector and the agricultural sectors. Lots of decision-makers who do not realize the effects of their decisions. The WFP wants to show them those trade-offs. For example: For this % malnutrition reduced, this is the economic growth you see in 20 years.
3D	7 Objective of the dashboard is to show reality, not politically motivated what it is. 8 Show current situation and give references for improvements studies and show goals being met. A dashboard can provide a snapshot. 9 Should be used for thinking about policy-making.
4A	2 The purpose of the dashboard is to show information and be used for advocacy. 3 A dashboard is helpful for instance on a topic like veganism to show that such a diet is lacking in nutrients. 4 Or for perspective analysis: how much was spent in a program versus how much has it achieved.
Category: Decisions Made
1B	9 At the political level this would be investment plans, nutritional policies like "we want to prioritize …. " and then be able to see the best option to do that. 10 But also decisions on emergency type of food assistance. 11 See where it is needed, identify bottlenecks in the region and the best interventions.
1C	15 The decisions could be program decisions: designing or tweaking for example adjusting rations. 16 Could be decisions about prioritization. 17 Also awareness in policy: being able to speak in a nuanced and easy to understand way will be able to better get a message across for advocacy.
1D	8 Not sure if decisions would be made based solely on dashboard. Could influence the objectives and directives of the analysis of the FNG. 9 We can expect policy decisions to improve aspects of nutrition status. For example some countries have changed certain supplements, those are real policy consequences from CoD analysis.

2A	4 Decisions about diets, for instance should certain foods still be imported or what should be done if prices change.
	5 Support decision-making on healthy, affordable and sustainable diets.
2B	4 Originally CoD is used in Fill The Nutrient Gap (FNG) program where they analyse the food system in a country and then give recommendations on decisions about for instance food reinforcement
3A	10 Oh so many! I want the Ethiopian government to look at the dashboard and see the importance of for instance food fortification, as an example. Project of the FNG, analysis found that fortification would be really helpful to improve malnutrition. Government would look at it and see the importance of fortification and make policy decisions on this. So policy advocacy and policy-making.
3B	6 Decisions in the ministries on prioritization of resources or geographical areas, target groups, so see who needs support the most. The government in Ethiopia has limited resources so they need to prioritize.
3C	15 In an ideal world some policy-choices such as investment choices, legislations, regulations. The model could inform these decisions.
	16 A simple example is around fortification of foods, where for example you could make import restrictions of food that only meets certain nutrient requirements.
	Category: Context of Use
1A	31 "Analytical is attractive to me for my role, but would only be appropriate for internal use"
1C	14 Reports are tailored for a specific audience, a general dashboard can't replace that. It would have to be customized.
1D	7 I would expect it to replace the Cost of the Diet Software.
2B	5 "Just presenting numbers is not accepted by people, they want to see something nice."
3B	10 A dashboard is more quantitative and is more suitable for technical people or different partners, or different country offices. But a pdf report is more narrative/qualitative. You need the two components.
	11 If you put a person who doesn't know the context in front of a dashboard then they can't use it unless the key messages are highlighted very well.
3C	6 If a dashboard is user-friendly so that the decision-makers don't have to go into databases. Especially models are more difficult to understand, even more so when you can play around with it.
	7 By far the biggest challenge is to make an interface that is intuitive to the audience. It will need to be customized really for an audience.
	28 You are often talking to economists so you need to be able to speak their language.
	29 You have a really wide range of users. The more it is designed for a wide user range the more successful I think it will be.
4A	1 "You don't need a dashboard if you understand what is behind the dashboard"
4A	6 The dashboard is focussed on nutrition advocacy. But the food production is usually more important (ministry of agriculture usually more important than ministry of health). Dashboard can only be effective and used when ministry of agriculture uses it. Technical people use this information from dashboard to advocate with it in governments.
	7 Most important is that the dashboard should be adopted at the highest level worldwide in order for it to be effective. Power at country-level is in the hands of UNICEF not at the WFP.
	8 Start with something that is a technically solid tool. It can then be used by certain country offices. But those are not very powerful in government decisions. Then you still have to market it. For instance promote/market it internally and then UNICEF/WHO/etc. Final goal is that the ministries in countries should use the tool.
4A	13 "The moment you start having an ideology behind a dashboard it is doomed to die"

User Analysis

Resp#	Line Number & Note
Category: Expected User	

Resp#	Line Number & Note
1A	11 The users of the dashboard would be country offices of the WFP and governmental staff of different ministries. 12 With the WFP – System Analysis team input behind it with regards to data and oversight.
1B	12 At the WFP the user would be people using the dashboard for analysis assistance. 13 Then some people would use the tool for research. 14 Decision-makers at the ministry-level could look at more of a result dashboard.
1C	19 The users will be a mix of technical governmental staff, those working just below the decision-makers, program directors, and academia but those won't want a tool that makes decisions for them. They want to do stuff their way.
2A	6 People of nutrition at WFP but can also be policy advisors in other countries so they can for example find out what kind of crops they should grow.
2B	6 Mainly people at the WFP and partners of the WFP.
3A	11 The user would be multiple people at different levels of the process. Country office level: most important partner of processes like this is the government. Especially in Ethiopia you want the government on your side for this research and secondary data that the government has, so you want good relationships. Then second user: donors. 13 Third user: WFP: I would say be the producer of the dashboard. Or whatever UN agency is producing it. Then fourth user. you have the data collectors, the field monitors. So they see how the data is being used, how the project is doing.
3B	4 To make the CoD software dashboard available for everyone: wfp, ministries, donors etc.
3C	18 Policy-makers at government level. It should not be restricted to just the WFP. Should be accessible to a broader group. For example technical professionals at the government and then more senior level also.
3D	10 Nutritionists. Academia. Ministries. It is quite a broad group.

Resp#	Line Number & Note
Category: Technical Expertise	

Resp#	Line Number & Note
1C	20 The users will probably have a huge gap and wide range in technical experience. Government officials are usually not very technical.
1D	10 I would expect certain level of technical knowledge. People working at WFP or research institutions/UN organisations with technical knowledge.
2A	7 I hope that the dashboard is so user-friendly that it is straightforward how they can use it. So I don't think the users will be technically experienced.
2B	7 The ones at the WFP who are analysts, those are pretty technically experienced. But the local partners not so much. They wouldn't understand the model, but they would understand the output.
3A	14 Not that technically experienced. Donors: you have like bankers (KFP, the German bank for example), you have a CEO that doesn't have a technical background I wouldn't expect them to be highly technically skilled to manoeuvre through the data. That is what is great about dashboards, that it can be so intuitive to use. At government level, we do have a central statistical agency where we get some secondary data from. Okay skills, but not that high in a developing country. Our field monitors depending on their background, but not that high.

System Requirements Analysis

Resp#	Line Number & Note
Category: Form	
1A	13 Dynamic so that information can change with contexts, simple; user can say I want to look at a diet with the most … or the least …, not like the food systems dashboard
1B	16 The technical dashboard should be online for everyone to access.
1C	22 There should maybe be two interfaces: one to see results and one to calculate results in. 33 The challenge would be to tailor to very different audiences. Some kind of toggle/switch between standard and tech version. The tech version would have more parameters and integrate with other solutions
1C	23 I would say online based and with a browser interface.
1C	24 If you can make a mobile version good looking that is also nice, but more extra.
1D	11 Prefer to see something that is offline as internet connection is not always great at places where we work.
2A	8 What I envision is kind of a computer application. 9 Not so many screens. 10 Interactive. 11 Nice if we could do it online since you have to use lots of online databases. 12 And also WFP has limited heavy computers in the countries. 23 Maybe some kind of game would be good.
2B	8 I prefer a website over an phone app.
3A	15 I would want it to be on a computer. Interactive, because I want to dig into the different features and read information on the different aspects of the dashboard. I would want it to be online. 19 There are always internet connectivity issues. Can't have too many gigs to load, most efficient tool that will load easily and lightly in a low connectivity area.
3B	8 We would like to have a web based kind of thing. 9 Reports now have a lot of text, but online data dashboards are usually without. 10 A dashboard is more quantitative and is more suitable for technical people or different partners, or different country offices. But a pdf report is more narrative/qualitative. You need the two components.
3C	29 It has got to be light enough for all user environments, can't take 10 minutes to run. Ideal if you would have both online & offline, but online should not be a problem.
3D	11 We have an on and off internet connection, so the dashboard really needs to come with a good internet connection.
Category: Download Requirements	
1B	8 So if we have a dashboard then we should be able to export data. 19 Results can be downloaded with the most important data.
1C	34 Also for the tech version I would want the option to export data in csv or other kind of software.

1D	12 Would be great if you can download data in a way that is usable: for example csv. Not like the CoD download link that is quite useless, but more similar to downloading data from the World Bank databank or FAOSTAT.
3C	20 You would want to be able to print out the graphs that you visualize. To print as a report including the context of the graphs, so their settings and meaning.
3D	12 Downloading of data should be possible.
	Category: Other System Requirements
1B	40 For the dashboard it is required to build something which can analyse lots of data quickly but the data will come from many different sources. A main issue would be matching/linking the data.
1C	18 The dashboard should be open source and open access. 25 Additionally, if it is open source then a GitHub page from which you can download the dashboard for offline use for technical people.
1C	21 It would be good to have a good tutorial
1C	41 The interaction with the dashboard is very important. The level at which you can modify.
2A	28 The response time of the dashboard should not be overlooked: sometimes optimization can take some time, so should be a set-up in the interface so that things can be run in sequence or so that calculations will be done if you come back in the morning. Would want to see how long a calculation will take place, but he doesn't think that is possible to calculate.
3C	19 Perhaps two layers so that a tech person can unpack the data but a government person can see it more as a communication and advocacy tool.
3D	6 You will need someone to look at data consistency

Information & Data Requirements Analysis

Resp#	Line Number & Note
	Category: Information
1A	14 Information about the general prices of the food, linked to a mapping of the regional prices not just national; 16 Information about the nutritional content of food would also be nice, but this is information the FHO has so more their territory
1B	21 Same information as the information we have in the Cost of the Diet software, with information on nutrition and age group and gender. 22 The nutritional consistency of foods and the option for people to add new foods. 23 To calculate the affordability of food expenditure diet. 24 Information on the type of diets, a specification of what is a vegetarian diet or if you want a diverse diet. 25 Information on the environment, main production type of the food source, information on seasonal influences. 26 Information on infrastructure, road and access of food. 27 Information from DHS on education and health of demographic and general utility access statistics on population for research purpose.
1C	26 We have a long list for that. There is a lot of different information though and most of the data isn't very clean. Information on environmental systems and how food interacts with that: greenhouse gasses, water, land use, footprints. Information on nutrition & diets. Nutritional needs and different diet types. Incorporate some kind of nutrition guidelines and the cultural information on diets. Information on supply chain Information on trade Information on food use, food loss and food waste. Plus generic production data. Some way to look at health outcomes: link with diets.
1D	13 Nutrient requirements of different age and sex groups. Food composition based on food composition tables and option to choose what food composition table you want to use. Also environmental information which you can find on FAOSTAT, like water use and greenhouse gasses. The typology of the food system of a country per country. 14 "You can add many more things, but those are the most relevant"
2A	13 Most important: how a diet is composed. Nutritional, footprint: co2, water; and how much of each food type is in it.
2B	9 Trade-offs between different objectives: cost, environmental, nutritional. 10 If you have a diet you select, see relatively similar diets given certain parameters.
3A	16 Something that tracks locations of projects that are being conducted. The partners that are involved. An area where the main findings are summarised per subject, depending on the analysis: they call it the key slide in the slide deck that they present at donors meetings. For instance the Cost of a Diet at a nutrition level and how many households can actually afford this cost. 17 I want a feature that shows the status of the project: include the completed ones, the ones that are in progress and also the ones that are planned for the future.
3C	11 If it provides information for decision-makers then you are looking at a very broad ecosystem, so you should also look at macro economical factors such as trade, import and export. 12 For policy-making you also have to look at policy-levers such as subsidies.

	13 But really look at trade-offs for policy-makers. 14 Nutritious diets are already not affordable. But you also want to look at environmental factors such as CO_2 of imported goods. 17 It is a very different perspective if you aim for the best food system or for the most nutritious decision, so you need to see the trade-offs.
3D	13 Information on national level is important, but even more so on regional level. 14 More information on supplementation & fortification. We don't have micronutrient profile of country, so we only know iron deficiencies. 16 Data should be useful for all ministries, that is why data needs to be consistent.
Category: Top 3 Things
1C	27 Top 3 things: Aggregated nutrient score: how nutritious the diet is. Environmental Impact: but tricky how to define that. First chose dietary habits to bring in the behaviour side, then switched to -> Food prices.
1D	15 Top 3 things would be: Obtain cost: minimum and optimized based on certain parameters. For example coverage of min 50% of all nutrient requirements. What environmental impact of a diet would be and optimize based on that. Nutritional value of a diet.
2A	14 Top 3 things: 1. Affordability diet. 2. CO_2 footprint. 3. Water usage
3C	20 Top 3 Things: 1 Nutritional outcomes, 2 Environmental outcomes, 3 Economical outcomes
Category: Data Type
1A	17 As much granular data as possible, to give as many changeable parameters as possible
3C	23 Should offer enough granularity at country level so that country level people find it useful.
3D	15 Data should be separated by gender and age groups.
Category: Data Time
1C	28 If we can look into the future that would be great, but I am sceptical about that. It is difficult already to get people to agree on current data let alone on future model data. 29 Definitely want to look retrospective, missing that option in the Optimus tool.
2A	15 That is something we haven't discussed yet. 1 week or 1 month into the future, so that all people could use it to plan their personal diet.
2B	12 Depends on the method: look at price changes. It is better to look at longer periods, but future looking might also be interesting to look at.
3C	21 Forecasting is very valuable. A projection based modelling. Looking at 50 years or so in the future to see the results of different choices.
4A	10 Trend analysis is very important. Mostly being able to look forward. Looking backward is not that important.
Category: Data Updates
1B	17 It should be regularly updated so every month new data can be uploaded.
1C	30 It depends on the data set, a lot of data doesn't change. For production might change. 31 Market price data is really important and changes quite regularly: that is to say monthly.
2A	16 Data should be updated relatively fast (every 15 min). In the beginning of the dashboard's days it is fine if the data is updated every day. Food prices can vary a lot.
2B	13 Most countries often have two off/on seasons with a big difference in prices. So at least four times a year.

3A	18 As often as the project allows. For example we have this program called the fresh food voucher, where we distribute vouchers so that households can buy fresh food. The distribution of the vouchers occurs only once per month, but the households will use it at different times during the month at the market. So to track that specific project, the dashboard needs to be fed with data on a daily basis.
3B	12 There is staff in the field who submit data to complement data from the government, this is daily data. 13 But the dashboards are updated monthly.
3C	22 Not talking about day to day decisions. Certain data sources are updated once a year. For example social accounting data at a country level. Country health levels and also for demographics. But for some countries that data is only updated every 3 years. Economic budgets are usually updated once a year.
3D	17 Data should be updated at least quarterly, but big issues that are critical should be updated monthly.

Functional Features Requirements Analysis

Resp#	Line Number & Note
	Category: Functional Requirements (tasks you can do in dashboard)
1A	15 The option to compare regions.
	18 Select different types of diet scenarios (food baskets), for instance meets energy values or is vegan or pescatarian.
	19 Show greatest contributor in the basket in terms of cost, water footprint, greenhouse gas footprint.
	20 Select different scenarios and their influence on food and prices, for instance a flood.
1B	23 To calculate the affordability of food expenditure diet
	28 The first task is optimizing diets with different weights and in different regions.
	29 The second task is correlating the diets with different data.
1C	32 The task to say this is my requirement for nutritional impact (for example meet this guidelines for 100%) and these are my other requirements (for instance environmental and costs) and then it spits out a diet. But also give me suggestions for a few settings with the parameters.
1D	16 Calculate the cost of a diet, set and modify criteria to calculate.
	17 Be able to creating a basket for a household with different compositions (i.e. not just replicating a standard value x number of times, but accounting for different individuals within the hh), that meets the criteria for all those members of the hh.
2A	2 "At ENHANCE we look at a larger number of indicators, we need to be able to compare them and see how they differ where."
	17 I want to play around in the dashboard.
	18 Task 1: be confronted with a solution from an algorithm. I have a diet in front of me and then dive into the details. For instance which daily requirements are met and what part of the diet contributes to that.
	19 Task 2: Play around: give some input so I can see a different solution. Sliders and knobs, push a button and then it is optimized again.
	20 Task 3: Then compare different diets in their composition and learn from that.
2B	14 See all the trade-offs between different objectives.
3A	7 I would want this feature where it tracks where all the locations where this project is being done (for FNG in 20something countries); Tells me where this specifically project is being conducted and see the status on each one: how far along they are on the project.
	9 The status of each project at the end. Another feature that shows the key findings of each FNG project, something catchy that sticks out to governments
	12 Maybe include a feature where you can filter information in the dashboard for specific audiences. You wouldn't want them to see the raw data.
3C	24 Needs to provide an option to play with parameters and situations.
	25 Needs to show not just the ideal situation but multiple options.
	26 Model should not be biased in one direction or the other.
3D	18 Look at if they are meeting the SDG goals and their local SDG goals. Data trends should be in the dashboard.
4A	11 You want to be able to compare countries.
	Category: Extra functionalities
1D	19 Would be nice if you can use keyboard shortcuts instead of mouse clicking.
2B	15 There has to be some way to input your data in a nice way which checks for input errors.

Visual Features Requirements Analysis

Resp#	Line Number & Note
	Category: Visual Requirements
1A	3 The visualisation should then also be very easy and a standard format for each country would be nice. 22 For her own role (analyst) in the dashboard it could be more excel-like, as they are quite technical but not data scientists. 23 For the end-user it should be simple, intuitive, clean it we want people to use it. 32 The operational one looks old school, I would want something more fresh looking.
1B	30 Depends on type of analysis you would like to do. 31 During the bootcamp there was a plate example or like a spiderweb to see the optimalization. 32 Seasonal differences or regional differences on a map of the country. 33 For results could be a table or a graph.
1C	4 On a visual site there should be a map to draw decisive situational analysis. 35 Maps and bar graphs. Time series: See overtime the results. Results and comparison across results: bar graphs for this. But also box and whisker graphs to see outliers. Just no pie charts, I don't like them. Maybe a scatterplot though. 37 Must-see: unpack information on an individual level (woman or man) and geographical level (subnational) with a drill-down functionality.
1D	18 Because of the main user I expect to use the dashboard, I don't think it will be that visually friendly. Wouldn't worry so much about that. Maybe not make it such a steep and long learning curve, but it will be a bit complicated. 20 Should have the results in a graph but not from the beginning.
2A	24 I don't think maps are useful, you don't need to know where the food comes from. A pivot table with drill-down functions. Sliders for constraining KPI's: lower and upper bounds. Only a few buttons. Some bar charts to compare solutions. And also see what is in the diets. See to what kind of limitations this diet has bounced: CO_2 from two to onepointfive and then which parts of the diet are then at their lowest possible level.
2B	16 A button which says start optimizing. Sliders to say I want to pay more attention to this. A graph (spider chart) to see the effects. Spider charts, they show trade-offs really nicely. Line graph to only see two factor comparison of a selected diet plus see a bar chart of all the nutritional values. Look at affordability of type of diets.
3A	20 Make sure it is user-friendly. In your stakeholder group you don't have the same capacity level. You want it to intuitive, user-friendly, aesthetically pleasing as well. Colourful, that pops out and grabs users attention (personal preference). Wouldn't want it to be too crowded. 21 There should be charts for sure. There should be as little writing as possible, the least words because when you represent this kind of information with things like drawings, figures, icons then people can pick up on the information more quickly in my experience. Numbers that are easy to understand and are just simply on their own.
3D	19 Should be sexy and catchy. 20 Should be accessible for the audience in terms of appearance. 21 Not just showing numbers, but translate to pictures.

Appendix D: Evaluation Notes of Pre-Made OTSA Dashboards

Resp#	Ranking	Answer
1A	1. Operational 2. Tactical 3. Strategic 4. Analytical	(24) "Can I pick two?": couldn't decide between operational and tactical. (25) I first selected the tactical one; as based on our conversation at the beginning of the interview about the purpose of the dashboard should be for a wide variety of users. (26) They could use it to create strategies in short/medium timeframe, (27) You could look at different parameters for strategies.; (28) But also to monitor cost variations at least monthly, because daily variations would not be so relevant. (29) "Some kind of middle ground" (30) *Then when asked to rank them, changed her mind and decided on a different order*. 1. Operational, 2. Tactical, 3. Strategic, 4. Analytical. (31) "Analytical is attractive to me for my role, but would only be appropriate for internal use" (32) The operational one looks old school, I would want something more fresh looking. (33) But the operational one would actually be more suitable for monitoring than the tactical one.
1B	1. Analytical 2. Strategic 3. Tactical 4. Operational	34 Analytical and Strategic 35 Two different type of users: for the analyst it would be a mix of analytical and strategic to upload new data and manipulate it. 36 For the user who is more involved with key data the strategic one would be better. 37 The tactical one is a bit cleaner, I prefer it visually. 38 But just the analytical one and then the results in strategic, as the analytical one would not be easy to understand. 39 1. Analytical: would need to analyse a lot of data, so more the back-end of the dashboard not the front-end 2. Strategic: for strategic purposes; don't want to see a lot of data 3. Tactical: more like a supply chain tool 4. Operational: because real-time monitoring is not that necessary; most data won't change that often like nutritional requirements. Prices and availability would change but not daily. Earliest would be weekly but usually monthly. Operational is more for business rather than what the WFP does, there are not so many daily changes and research is more of a long process.
1C	1. Tactical 2. Analytical 3. Strategic 4. Operational	38 Mix between tactical and strategic. 39 Like the tactical display where you stand for urgency and for policy work. Strategic for the quick overview. Analytical for the majority of the work. Would really be a mix of the 3, depending on the user. 40 Ranking: 1. Tactical: Shows a goal and it shows progress. 2. Analytical: That level of detail is key

		3. Strategic: Too abstract, it doesn't give you a goal. 4. Operational: focusses on day to day and that doesn't apply here.
1D	1. Analytical 2. Tactical 3. Strategic 4. Operational	21 Analytical one, definitely. 22 Because of who I expect the user to be. It does not have to be visually friendly as operational and it will not have to be updated daily for data. The use will be very different for each user. So analytical will provide more flexibility. Get more information on the why behind data. 23 Ranking: 1. Analytical 2. Tactical: chosen for what it is meant to do. Helps to create short to long-term strategies. Allows for more information to be displayed and what changes would be. 3. Strategic: don't like the analysis is conducted interactively. 4. Operational: same reason as strategic.
2A	1. Tactical 2. Analytical 3. Operational 4. Strategic	25 Tactical. 26 Really see particular aspects. Time is not so critical, you can take your time to develop it. But maybe some analytical aspects of filtering. 27 Ranking: 1 Tactical: good combination of fixed data & variations plus good for looking at solutions. 2 Analytical: gives more insights and more interactive. 3 Operational: Details are good but maybe here too much detail 4 Strategic: Doesn't give much detailed information. For something like ENHANCE it is too high focus.
2B	1. Strategic 2. Tactical 3. Operational 4. Analytical	17 Strategic more suited for ENHANCE. Operational design is nicer because you can look at many aspects of the problem and visualise many different types of graphs. But real time data isn't necessary. 18 You look more at long-term planning. Advice by WFP to partners is usually for a couple of months/half a year. You are not changing the diet every week/day. You have to make a more long-term planning. 19 Ranking: 1. Strategic. ; 2. Tactical: looks at a medium timeframe 3. Operational; 4. Analytical: doesn't look very engaging and it doesn't really help to make your point.
3A	Did not want to rank the 4 types	22 A mix of all. Catering the dashboard to each audience would then be possible. Really can't rank them, that wouldn't be accurate for me. 23 Explains how each type matches a user group Operational: For MNE purposes. You want to see how the reach of the project is going. For managers and MNE people. Tactical: For the government as the main audience. You want them to see the progress of the project. Strategic: for donors and higher managers in WFP. And also governments to see the financial gaps for specific projects. . Analytical: The analytical one for the people at the field level, to see how their data is used later. And for the analysts at the WFP.
3B	Did not want to rank the 4 types	14 To me: analytical is more suitable for our dashboard builder. Strategic is more suitable for my boss. Tactical is more at his level as program manager and policy-making. Operational is more for partners but at a technical level. 15 Which audience are you making the dashboard for is the real question, like how choosing a language depends on who you need to talk to.

		16 If I can only pick one then Strategic, because then everyone will be able to understand it. For the purpose of overall top-level communication. In it would be data from programs & the government. It would be for communication externally as a fact sheet of a project, to keep partners information on spending and progress instead of monthly report. Internally it would be for course correction. 17 You would want to be able to customize the dashboard for each project and audience.
3C	1. Tactical 2. Analytical 3. Strategic 4. Operational	21 Tactical. 22 But it really depends on the audience. 23 Analytical gives you to the option to really go through the data but that would be met with a blank stare. 24 Strategic is hard to understand the context, why trends are the ways they are, too much of a summary level. 25 I am most familiar at my function with the operational type, but that daily frequency of data update is for the new dashboard unnecessary. 26 The tactical gives you a more nuanced picture. 27 I see tactical and analytical as suitable for different audiences but complimentary to each other. 28 Ranking: 1. Tactical 2. Analytical 3. Strategic 4. Operational
3D	1. Tactical 2. Operational 3. Strategic 4. Analytical	22 Tactical: 23 more easy to understand the progress. 24 Dashboard should give a snapshot for understanding and then later go deeper to understand a specific topic. 25 Ranking: 1. Tactical 2. Operational 3. Strategic 4. Analytical
4A	Did not want to rank the 4 types	12 *Didn't choose one or ranked them; just gave descriptions of each of the contexts where that type would be useful.* Strategic: most useful for the people you want to influence to show information to. Mostly used in policy setting. Tactical/operational: more for people to provide information to country directors. Analytical: Not interested in this information anymore at a senior level in the WFP. "Some people will only want to see data at the strategic level and others also at the tactical/operational level. "

Appendix E: Survey Questions & Sources

Section of Survey	Question	Source
General Information on Respondent	Please Select your Organisation	Personal Creation
	Please select the department or role which most closely matches your role at the organisation	
Likert-Scale questions to evaluate mock-ups individually *Note: questions were repeated twice for each mock-up in the survey*	The dashboard would help me to achieve my goals	(Matheus, Jansen and Praditya, 2019)
	The dashboard would be useful to me	
	The dashboard would help me to make better decisions	
	I am generally satisfied with the dashboard	(Li, 2019)
	I have the knowledge necessary to use the dashboard	
	The dashboard does not require high level technical knowledge	(Matheus, Jansen and Praditya, 2019)
	My interaction with the dashboard was satisfying	
	My interaction with the dashboard is clear and understandable	
	The data in the dashboard can be easily interpreted (easy to understand)	(Li, 2019)
	The dashboard contains useful data metrics	Personal Creation
	The dashboard contains data at a sufficient level of detail	
	The dashboard focusses on a useful time-frame	
	What are your suggestions to improve this dashboard with regards to the data in it?	
	The dashboard provides all the functionalities I am interested in	(Matheus, Jansen and Praditya, 2019)
	The dashboard is easy to use	(Li, 2019)
	What are your suggestions to improve this dashboard with regards to its functional features?	Personal Creation
	The dashboard has a clear visualisation	(Matheus, Jansen and Praditya, 2019)
	The visualisation provided by the dashboard makes better interpretation of the data	
	I am satisfied with how the data is visualized in the dashboard	(Li, 2019)
	What are your suggestions to improve this dashboard with regards to its visual features?	Personal Creation
	I would use the dashboard frequently	

	The dashboard would be accepted by my colleagues	(Matheus, Jansen and Praditya, 2019)
Choice-Questions between the two mock-ups	In which dashboard do you prefer the visualisations?	Personal Creation
	In which dashboard do you prefer the functional features?	
	Which dashboard do you think contains the most useful data?	
	Which dashboard do you think would be the most useful for your job?	
	Which dashboard do you think would be the most useful for Project ENHANCE?	
Room for final comments	Any final thoughts?	Personal Creation

Appendix F: List of Requirements per Mock-up

Operational Mock-Up	Strategic Mock-Up
I17 - WFP Country Office Projects D5- Be updated every day D6- Be updated every month V2- See on both national level and regional level V5- Very easy to understand V7- Standard format for each country	I16 - Education, health of demographic, general utility access D4 - Show the future D7 - Be updated every quarter D8 - Be updated every year F12 - To compare countries V4 - See if they are meeting their SDG goal V5 - Very easy to understand
Tactical Mock-Up	**Analytical Mock-Up**
I1 - Prices of food, both regional and national I2 - Affordability of diet I8 - Cultural information on diets I9 - Typology of the food system in the country I10- Environment aspects of food I11- Environmental impact of diet I12- Food production data I13- Food use, food loss, food waste I14 - Infrastructure I15 - Trade: import and export of food D4 - Show the future D6 - Be updated every month D7 - Be updated every quarter F4 - To select policy levers such as subsidies F6 - To compare regions F8 - To select different scenarios and see their effect V1 - See trade-offs between different objectives V2 - See on both national level and regional level V6 - Include drawings, figures, icons V8 - Plate or spiderweb to see optimalization V9 - Map to see situational analysis	I1 - Prices of food, both regional and national I3 - Aggregated nutrient score of how nutritious the diet is I4 - Nutritional consistency of food I5 - Nutritional needs of different age and sex groups I7 - Type of diet: vegetarian, vegan, etc D1 - Be as granular as possible D2 - Separated by gender and age groups F1 - To add a new food F2 - To calculate the affordability of a diet F3 - That if you select a diet to see similar diets given certain parameters F5 - To optimize the diet based on certain parameters or see multiple suggestions F7 - To compare different diets F9 - To correlate the diet with different data F10 - Create a basket for a household with different household members, that meets criteria for all those members F11 -To adjust parameters and situations V1 -See trade-offs between different objectives: cost, environment, nutritional V3 - See greatest contributor in diet in diet in terms of cost, water footprint, greenhouse gas footprint V10 - No pie charts V11 - No maps V12 - A button which says start optimizing

Appendix G Data Sources for Mock-Up Dashboards

Strategic Mock-Up

Indicator	Source
Prevalence_ undernourishment	SUITE OF FOOD SECURITY INDICATORS - PREVALENCE OF UNDERNOURISHMENT (PERCENT) (3-YEAR AVERAGE) - 210041 - VALUE - 6121 - %, data from Food and Agriculture Organization of the United Nations (FAO) (2020), via https://sdg-tracker.org/zero-hunger
Prevalence_ stunting	Prevalence of stunting, height for age (% of children under 5), data from World Bank – World Development Indicators, via https://sdg-tracker.org/zero-hunger The intermediate target is a reduction in the prevalence of stunting by 40% by 2025 (from 2012 levels).
Prevalence_ wasting	Prevalence of wasting, weight for height (% of children under 5), data via World Bank – World Development Indicators, via https://sdg-tracker.org/zero-hunger
Average_income_ foodproducers	Indicator 2.3.2 is the average income of small-scale food producers, by sex and indigenous status.; From 2012 measured Goal: By 2030 double the average income of small-scale food producers. Two times the value in 2012 of that country. Via https://sdg-tracker.org/zero-hunger
Human Trophic Level	The long-term objective for this indicator is a value of 2.04. Trophic levels are a measure of the energy intensity of diet composition and reflect the relative amounts of plants as opposed to animals eaten in a given country. A higher trophic level represents a greater level of consumption of energy-intensive animals. Via https://dashboards.sdgindex.org/profiles/ETH, https://dashboards.sdgindex.org/profiles/IDN
snmi	The long-term objective for this indicator is a value of 0. The Sustainable Nitrogen Management Index (SNMI) is a one-dimensional ranking score that combines two efficiency measures in crop production: Nitrogen use efficiency (NUE) and land use efficiency (crop yield). Via https://dashboards.sdgindex.org/profiles/ETH, https://dashboards.sdgindex.org/profiles/IDN

Project Name	StartDate	EndDate	Project Description & Source
Emergency Response	2000	2002	WFP provides unconditional food and cash transfers to the most vulnerable families. Contingency stocks of food are prepositioned in case of conflict or climate-related shocks. WFP supplies food in the Somali region and part of Oromia region while the Government and its partners cover the remaining needs across the country. Via https://www.wfp.org/countries/ethiopia
PNSP	2017	2018	Through the Productive Safety Net Programme, chronically food insecure households receive food and cash transfers in lean seasons in exchange for building or rehabilitating community assets. The Government-led productive safety-net programme (PSNP) targets 8 million chronically food-insecure people. Since the inception of the PSNP in 2005, an average of 5.2 million of these PSNP clients a year have received transitory emergency assistance. Via https://docs.wfp.org/api/documents/WFP-0000103160/download

VAM	2008	2010	WFP's Vulnerability Analysis and Mapping (VAM) unit supports the Government on early warning action, emergency and market assessments. The R4 Rural Resilience Initiative includes building agricultural infrastructure and trainings in exchange for insurance and increased access to credit and loans. A satellite project for pastoralists also gives access to insurance payments for livestock feed and veterinary materials when droughts occur. Via https://www.wfp.org/countries/ethiopia
School Feeding Programme	2013	2016	WFP works with the Government and partners to improve nutrition and promote education for school children in the Afar, Oromia and Somali regions. Home-grown school feeding, with locally procured products such as cereals, pulses, vegetable oil and salt, brings additional benefits including increased income for farmers and a boost for the local economy. Via https://www.wfp.org/countries/ethiopia
Capacity Strengthening	2007	2009	WFP works with the Government on supply chain capacity-strengthening activities, including reducing port congestion with the Ethiopian Maritime Affairs Authority, strengthening the road transport sector with the Federal Road Transport Authority, and supporting the National Disaster Risk Management agency in its implementation of an end-to-end food tracking system. Via https://www.wfp.org/countries/ethiopia
Supply Chain	2010	2011	Ethiopia hosts one of WFP's largest supply chain operations, managing the movement of over 400,000 metric tons of food per year to 3,000 distribution points and 26 refugee camps. The WFP-managed UNHAS service provides air transport for humanitarian partners and cargo to seven destinations where transport infrastructure does not exist. Via https://www.wfp.org/countries/ethiopia
Fresh Food Voucher Programme	2015	2017	The Programme supports households with pregnant and lactating women/children under 2 years of age to improve their access to fresh food through vouchers. After a two-year pilot project subject to an evaluation, the Fresh Food Voucher Programme has been expanded to additional districts (woredas) the Amhara region. Via https://www.wfp.org/publications/ethiopia-stunting-reduction-programming-and-evidence-generation-fresh-food-voucher

Analytical Mock-Up

Source	Data Used
https://www.indonesia-investments.com/culture/population/item67	Population Data Indonesia
https://en.wikipedia.org/wiki/Demographics_of_Ethiopia	Population Data Ethiopia
Provided files by the Zero Hunger Lab	Totxx_med.csv & Percxx_med.csv. Data used from persons 9 (diet 2) and 212 (diet 1)