A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics.

# Incentivizing composting and tracking $CO_2$ emission reductions – building a mobile habit tracker using low-code – strategic recommendations for Mudatuga

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## Abstract

Household composting represents a sustainable solution to deal with the negative externalities connected to food waste such as $CO_2$ emission and pollution. However, only a small number of households in Portugal have integrated home composting into their daily habits. On that basis, this report documents the conceptualization and implementation of Compostuga, a mobile habit tracker developed in collaboration with the impact start-up Mudatuga using low-code technology. Compostuga incentivizes households to the continuous practice of composting through gamification and tracking of $CO_2$ emission reductions. Therefore, Compustuga will help to mitigate climate change by fostering low-carbon behavior among households.

The thesis elaborates on the conceptualization of features regarding input and impact tracking and distinguishes how gamification contribute to the desirability of Compostuga. The thesis is finally concluded by making strategic recommendations about further development possibilities of Compostuga and Mudatuga as a company.



Keywords: Product Development, App Development, Low Code, Sustainability, Composting

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# 1. Introduction

The world's population has grown steadily in recent years, and with it the global demand for food. Today, approximately 1.3 billion tons of food are wasted globally making up 45% of the total municipal solid waste in Europe and even reaching up to 55% in developing countries (Awasthi et al. 2020). The waste usually ends up as disposal on landfills or incinerations resulting in a high pressure on urban areas to manage waste and the environment. In recent years, this issue has led to many advances in this area and the introduction of more sustainable methods for dealing with food waste. Many countries decided to introduce new legislations regarding the management and final destination of organic waste. One popular solution for handling urban organic waste and therefore reducing the negative environmental impact is composting. The main advantage of composting over landfill disposal of organic waste is the reduction in greenhouse gas emissions. Given the fact that climate change has become a widespread issue in society, this method became more attractive not only for municipalities but also for private individuals. Through the practice of composting in their individual spaces, households can contribute to a lessening of organic waste and a reduction of greenhouse gases. Another advantage is that compost can be used as an organic fertilizer. Research states that composting outcomes at home result in an excellent stability of compost quality compared to varying results regarding industrial produced compost (Cerda et al. 2018).

Motivated by the positive impact of home composting on the environment, the Portugal based company “Mudatuga” was brought to life in 2020. The company's mission is to educate people about composting and to spread this practice throughout society. Mudatuga does this by conducting trainings, selling composting equipment, and educating people through their Instagram profile (Mudatuga 2022a). Although the company can look back on two successful years and has reached over 2000 people so far, it wants to further increase and accelerate its reach. With the main goal of promoting composting and its environmental benefits while collecting composting data, the company came up with the idea of developing a mobile application. To support Mudatuga with its objectives we decided to develop an application (Figure 1) which focuses on the composting habits of people. Before the development of the app, we had to answer the following two questions:

1. What are Mudatuga's main objectives and how can they be achieved with an app while securing a good end-user experience?
2. How can an app be implemented within the given time frame and scope?

This thesis presents a solution for a compost habit tracker app. For the implementation of the app, we used the low-code platform *OutSystems*. The environment offers a variety of built-in features with high extensibility, such as data access or user interface design (Martins et al. 2020). By using *OutSystems*, we were able to develop an app in the given timeframe, which, through a gamified experience, motivates people to track their composting and enables them to monitor their environmental impact. We called the app "Compostuga" and will use this name to refer to the app throughout this report.

Scan the code to access the app.

*Figure 1: Compostuga QR-Code*

# 2. Thesis Context

First, it is important that we explain the background of the present work in more detail. Our thesis focuses on the development of a composting app. Since the developed app and the related work was done in cooperation with the company "Mudatuga", we start by briefly introducing the company, followed by an overview about composting and its impact on $CO_2$ emissions.

## 2.1 Mudatuga

For our thesis we decided to work together with a company called "Mudatuga". Mudatuga is a startup based in Santo António dos Olivais, Coimbra (Portugal) that supports Portugal's waste management through training, awareness, and consulting related to composting in households and communities. The project was launched in 2020, shortly after the start of the Covid 19 pandemic. It was co-founded by Carolina Sapienza-Bianchi (a former environmental educator for Universidade de Coimbra), who has been the executive director since august 2021. Carolina led the incubation process of Mudatuga with a national Portuguese funding (Startup Voucher and IAPMEI) with a seed funding of 5,000 euros. Today, the company has three employees, was able to build a community of over 7,400 followers and trained more than 2,000 people about composting (Mudatuga 2022b).

Mudatuga wants to transform ordinary people into what the company calls "composting ninjas". This is done by raising awareness and consulting about composting in workshops and lectures for schools, companies, and municipalities as well as offering professional trainings regarding the teaching about composting. In addition to that, they offer educational content about composting as well as individual team building activities for companies with composting as a guideline. To promote composting, their services and to reach as many people as possible, Mudatuga makes use of social media and its website. The website includes information about the company and their services as well as an online shop, which offers composting bins and supplementary products (Mudatuga 2022a). Next to their website, Mudatuga uploads videos, photos, and stories on their Instagram page, focusing on the translation of scientific knowledge to everyday language as well as the promotion of their workshops and online shop (Figure 2). The company was able to co-create and host a composting summer school ("Escola a Compostar") which included 40 workshops within the time frame of five weeks. It also prototyped a sustainable compost bin made from natural materials, whose final development was, however, postponed. Because of the company's impact, Mudatuga was selected as one of the European top three companies fighting climate change, won the "Urban Solutions" category in the European stage of the climate Launchpad 2021, and was selected to be part of the World Economic Forum's innovation platform (UpLink) for the Youth Climate Action Challenge in 2022 (Mudatuga 2022b).

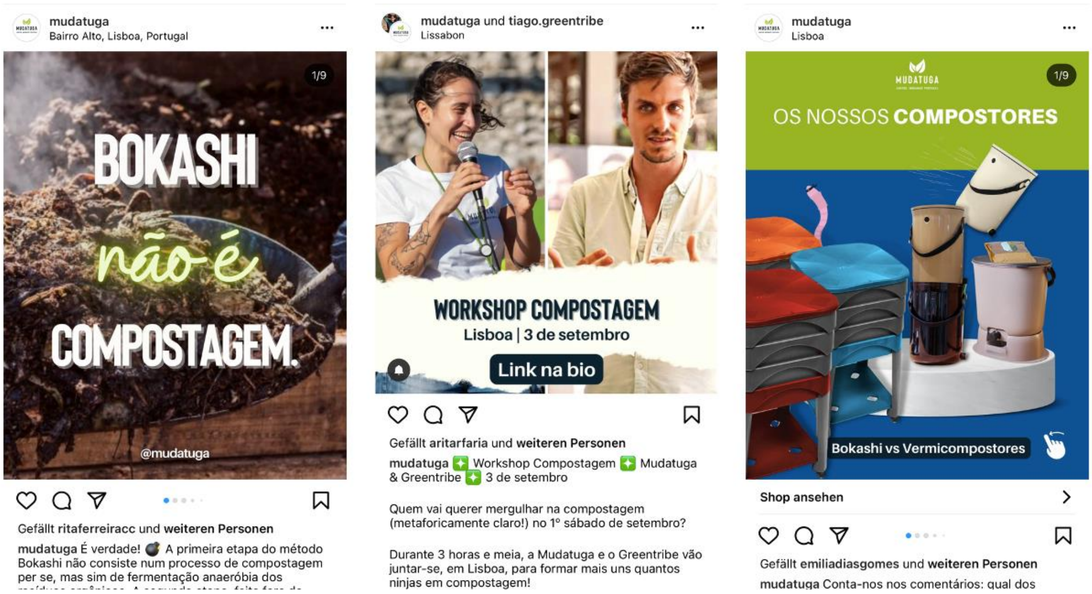


*Figure 2: Mudatuga Social Media Appearance (Mudatuga 2022c)*

The company bases its actions and content on the following values: environmental awareness, commitment to the future, regenerative impact, community building, and ethics and integrity. In doing so, it supports the achievement of the Sustainable Development Goals of the EU which were established in 2015 as part of the UN 2030 Agenda for Sustainable Development (United Nations 2022). It actively supports the following goals: sustainable cities and communities, responsible consumption and production, climate action, and life on land (Figure 3) (Mudatuga 2022a).


*Figure 3: Sustainability Goals 11, 12, 13, and 15 (United Nations 2022)*

Mudatuga now aims to create a platform for current and future customers. The objective is to create a compost habit tracker that encourages the continuous use of composting and complements it with interactive experiences and gamification. For this reason, Mudatuga approached NOVA SBE to create a Minimum Viable Product (MVP) together with our team as part of our master thesis.

## 2.2 Composting and its Impact on $CO_2$ Emissions

Now that we have some background on the company and its goals, it is important to develop a basic understanding about compositing. The following chapter therefore briefly explains the idea of composting and its environmental impact. Emphasis will be place on household composting, as our project was targeted at individual users who compost at home.

### 2.2.1 Composting

In general, the process of composting is referred to as the action of converting material into compost. More specifically, composting is the natural process of turning organic waste (e.g., yard waste, food scraps) into beneficial fertilizer that may improve soil and plants. In doing so, composting supports and accelerates the decomposition process by creating the perfect habitat for bacteria, fungus, and other decomposing organisms (e.g., worms) to carry out their functions. The end product of the overall composting process is compost. Compost is therefore the term used to describe the final decomposed material, which frequently resembles fertile garden soil. Farmers affectionately refer to compost as "black gold" because of its richness in nutrients and usefulness in agriculture, horticulture, and gardening (Cowan and Stroud 2016).

Composting became increasingly popular in the last decade and rose to be the preferred option of treating organic waste. This development took not only place in municipal waste treatment plants, but also in individual households due to its downward scalability (Sayara et al. 2020). Composting at home is a resourceful way to recycle organic food scraps and yard trims in a sustainable way, while requiring minimal effort, expense, and equipment. On top of that, the compost generated can be used to build healthier soil, which prevents soil erosion, conserves water, and supports natural plant growth when reused. There are many different methods for composting at home, which can be done indoor using special composting equipment or outdoors. Each method should be closely analyzed and chosen in accordance with personal preferences and living situation. To understand composting and its needed steps, the overall process of composting will be described in more detail below (United States Environmental Protection Agency 2022).

Based on information by the United States Environmental Protection Agency (2022), the overall (home-) composting process can be divided into four steps (Figure 4):

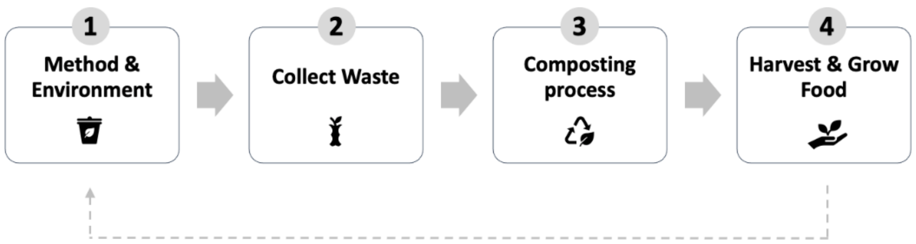


*Figure 4: Composting Process*

1) *Set Composting Method and Environment:* The first step of the overall composting process is the choice of composting method. Here it is important to assess the type of composting, the needed material as well as set the right environment.
2) *Collect organic waste:* The second step of the composting process is the collection of organic scraps in a separate container.
3) *Composting process:* The third step is the main step of the composting process. The food scraps can now be added to the chosen composting pile/bin. After the addition of the food scraps the focus should be on maintaining the composting pile.
4) *Harvest and grow more food:* The last and fourth step is the harvesting of the finished compost. It can be used immediately for gardening, soil amendment, and as mulch or stored for later use.

#### 2.2.2 Impact on $CO_2$ Emissions

In addition to the overall process of composting it is also important to understand its benefits and its impact on the environment. Therefore, we decided to go into more detail about the impact factors regarding $CO_2$ emissions.

Organic waste is usually transported to big landfills since it can degrade naturally. However, in landfills the waste gets buried under massive amounts of other waste, cutting off a regular supply of oxygen. The degradation therefore takes place in the absence of oxygen resulting in a drastic release of greenhouse gases (GHG), especially of methane, which is 25 more potent than $CO_2$, and a possible contamination of ground water (Shukor et al. 2018). Taking a closer look on the current population developments with an estimated increase to 9 billion by 2050, we can expect an increase in demand for food and food waste accordingly. Due to those aspects, it is of great interest to find a solution that addresses proper food waste management (Ermolaev et al. 2013).

The overall benefits of composting are a reduction in emissions, waste stream, improvements in soil health, a decrease in erosion and personal food waste, as well as a higher conversation of water. The main reduction in GHG emissions is because in composting food decomposes aerobically (in the presence of oxygen). Another indirect reduction in $CO_2$ emissions of composting can be attributed to the usage of compost as an organic fertilizer, resulting in a drastic reduction in energy consumption needed to produce artificial fertilizer. This also results in a decrease in general pollution, because of the reduction of chemical runoff from artificial fertilizer, which stimulates the growth of toxic algal blooms in rivers. Finally, additional reductions in $CO_2$ emissions can be achieved due to the decrease of transportation of waste to landfills (Al-Rumaihi et al. 2020). A side-by-side comparison of the $CO_2$ emission from (home-) composting and landfills makes the positive impact of composting clearer. Home composting systems have an overall net emission of -75kg $CO_2$-equivalent/ton, whereas landfilling have 1,200kg $CO_2$-equivalent/ton (Figure 5). These numbers refer to the treatment of one ton of kitchen and garden waste (European Environment Agency 2022). The findings clearly state that home composting has a variety of beneficial factors that have a positive impact on the environment compared to landfills.

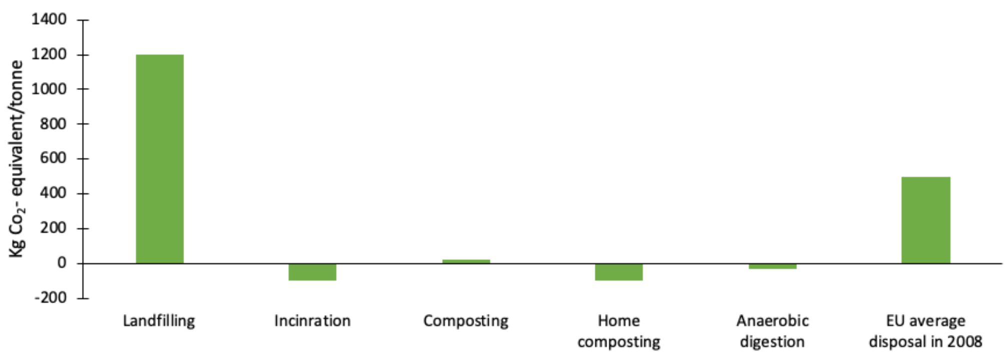


*Figure 5: Net Emissions in $CO_2$ Equivalents/ton (European Environment Agency 2022)*

## 2.3 Objectives

Following the previous introductions to the company and to composting we will go on by explaining the objectives of our project in more detail.

Although Mudatuga already has a website, is active on social media, offers e-books and workshops, it lacks a platform that customers could use and engage with on a regular basis. The overall goal of this project was to generate a mobile application (MVP) in form of a compost habit tracker in alignment with the companies' goals. To align on the overall objectives of the project, we conducted meetings with the company as well as our supervisor. During those meetings, we were able to identify the following objectives for our mobile application:

1) *Motivating people to start composting and making it a habit by creating game-like experiences within the app.*

   Composting in general is a process where no interaction with a community is needed. Creating a community and making the process more enjoyable and fun could increase the total number of people who compost. To design the app in a playful but educational manner, the implementation of a game-like features within the app could be leveraged. This would not only lead to more people taking up composting and increase their overall motivation, but also help them to uphold composting as a habit. Those factors would ultimately lead to a larger positive environmental impact.

2) *The measurement, display, and communication of the positive environmental impact of composting, with a focus on the $CO_2$ impact.*

   The collected data could also enable the company to study the impact of composting in Portugal per household. This data is currently not available, and the impact can hardly be measured. Potential impact data could have a positive influence on the development of composting in Portugal. It could for instance be used to influence policy makers in initiating new legislatures or government initiatives. Additionally, the collected data and its impact could be shown to the user to highlight its' individual impact on the environment further encouraging regular composting.

3) *The collection of data about people and their composting habits.*

   Although the company already has a large pool of customers with whom they communicate via workshops or emails, they currently have little information about them. Obtaining more data about their customers and their composting behavior would significantly help Mudatuga to spread the practice of composting even further. This could be used to initiate new measures, launch new products/workshops tailored to their customers' needs, or get additional subsidies.

### 2.4 Challenges and Limitations

Having described the overall objectives of our project, it is now important to look at the challenges that go along with it. Therefore, the following chapter analyzes the challenges as well as the limitations we had.

*Challenges*

When working on the objectives of the app, we asked ourselves the following questions:

1) *Overall Layout and Composition:* How to provide an intuitive and user-friendly app framework with an informative cost optimized sign-up logic?
2) *Input Tracking:* How to align user experience and accuracy in compost weight tracking?
3) *Impact Tracking:* How to measure the $CO_2$ impact of composting while creating a strong impact narrative that makes composting more tangible?

4) *Gamification:* How to motivate and incentivize people to start tracking their composting regularly to foster a habit?

*Limitations*

In addition to the challenges, we had to face some restraints regarding the project's scope. Since we were creating an app as part our thesis, we had a very limited amount of time to develop and test the app. The second major limitation was that our group consisted of students that specialized in different academic fields before and had little to no previous programming experience. We therefore had to set some limitations regarding the overall scope of the app, specifically the number of implemented features and depth of the MVP. However, given these limitations, the result of the app exceeded our expectations in terms of complexity and quality and met the features most desired by the company.

## 2.5 Project Approach

During the project, we took the following approach: We started with a kick-off meeting with Mudatuga and our supervisor, where we got to know each other and identified the previously mentioned objectives, challenges, and scope of the project. Shortly after, we exchanged our visions and ideations and made sure to agree on an equal approach. This set the base for the app development which in the next step would involve the overall concept of the app as well as the ideation, concept, and display of each selected feature. After this was developed, we used low-code technologies (*OutSystems*) to implement the MVP. After the finalization of the MVP's first version, we decided to test the app to get additional feedback concerning bugs and content improvement.

## 2.6 Document Structure

This report is intended to serve as comprehensive documentation of our project and the MVP and is structured as followed: In Chapter 1 we introduced the topic of our thesis and gave a summary about its content. We then gave an outline of its context in Chapter 2. This included the company profile as well as information about composting, followed by the objectives, challenges and limitations. Chapter 3 goes into detail about the overall development approach by describing the overall ideation and feature prioritization of the app. We next describe the overall conceptualization of the app in Chapter 4, which analyses the navigation, composition, and main processes in the app. This is followed by the conceptualization of the three main features: Input Tracking, Impact Tracking and Gamification. Chapters 5-7 include research and benchmarking, ideation, concept, and the final display. We then focus on the user of the app by featuring a persona, a customer journey as well as scenario journeys in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. After having focused on the overall design and user of the app, we wanted to concentrate more on the technical aspects. We therefore go into detail about low-code technologies in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** and explain them as well as introduce *OutSystems*. This is followed by Chapter 18 which explains the entire technical implementation of our app, including the data model, the logic as well as the deployment. After the technical implementation we made sure to test the app. This process is described in more detail in Chapter 0. In the final two chapters of our thesis, we elaborate on strategic recommendations (Chapter 9) and end it with a final conclusion (Chapter 10).

# 3. Ideation & Feature Prioritization

Now, that there is a general understanding about the context of this thesis, we will start to dive deeper into the development process of the app. Before we specify how the app is ultimately composed and how each of the individual features function, we want to explain how we got to the final concept of the MVP.

First, our general ideation methodology will be explained in Subchapter 3.1. Second, an overview of all features considered in the beginning of the project and of the features that were finally chosen will be given in Subchapter 3.2.

## 3.1 Ideation Methodology

We viewed the ideation process as a reflection on how to create a well-thought-out MVP considering and canceling out different kind of ideas. The initial approach was inspired by a framework from Rothe et al. (2020) and composed of two logics: An *exploration* and a *validation logic* (Figure 7). The *exploration logic* on the one hand dealt with academic literature research: Ultimately, some concepts for the features had to be researched and best practices had to be identified. Questions like how to measure $CO_2$ savings for composting waste or how to best determine the weight of the compost waste were looked for. Furthermore, we also benchmarked related apps with similar frameworks or user interfaces: Questions were explored like which apps can be used as inspiration for the most effective gamification logic or a suitable dashboard.

Once we had gathered enough substantial information, we further concretized the concepts in a *validation logic*. The associated goal here was to have a completely mature concept of all features for implementation. We also followed a two-pronged approach: First, we carried out such validation in the team internally. In so-called on-site working sessions, the ideas were discussed by getting inspiration from design thinking innovation (Figure 6).

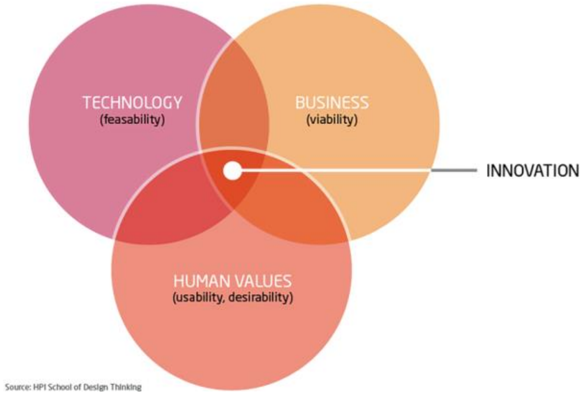


*Figure 6: Three lenses of design thinking*

For us, the main criteria were *usability, desirability,* and *feasibility*, i.e., how the app can be designed in the most user-friendly way and which ideas can be implemented technically. In that sense, we were able to benefit greatly from the interdisciplinary orientation of our team – covering both business and tech background. Financial sustainability (viability) was not that relevant looking at the scope of this project, although we also considered questions like how to design the app in a way that one could commercialize certain aspects or realizing potential business models at a later stage (Inder and Reay 2014). Moreover, external help was consulted for validation: In regular meetings with Mudatuga's founding team, we presented our ideas and were able to refine or adapt them very precisely based on their expertise in the field of composting. We also solicited ideas from industry experts such as product managers of startups who had experience in building a gamified app in the EdTech space.

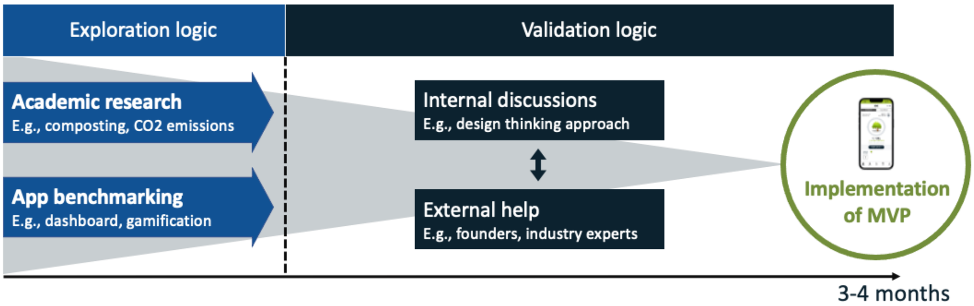


*Figure 7: Ideation methodology*

Thus, this structure of *exploration and validation logic* was used for achieving our objectives and tackling our main challenges stated in the previous chapter. Before we start covering this in higher detail, however, we briefly explain which features at choice were selected at the beginning of the project.

## 3.2 Feature Ideation & Prioritization

When selecting the main features to be integrated into the app, there were a lot of ideas from the founding team that could have been implemented. The following features were part of the discussion (Table 1):

**Possible features for implementation**

| Features | Description | Chosen? |
|---|---|---|
| *Input Tracker* | A tracker for entering weights of composted waste | Yes |
| *Impact Tracker* | A tracker for measuring $CO_2$ emissions saved | Yes |
| *Gamified XP-System* | A system, where users are getting rewarded by XP-points due to preferable composting behavior | Yes |
| *Education section with videos & lessons* | A database where users have access to educating video material about composting | No |
| *Visual map for sharing waste* | A map, where users see businesses, which they can donate their compost to | No |
| *Social-media feed* | Community section where users can post, like and comment about composting activities (of others) | No |

| | | |
|---|---|---|
| *Integrated web-shop of composting* | A fully integrated web shop, where users can buy composting materials such as bins, container, … | No |
| *Quiz with questions about composting* | Educational section, where users learn about composting through a quiz format | No |
| *Chatbot* | Users can ask questions related to composting that are answered by a chatbot | No |

*Table 1: Possible features for implementation*

As can be seen on the table, at the end only three features were chosen for the implementation of the app. The rationale behind selecting fewer features for the final MVP was to develop them in the necessary depth and quality. The most important aspect was to choose the features that were closest to the objectives for the app (see Subchapter 2.3) and were feasible considering the challenges and limitations (see Subchapter 2.4). Therefore, an input tracker, an impact tracker, and a gamified XP-system were the most essential features for the vision of building an app that will make composting an enjoyable experience through environmental incentivization. All other features were excluded due to two types of reasons (see Smith 2017): Either they were less *impactful*, as they only contributed partly to the vision mentioned (e.g., the chatbot or a fully integrated web shop), or the amount of *effort* would have been beyond the scope of our project. For example, a fully elaborated map would have probably taken more weeks for implementation compared to an input tracker (Figure 8).

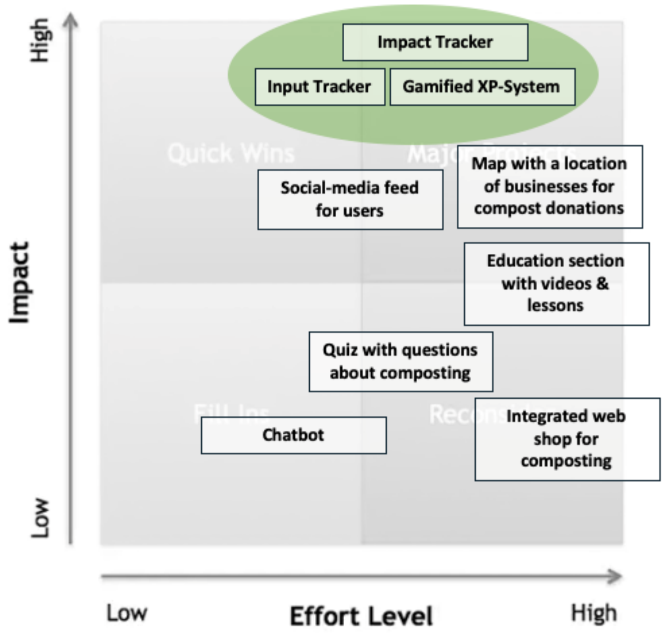


*Figure 8: Feature prioritization*

## 4. Overall Layout & Composition: How to provide an intuitive app layout with an information-cost optimized sign-up logic.

Now that we have established the ideation methodology and feature prioritization, we will start explaining the conception of the app. We follow a top-down logic by first showing in this chapter how we solved the general challenge of creating an intuitive and user-friendly app layout. This chapter should also serve as a guidance helping the reader understand the overview of all screens, the general navigation in the app and the sign-up & profile logic. In the proximate chapters (Chapter 5-7), we will then specify on the challenges associated with the three main features of the app: The input tracking, impact tracking, and gamification.

### 4.1 Composition

To understand the app in its overall completeness, the following 8 screens (Figure 9) are relevant:

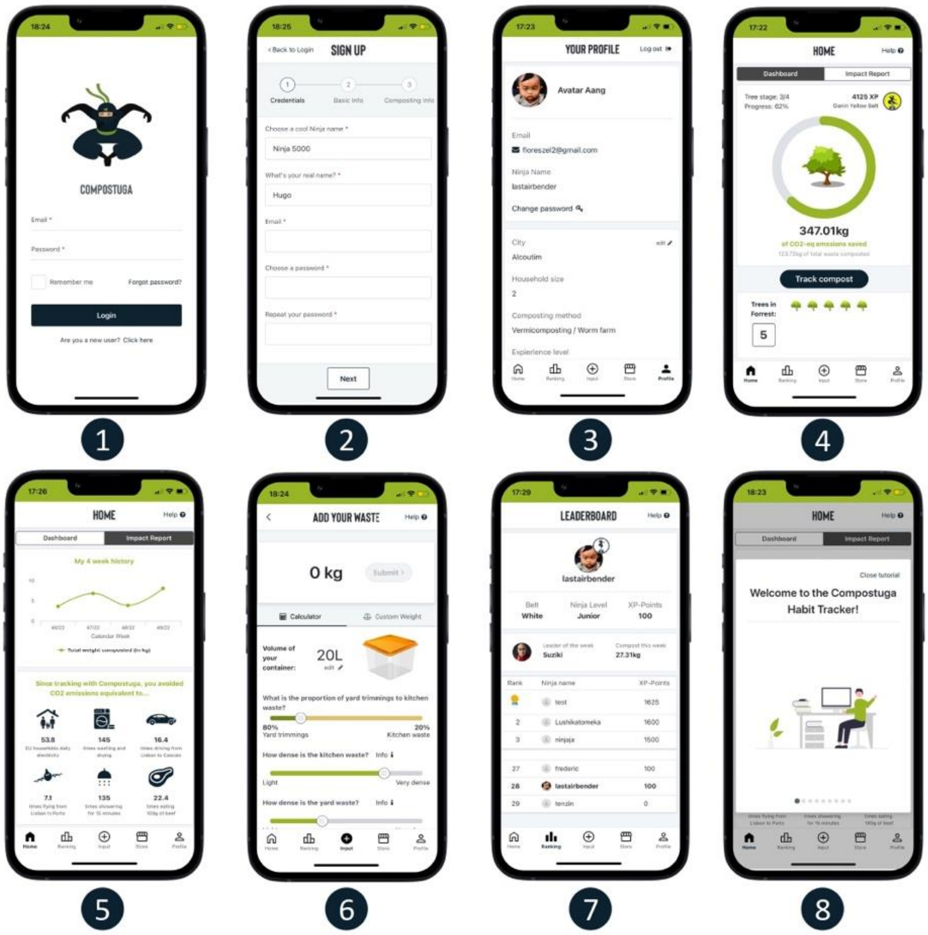

*Figure 9: Overview of screens*

*1. Login:* This is the first screen when a user opens the app.

*2. Sign-up:* If a user has not registered yet, this page will open. It consists of three individual pages (only the first page is shown in the graphic, see more in Subchapter 4.3).

*3. Profile page:* As shown above, this page is available in the menu. It displays all the information that the user provided in the sign-up.

*4. Dashboard of home screen*: This is the core page of the app. The $CO_2$ savings impact of each user is illustrated in the form of tree gamification.

*5. Impact report of home screen* (see Chapter 6.2): This page constitutes the second part of the Home Page. The user is shown how much composting waste he has already generated, as well as other $CO_2$ equivalents.

*6. Input tracking* (see Chapter 5.4): This page serves as the input for all processed data shown on the previous pages (dashboard and impact report), as well as the leaderboard. Any waste that is composted by the user is included here.

*7. Leaderboard* (see Chapter 7.4): This is where the gamification of the app is extended. On the one hand, the progress in XP points and ninja levels is shown to the user. In addition to that, there is also a ranking where users can compare their composting habits with other users.

8*. Tutorial pages / help buttons:* To avoid that the user is stuck in case of ambiguities on the main pages, there are help buttons on every screen. In addition to that, the user is shown a compelling tutorial when opening the app for the first time.

This information should serve as a guidance for the proximate chapters of the report. Since it is not only important what screens the app consists of, but also how the basic structure is built, the navigation of the screens is explained next.

## 4.2 In-App Navigation

For the general method of navigation, we decided to use bottom bar navigation (Figure 10), as used by many of the world's most popular apps, like Instagram, Spotify, and Google Maps. This method brings several advantages, as pointed out by studies and articles from Tsiodoulus (2016), Babich (2016) or Leonovas (2019): All menu items are easily accessible with one thumb, even on increasingly larger phones. Additionally, the user always knows which page is currently shown and can access all other important pages with only one click. When opening the app for the first time, the user also immediately gets an overview, of what the app's main areas are. In the case of the app, we made five main *Screens* to be accessible from the bottom bar: The main dashboard (accessible under "Home"), the leaderboard or ranking page, the composting input page, the store, and the profile area.

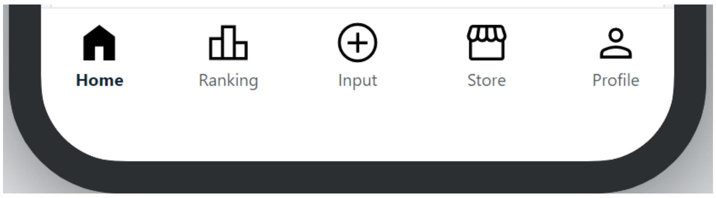


*Figure 10: Compostuga bottom bar navigation*

The header section of the app only contains a title of the current screen for further orientation (Figure 11). In case of the home page, ranking page, and input page, the header additionally contains a "Help" link that opens a tutorial pop up window, with general explanations about the app and/or instructions about how to use that specific page.

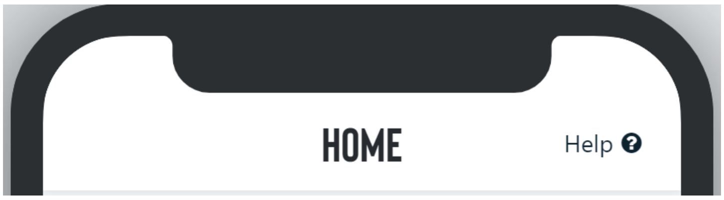


*Figure 11: Header section on home page with "Help" link*

### 4.3 Sign-up & User Profile Logic

Finally, it is important to explain the sign-up logic (Figure 12), otherwise one might not correctly understand the features described in the next chapters (Chapter 5-7). Specifically, it is relevant to explain why which data was requested in this sign-up flow.

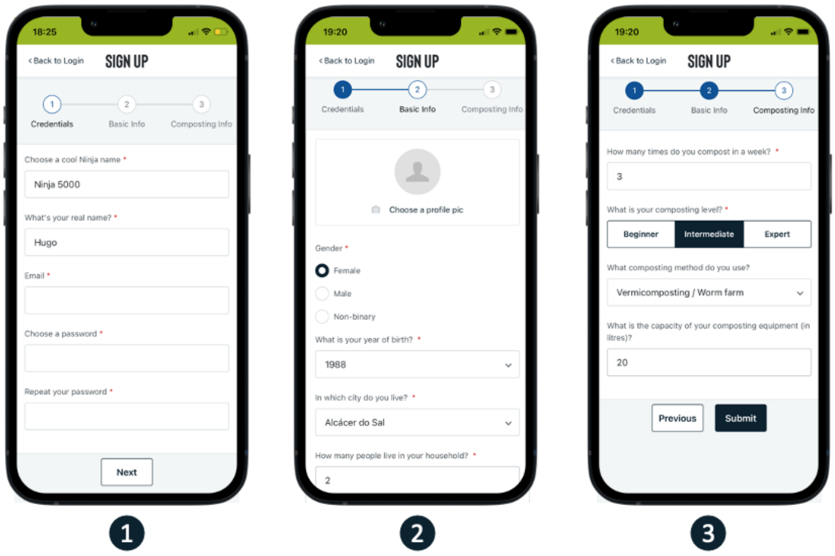


*Figure 12: Sign-up logic*

The main challenge of the sign-up flow was to identify and integrate the most valuable data of users (e.g., what data can Mudatuga leverage for product improvements or their future business model), while not making such process too tedious respectively diminishing the conversion rate from downloading the app to creation of the user profile ("information cost", see Balaji 2022 and Asatryan 2017). Considering this, we decided on the following data points and designed the sign-up process in three separate steps:

*1. Credentials:* Here we asked for data categories such as nickname (used as a gamer-handle), email address and password. This data is necessary for the authentication and identification of a user and his/her profile.

*2. Basic info:* To get a deeper understanding about the background of all users, we ask for their home city, year of birth, and gender. Furthermore, we implemented a question about how many people live in a household because Mudatuga wanted to interpret correlation of composting behavior with the number of people in a household.

*3. Composting info:* We extended this concept by asking questions about other composting behavior: What is the composting level of a user? And what kind of composting method do they use? Besides such questions, we were also interested in the tracking behavior of user who would do composting for a while already. The intuition here was to get data that would be useful in terms of predictive analysis (e.g., is the weekly composting frequency congruent with the data that will be collected in the app?).

Lastly, we made sure that this information is then transferred to the profile screen (Screen 3, Figure 12) of each user. Therefore, user can still edit their information, e.g., change their user profile picture.

# 5. Input Tracking: How to align user experience and accuracy in compost weight tracking.

Now, that there is a fundamental understanding about the composition, navigation, and sign-up logic, it makes sense to explain the challenges for the core features in more detail. In that sense, we will use the same approach (already outlined in Chapter 1) by covering the whole process from first academic research and benchmarking (exploration logic), through ideation (validation logic) and conceptualization, to presenting the final screen of the app. The first core feature will be the input tracker.

The main challenge of the input tracking feature was how to precisely track the weight of waste items without having to physically weight or measure them. This became necessary since compost bins do not have sensors that can collect weight, volume, or other data for the tracker. Therefore, we had to develop a logic based on precise but also easy-to-understand estimation. Questions to be answered were:

*Measurements of composting*

- What are typical items that users throw away?
- What are the typical quantities users throw away?
- What type of measurement do users mostly use when composting?
- What is the best way for users to track weight of waste items? How can compost waste be classified (e.g., categorization of separate items, of yard/kitchen waste, …)

*Frequency* of composting

- How often do users throw away waste? How often do users track this in the app (weekly, daily, both options)?
- How often do users empty the compost pile?

In the first research, mostly information about the type of composting and the volume & weight were conducted.

## 5.1 Research & Benchmarking

By investigating different methods of household composting, we came to conclusion that the following differences should be considered when tracking composting waste: First, composting can involve either kitchen or yard waste composting. Respectively, both types differ in weight from light pieces like vegetables or leaves to heavy pieces like meat bones or branches. Therefore, we needed to research how to determine the weight of such items that substantially differ in density per kg. We came up with the following numbers of kitchen and yard waste density based on data from the Italian Composting and Biogas Association (2022):

- The bulk density of kitchen bio-waste is between 0.6 and 0.8 kg/liter
- The bulk density of yard waste is between 0.15 and 0.35 kg/liter

These numbers were thus a first reference point for estimation, but still missing was how this logic would be translated into a visual app interface with logical steps. Therefore, we started looking at similar apps with waste tracking features (Figure 13). Our focus was how the weight and volume are determined by the user and how the overall interface is designed. As you can see in the figure below, we found different ways to determine the weight and volume:

a) Have a database with all common food and garden waste types that already have a weight assigned to them (right). On this basis, the user chooses all items that he is composting (e.g., two banana peels & four medium-sized branches). The app adds all items together and one obtains the total weight of composted waste.

b) The composting waste is classified similar as shown above (kitchen and yard waste with different densities). By also entering the volume of the compost pile, one gets a comprehensive formula for the total weight of composted waste (left).

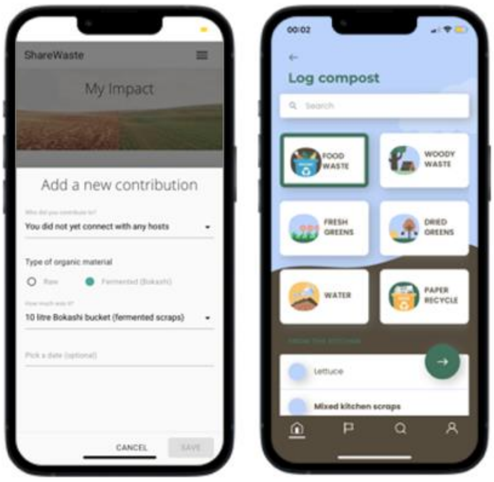


*Figure 13: Benchmarking of input tracking feature (ShareWaste 2022)*

## 5.2 Ideation

As you can see in Figure 14 below, the first mock-up draft was more oriented towards approach (a)). We thought that it would be easiest to enter all specific food and yard items rather than doing more general estimations. However, after validating this concept with the founding team, it was decided that approach (b)) should be included as well. This was because we received feedback that it would be too time-consuming and complicated to enter each food item individually. Rather, the goal was to identify which types of trash differed fundamentally in density and what weight ranges the individual components carried.

## 5.3 Concept

Based on our research and the company's feedback the following concept was created: Users should be able to submit the waste they collect (in their individual containers) into the app several times a week. Due to non-uniform container sizes and associated differences in measuring, two different types of measurement were defined. The dimensions of the container including the composition of the waste (kitchen vs. yard waste density) can be entered or the weight (in g) of the waste can be inserted manually. The weight is then calculated based on the specified dimensions and the composition of kitchen/yard waste and different densities.

## 5.4 Design

The display of the input tracking (Figure 14) is shown on a separate page called “Input” in the app. As described before, there are two different options for the user to input the amount of compost, which is why there are two different "windows". Both times the total weight (which is initially 0kg) is displayed at the top center, with the possibility to submit or delete it. Below the weight there is the possibility to enter the actual weight or the dimensions, as well as the density and composition. This is displayed by sliders, which are divided into two different colors (e.g., 30% Kitchen Waste (green) - 70% Yard Waste (yellow)). The input page will be accessible from the main dashboard as well as from the menu bar.

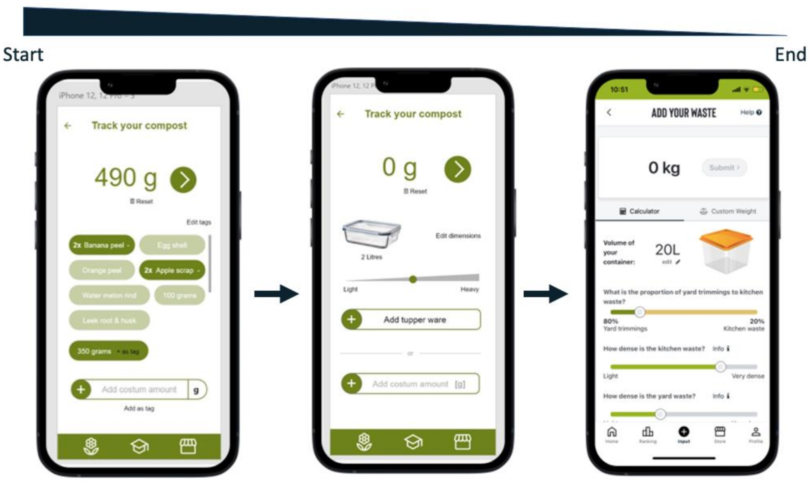


*Figure 14: Ideation of input tracking feature*

# 6. Impact Tracking: How to measure the $CO_2$ impact of composting while creating a strong and tangible impact narrative.

The impact tracking feature described the challenge how to calculate and illustrate – in the most user-friendly way - the $CO_2$ savings effect of composting in the app. The important aspect here was to create a strong impact narrative about appropriate equivalencies of $CO_2$ emissions. Questions to be answered were:

*Measurability*

- What are the most common and accurate ways of measuring $CO_2$ emission savings in relation to composted material?
- How much detail is needed for this measurement? Are there indirect effects that would make sense to discard?

*Equivalents*

- What are suitable equivalents for $CO_2$ savings? Which are particularly effective?
- Which equivalents best fit the weight scale of composting?
- How do you mathematically convert $CO_2$ savings into these equivalents (e.g., what is the factor of calculating the $CO_2$ savings of a 1-year living tree?)
- What is the best way to illustrate these equivalents in the app?
- In what way can these equivalents be integrated into a gamified logic?

## 6.1 Research & Benchmarking

*Measurability*

In the literature review, we looked at the following papers on the measurability of $CO_2$ savings for home composting: A very comprehensive overview was given by Colón et al. (2010) who showed all associated effects ("life-cycle view") from direct effects like carbon sequestration and fertilizer offset benefits to indirect effects such as avoided emissions through waste transportation. Al-Rumaihi et al. (2020) gave interesting insights about the difference in $CO_2$ emissions savings due to different composting techniques such as Vemicomposting or Bokashi composting and respective factors like equipment used, sequestration or transportation required. Although differentiated approach seemed promising, we concluded with the founding team to assume average $CO_2$ kg savings per waste and only consider direct effects in that regard (see Subchapter 6.2).

*Tree* Equivalent

In addition, there was the question of how we could relate $CO_2$ savings to other equivalents. We quickly decided to use the equivalent of a tree, as we found this to be particularly effective in contrast to other reference values such as the number of kilometers flown, or kilograms of beef eaten. The rational was to incentivize the user not in an avoidance narrative („my composting actions are equivalent to avoiding flights, meat, ...“) but in an addition narrative („my composting actions would help growing trees“). The central question was therefore how many kilograms of $CO_2$ kg a tree emits in a year. Organizations such as Encon (2022) or Ecotree (2022) provided calculators in that regard. Besides these research findings, we started doing benchmarking by finding an answer to what is the most effective way to illustrate these equivalents in the app?

*Tree & Forest Logic*

Since we wanted to include the tree as a central motive for impact tracking, we found a lot of inspiration in the app "Forest" (Figure 15). “Forest” is a productivity tool where you are incentivized to work longer and more focused by collecting virtual trees. Such trees will be planted in real-life later. Consequently, a user is rewarded for his/her productivity by contributing to the environment.

For us, the most relevant point was how a user can collect such virtual trees and have them displayed in his profile on the dashboard page. At the same time, we wanted to make sure that a user can see his progress of saving $CO_2$ emissions in the most effective way. In that regard, a forest (see left screen) with all collected trees inspired us. The right screen, however, served a role model the design of the dashboard page.


Figure 15: Benchmarking of tree & forest logic (Forest 2022)

*Tracking History*

In addition to that, we thought about how to best display the tracking history of a user. Therefore, we looked at different elements like an integrated calendar or a monitoring graph of the past composting inputs (Figure 16). We discarded the former due to the high complexity level of showing your actions for each day. Instead, we considered showing a simple tracking history per week, which the founding team thought would have the right level of insightfulness.


Figure 16: Benchmarking of tracking history (Mudatuga 2022c)

We also wanted to expand other equivalents for $CO_2$ savings in the impact report. In that sense, the founding team sent us an impact report from their company with some exemplary equivalents. However, we realized that our logic had to be refined, since the reference values should refer to $CO_2$ savings of a household and not of a whole company, as in the example below (Figure 17). Consequently, it would have taken a long time for a household to reach equivalents such as a flight from London to New York. Thus, some quantities were replaced by smaller equivalents like taking a shower, doing laundry, eating 100g beef or short distance flights.


*Figure 17: Potential $CO_2$ equivalents*

## 6.2 Ideation

The research and benchmarking findings were then validated with the founding team. Regarding the *measurability* of $CO_2$ savings in composting, we were provided with the following information:

1. Each kg of composted bio-waste avoids the emission of 2.822 kg$CO_2$eq. in landfills.
2. Each kg of composted organic waste, without transportation, represents the sequestration of 0.001723 kg of $CO_2$eq from atmosphere.
3. The global balance of each kg of composted organic waste from each Compostuga user is the avoided emission of **2.80477kg $CO_2$eq**.

Therefore, we decided to use the number of 2.80477kg as a conversion factor from getting to the composted amount to the associated $CO_2$ savings (Mudatuga 2022).

Regarding the questions how to convert $CO_2$ savings of composting into $CO_2$ savings of other equivalents such as tree $CO_2$ absorption, we were given an impact report from the company, where the total $CO_2$ savings effect in a year was shown (Figure 18):

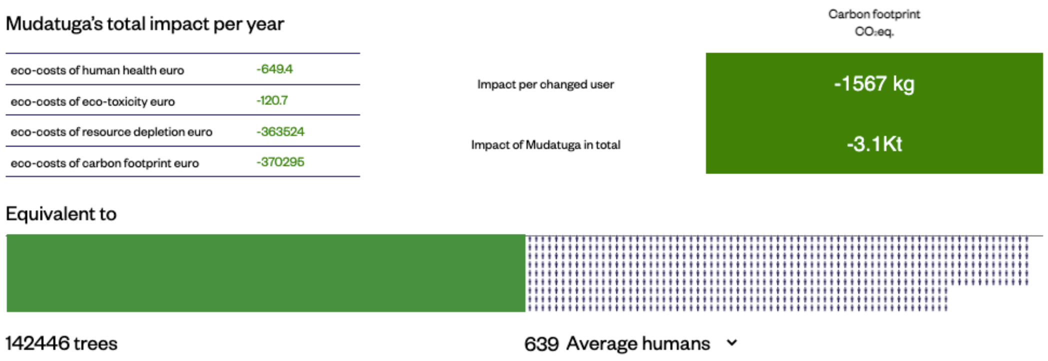


*Figure 18: Mudatuga impact report data*

Therefore, we could calculate how much $CO_2$ one tree would absorb per year and relate it to composting weight (Impact Forecast 2022). The exact calculation is shown in the next chapter.

## 6.3 Concept

*Tree & Forest Logic*

Based on the exploration and validation of our ideas, we came up with the following concept: The general framework of impact tracking feature entails a tree and forest logic. The goal is to collect trees by composting. Multiple trees collected make up the forest. One tree collected represents the equivalent $CO_2$ absorption rate of a 3-year living tree (on average). The mathematical calculations are as follows (Figure 19):

**Step 1: Calculate $CO_2$ absorption amount of one tree per year:**

142,446 trees = 3,100,000 kg // *See ideation chapter*

<=> 1 tree = 21.76 kg

**Step 2: Calculate amount of composted organic waste needed to reach CO2 absorption amount of one tree per year:**

-> Each kg of composted organic waste from each user is the avoided emission of 2,80477kg CO2eq. // *See ideation chapter*

= 21.76 kg / 2.80477 kg

= 7.76 kg

**Step 3: Adjust both numbers *per 3 years*:**

1 tree (1-year life) = 21.67 kg

1 tree (3-year life) = 21.76 kg * 3 years = 65.28 kg

-> Composted organic waste equal to 3-year life tree:

= 7.8 kg * 3 years ≈ 22.5 kg

*Figure 19: Calculation of $CO_2$ equivalents*

Therefore, a user needs to collect 22.5 kg of waste in order to collect one tree. The collection of one tree happens in four different tree stages (Table 2):

**Level stages of one collected tree**

| Stages | Composted waste needed to reach stage (in kg) | Composted waste needed to reach stage (in kg) (accumulated values) |
|---|---|---|
| 1 | 3.0 | 3.0 |
| 2 | 4.5 | 7.5 |
| 3 | 6.0 | 13.5 |
| 4 | 9.0 | 22.5 |

*Table 2: Level stages of one collected tree*

Each tree stage has different requirements regarding the amount composted. As you can see, it is getting increasingly difficult to reach a level (to reach level 1 you need to track 3kg of compost, for level 2 you need another 4.5kg, etc.). The user can track its progress within a tree stage by reviewing a progress circle (Figure 20). After completing the fourth and final stage of a tree, the tree will be added to the forest.

*Tracking history*

The tracking history will be displayed in a diagram, showing the four-week history of composting (per week and kg) per user. Additionally, the impact each user has by composting will be shown as an overview with examples of the avoided $CO_2$ emissions equivalents since the user started using the app. Examples would be EU households' daily electricity, the number of times driving from Lisbon to Cascais as well as the number of times flying from Lisbon to Porto and so on (Table 3):

**Tracking history – $CO_2$ equivalent conversions rates**

| Equivalent | $CO_2$ equivalent in kg | Source |
|---|---|---|
| EU households daily electricity | 6.45 | Impact Forecast (2022) |
| Washing and drying | 2.40 | Berners-Lee and Clark (2010) |
| Driving from Lisbon to Cascais | 21.20 | Impact Forecast (2022) |
| Flight from Lisbon to Porto | 48.77 | ICAO Carbon Emissions Calculator (2022) |
| 15 min shower | 2.57 | Hansgrohe Group (2022) |
| Eating Beef (100g) | 15.50 | Poore and Nemecek (2018) |

*Table 3: Tracking history - $CO_2$ equivalent conversion rates*

## 6.4 Design

*Tree & Forest Logic*

The tree and forest logic will be shown in the "Dashboard". Center of the page will be a tree, having different sizes according to the different tree stages, as well as a grey/green progress circle framing it. Users will start with a small tree, which increases in size upon completion of a tree stage. These stages are displayed in the top left corner (e.g., 1/4, 2/4, 3/4, 4/4) followed by the progress (in percentage) of the overall tree progress. The progress circle framing the tree shows the progress within each tree stage. If a user composts, the progress circle will fill in green until the user composted the required amount to reach the next tree stage. Upon reaching the next tree stage the progress circle will be back to grey. The collected trees will be displayed in the bottom of the main dashboard. Finally, there will be a small image of the collected tree next to the total number of collected trees (Figure 20, screen 3).

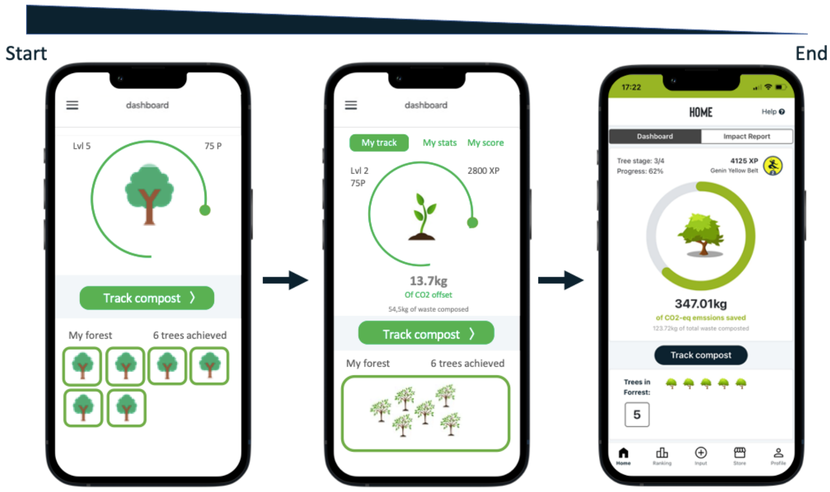


*Figure 20: Impact Tracking Design - Tree*

The display of the overall impact of composting is illustrated in two different ways: There will be a number displayed in the main dashboard which shows the total amount (in kg) of $CO_2$ equivalent emissions saved. This will be highlighted in a green font color.

*Tracking history*

Additionally, the main dashboard will have a second window called "Impact Report". The user can open this window and see its four-week composting history. It includes a graph (green) of the last four calendar weeks (x-axis) including the total weight in kg (y-axis). In the bottom of the "Impact Report" page, the user can review its avoided $CO_2$ emission equivalents. Those equivalents are shown with icons, followed by the individual numbers as well as a short description (Figure 21, screen 2).

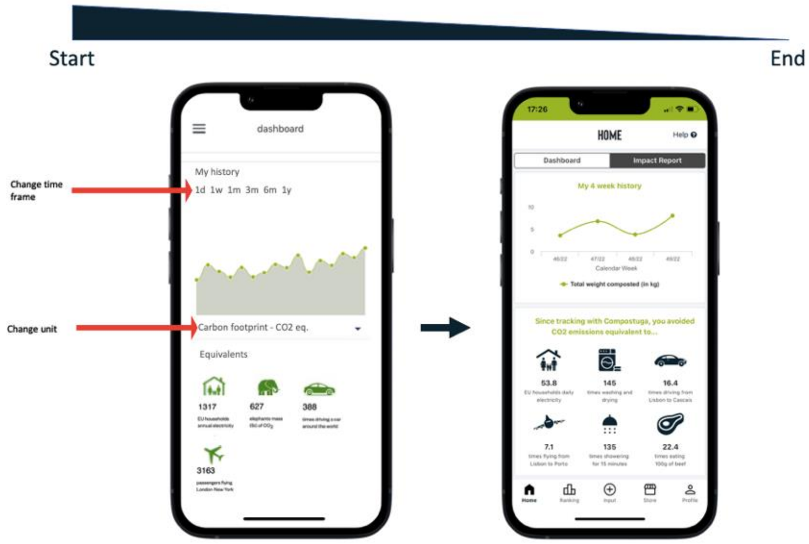


*Figure 21: Ideation of impact tracking feature*

# 7. Gamification: How to motivate and incentivize people to start tracking their composting regularly to create a habit.

The elaboration of the gamification feature relied on the challenge of designing the app in a way that would motivate and incentivize people to pursue their composting through gamification. This gamification was found in exactly three things: a) *An XP-System Logic* b) *A Ninja-Level Logic* c) *A Leaderboard*. Questions to be answered were:

*XP-System Logic*

- How is the logic structured (leagues, levels)?
- When do you get points (Streaks, Milestones, ...)?
- How fast should you get points?
- In which order of magnitude should the points be?
- How is the logic related to the Tree-Forest logic?

*Ninja-Level Logic*

- What names could the Ninja levels have?
- How is the logic related to XP-System Logic and Tree-Forest Logic?

*Leaderboard*

- How can a ranking look like?
- What information (name, XP points) should be displayed?

The initial research focused primarily on finding sources about what the most effective gamification logic could look like.

## 7.1 Research & Benchmarking

Gamification became more and more popular with the rise of technology. It can be defined as followed:

*"Gamification is an innovative approach to foster motivation. It refers to the use of game elements in non-game contexts."* (Sailer et al. 2013, 28)

The general idea is therefore to transform and leverage the motivation that comes naturally when playing games to a non-game context. Currently, gamification is especially used to influence environmental and self-driving behavior, to motivate people for physical workouts, and to improve learning in schools (Sailer et al. 2013). Especially the use of gamification in applications became more and more popular. One example would be the previously mentioned "Forest App" (see Subchapter 6.1, *Tree & Forest Logic*) which rose to popularity in the last years. The app makes use of gamification in form of a tree to help users stay motivated and focused. Users can plant and grow a tree which they then collect to create a forest. As soon as the user leaves the app halfway (which is associated with an interruption of the focus) the current tree will die (Forest 2022). This type of gamification in apps has proven to be highly effective regarding motivation, user interaction, and social effects (Saleem, Noori, and Ozdamli 2022). Furthermore, Sailer et al. 2013 investigated how game elements can address different motivational mechanisms. They were able to prove, that gamification addresses different motivational mechanisms and thereby fosters motivation.

As we researched gamification and the best way to incorporate it into our app, we chose to analyze different existing apps that already make use of gamification or are pure gaming apps. We analyzed applications like Candy Crush, Subway Surfers, and video games like Fortnite. Additionally, we were going through different apps trying to find visual inspiration for the display of possible leaderboards (Candy Crush 2022, Subway Surfers 2022, and Fortnite 2022). In the following, the findings of this research process will be described in more detail.

*XP-System Logic*

While elaborating the gamification logic for the app, we wanted to make sure to include a system, where users could collect points. Our research showed that many apps offer users to collect points when achieving milestones. Hence, we quickly developed the idea of an XP system in which the user can collect points by fulfilling various requirements. Research has additionally shown that the XP points are usually greater numbers (e.g., “Congratulations! You just earned 500 XP points!”), as a higher score seems like a greater achievement to the user. Eventually, a system for structuring these points into leagues or levels is necessary. Lacking this structure in the final app, would otherwise lead to a missing incentivization for the user to collect points.

*Ninja-Level Logic*

When conducting research for a possible level logic linked to the XP system, we had analyzed different apps and were able to identify the structuring of levels, their names, and their timing. The level structure is designed in a way that levels are always in an ascending order with an increasing degree of difficulty. In doing so, reaching the first levels is relatively easy, whereas reaching higher levels is increasingly difficult and comes in hand with a more regular use of an app. This goes along with the timely distribution of levels. A very popular approach here is that the first couple of levels can be reached within the first hours/days/weeks (depending on the kind of app and the amount of usage). If an app can be used for several hours a day (e.g., Candy Crush), reaching a new level in the beginning will be possible after a couple of minutes. This ensures that the user will be rewarded for playing and motivates the user to continue to play. The higher the level the longer it then usually takes the user to reach the next level, due to an increase in difficulty or an increase in the needed XP points to reach the next level (higher gaps). Finally, there are two ways levels are named/displayed: The first option is to give level numbers (e.g., Level 1, Level 2) whereas the second option is to name them individually. When giving names to level the names were either related to the game/company or they used generic terms (e.g., Beginner, Intermediate).

In addition, research demonstrated that different levels can also be categorized into e.g., different leagues. A user must go through all the levels in one league to move up to the next one. This categorization is used to add an additional classification to the level system and to incentivize and reward the user even more.

We also conducted a meeting with Mudatuga about a possible level logic. The company suggested to name the different levels "Ninja Level" as they call their customers "Ninjas". In addition, they also proposed that it should not take the user a long time to reach the next level in the beginning, as they want to motivate and reward the user in the early stages to continue using the app. This is in line with our research.

*Leaderboard*

A lot of the apps using gamification on the market make use of a leaderboard showcasing the best users of the app as well as the current user's position. We consequently decided that a ranking could be a valuable feature in the app to motivate and incentivize people even more. Beyond that, the creation of a leaderboard would also contribute to the creation/presentation of a composting community. Based on those findings, our research then focused on possible methods to display a leaderboard. Some examples of leaderboards in other apps can be seen in Figure 22. Generally, the name, rank and number of points are displayed with an additional visual highlighting of the user's position.


*Figure 22: Benchmarking of different leaderboards (Strava 2022)*

## 7.2 Ideation

The first draft of the overall gamification logic followed our research outcome closely. We decided to reward users with XP points for reaching e.g., a new tree stage. In addition to that, users should get points starting from 100 XP, to be coherent with our research that higher numbers are more rewarding than lower ones. We then implemented "Ninja Level" as well as different categories. Each category (bronze, silver gold) has four ninja levels, and it gets increasingly difficult to reach the next level/category. We changed this approach after we got feedback from Mudatuga, that they would prefer categories named after karate belt colors rather than the before mentioned categories. Finally, we came up with a draft of a possible leaderboard followed by an additional feature called "weekly leader".

## 7.3 Concept

Based on our research and benchmarking we came up with the following gamification concept: The XP systems is a system, where every user can gain and collect so called "XP-Points". Those points can be earned by:

- Reaching the next tree stage (125 XP per tree stage)
- Earning trees (500 XP per tree)

- Composting every week (100 XP for every week composted, plus additional 100 XP for composting every week in a row)
- Being the weekly leader (400 XP - user with the highest amount composted per week).

There are also different "Belt Categories", which you can move up to by going through different "Ninja Level" which are based on XP points. Every belt category has the same four "Ninja Levels": *Junior, Genin, Jonin,* and *Chunin*. The user starts in the *White Belt Category* and can move up to the next category by going through all four ninja levels. The next belt category is the *Yellow Belt Category*, followed by the *Orange Belt Category* and so on (based on the karate belt colors). Our numerical approach and the expected timeline of a user going through the different levels can be found in Figure 23. Additional details about the XP Logic and its calculations can be found in Appendix 1.

| Categories | Level | Ninja Name | Total Points<br>in XP | Time<br>in weeks | Tree Points<br>500 per tree | Tree Stage Points<br>125 points per level | Streak Points<br>First time 100 points<br>200 per streak | Leader Points<br>400 per leader |
|---|---|---|---|---|---|---|---|---|
| White Belt | 1 | Junior | 0 | 0 | / | / | / | / |
| | 2 | Genin | 325 | 1 | 0 | 125 | 200 | 400 |
| | 3 | Jonin | 650 | 2 | 0 | 250 | 400 | 400 |
| | 4 | Chunin | 1800 | 4 | 500 | 500 | 800 | 400 |
| Yellow Belt | 5 | Junior | 2450 | 6 | 500 | 750 | 1200 | 400 |
| | 6 | Genin | 3600 | 8 | 1000 | 1000 | 1600 | 400 |
| | 7 | Jonin | 4250 | 10 | 1000 | 1250 | 2000 | 400 |
| | 8 | Chunin | 5400 | 12 | 1500 | 1500 | 2400 | 400 |
| Orange Belt | 9 | Junior | 6375 | 15 | 1500 | 1875 | 3000 | 400 |
| | 10 | Genin | 7525 | 17 | 2000 | 2125 | 3400 | 400 |
| | 11 | Jonin | 8175 | 19 | 2000 | 2375 | 3800 | 400 |
| | 12 | Chunin | 9325 | 21 | 2500 | 2625 | 4200 | 400 |

*Figure 23: XP Logic*

The outcome of the XP system is a leaderboard within each belt category, which ranks the users in each belt color based on their total amount of XP points. Dividing the leaderboard in belt colors supports new users in having the opportunity to be displayed in the leaderboard despite having less XP points than user who have been using the app for a longer timeframe.

Finally, we also included a leader of the week. The leader of the week is the overall top performer with the highest composted amount overall (not connected to belt colors).

### 7.4 Design

Every user gets a round icon where a picture of a ninja is shown, the ninja level as well as the belt color. The picture of the ninja, the ninja level as well as the belt color will change according to the current amount of XP points and the connected ninja level as belt colors (Figure 24).


*Figure 24: Yellow belt level icons*

The app features a screen called "Ranking" (Figure 25) for the gamification element, which displays the users profile picture with its name as well as their ninja icon. The belt color as well as the ninja level and the total amount of XP points are displayed on the page, too. Below the ranking, the respective belt category is shown. There is a total of six users being displayed: the top three users, followed by the user in front of the current user, the current user (displayed in bolt font), and the user after the current user. In the bottom of the page the overall leader of the week gets displayed with its name and total amount of kg composted this week.

Additionally, the icon with the written ninja level and belt color as well as the total number XP points will be shown in the top right corner of the main dashboard (Figure 20).

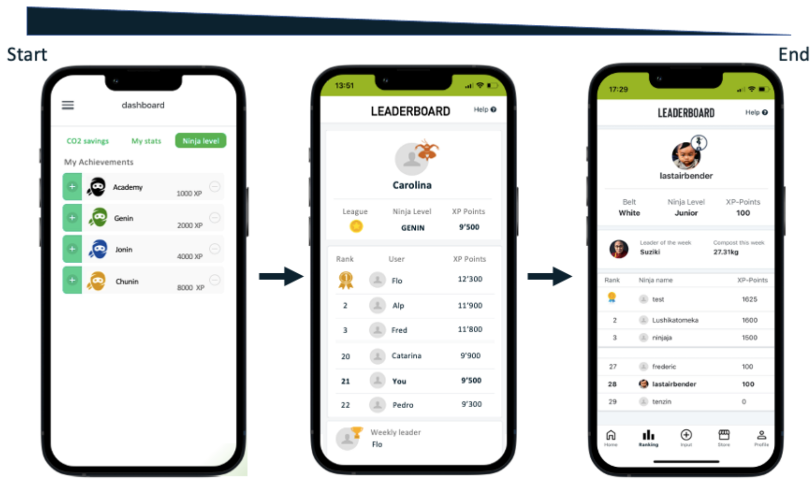


*Figure 25: Ideation of Gamification Concept*

# 8. Technical Implementation

In the beginning of this report, we have described the main idea, the *Screens*, as well as the features and their concepts of Compostuga. We are now ready to dive deeper into the technical implementation of Compostuga. In the following chapter, we explain how we implemented the app, starting with the data model, followed by the logic, and ending with a brief explanation of our deployment strategy and the release of the app.

## 8.1 Data Model of Compostuga

As the data model is the basis for most applications it was also the starting point of our implementation. The first data *Entity* in any user-account based application, such as Compostuga, is usually the “User” *Entity* (Figure 26). *OutSystems* provides a pre-defined “User” *Entity*, with non-modifiable attributes. To define additional user attributes, specific to the Compostuga use case, we extended “User” by creating another *Entity* called “AppUser”. Note that, as of now, we defined a one-to-many relationship between “User” and “AppUser”. The reason for this was that we had originally planned for a "User" instance to have multiple "AppUser" instances, similar to Netflix where one user can have multiple profiles. If such logic will not be needed in the future, the “AppUser” *Entity* might be refactored to have a one-to-one relationship with “User”. Further we defined a “UserLoginInfo” *Entity*, which contains information about whether it is the first time a user accessed a specific screen to trigger the respective onboarding popup. Another *Entity* is “AppUserImage”, which stores the profile picture of each app user.

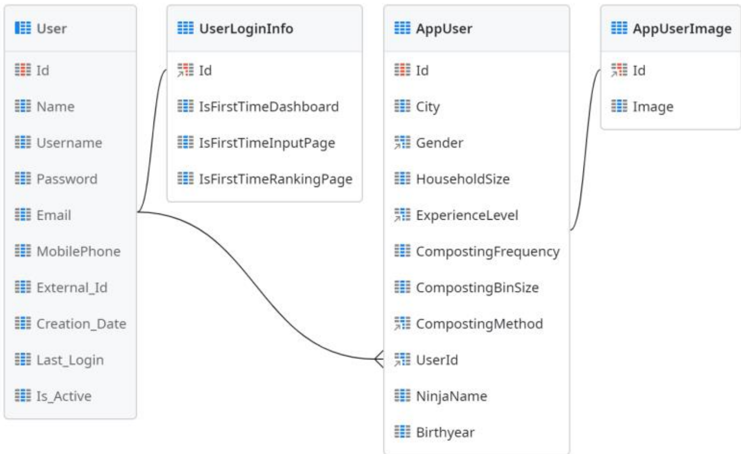


*Figure 26: Entity diagram for the Compostuga user logic*

The next business concept of Compostuga that needed to be represented in the data model was compost tracking. For this purpose, we defined two entities: "CompostPile" and "UserCompostInput" (Figure 27). The *Entity* “CompostPile” has a one-to-one relationship to “User” and stores the weight and $CO_2$ savings of the total amount each user has composted. Each time the user tracks his/her compost with the app an instance (or row) of type “UserCompostInput” is added to the database, containing information about this particular input, such as the volume, weight, and entry date.

“UserCompostInputSettings” is an additional *Entity* storing the default settings for the compost input screen for each user, such as their waste characteristics (proportion & densities) and the volume of their waste container. We defined “UserCompostInputSettings” to have a many-to-one relationship with “User” to leave the option open for future iteration of the app that users may save multiple compost input settings in their profile. “UserCompostInputSettings” is updated each time a user changes the settings (volume or input slider) and submits waste to their compost.

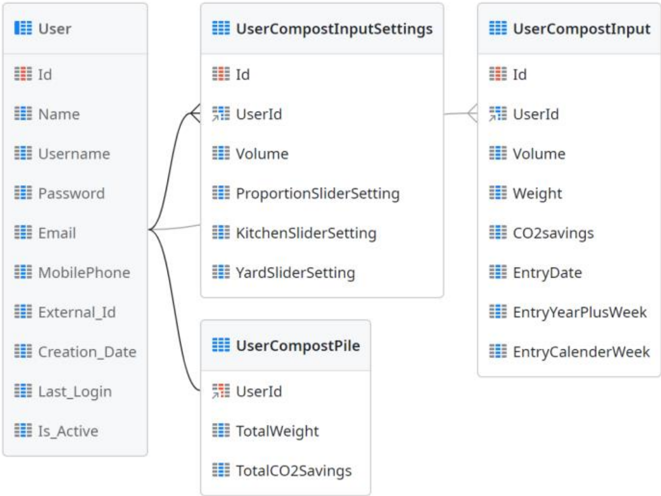


*Figure 27: Entity diagram for composting logic*

The concept of trees and the XP-System are represented with the help of three additional *Entities*: “UserXPProfile”, “UserForest”, and “UserCurrentTree” (Figure 28). All three have a one-to-one relationship with “User”. The “UserXPProfile” stores information about the user’s XP profile, including his/her total XP points, the current XP level, the streak duration (later explained in more detail), whether he/she is the weekly leader and if yes how much he/she composted during that week. Additionally, we store information about whether to show certain pop ups to the user, e.g., if he/she moves one XP level up. The “UserForest” simply stores the number of trees in the user’s forest. “UserCurrentTree” is used to store the stage and progress of the user’s current tree, which are needed to display and animate the tree on the main dashboard. The weight attribute of the current tree is used in the algorithm to calculate the new tree stage when making a composting entry. We will explain this later in more detail.

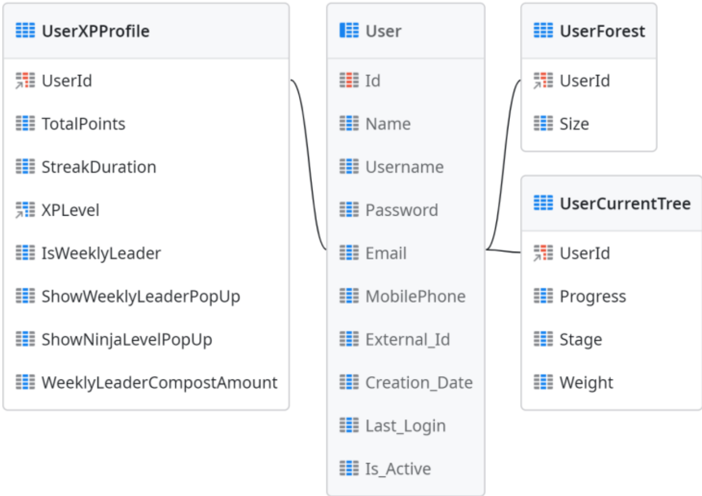


*Figure 28: Entity diagram XP and tree systems*

In addition to the "regular" *Entities* mentioned above we defined several static *Entities*:

- "CompostingMethod"
- "ExperienceLevel"
- "Gender"
- "TreeStages"
- "WasteDensities"
- "XPLevels"

Static *Entities* are *Entities* with predefined instances, called records, that cannot be changed during runtime. Static *Entities* are especially helpful when defining values like the minimum points and maximum points for the Compostuga XP levels that might have to be adjusted over time. These values are used in several places throughout the program. Defining them centrally in a static *Entity* allows those values to be easily and securely altered, without having to go through the entire code. For example, records in the *Entities* "TreeStages" and "XPLevels" might have to be extended or changed in the future as a result of testing or feedback.

## 8.2 Logic of Compostuga

In Chapters 4-7 we provided an overview of all *Screens* in the Compostuga app as well as a description of the underlying concepts behind the app's three main features. In the following section we will provide a more technical explanation about how we implemented those *Screens* and features in *OutSystem*, with a focus on the underlying logic. As this report's length is limited, we will not be able to explain how we implemented every aspect and every detail. Instead, we will focus on the most important parts of the logic along our three main features: Input tracking, impact tracking, and gamification.

### 8.2.1 Input Tracking Implementation Logic

On the input *Screen* the user can interact with the app in mainly three ways. Firstly, he/she can enter a specific composting amount, either by using the calculator (1) or by inputting a weight directly (2) and then clicking the buttons (1) "Calculate" or (2) "Enter weight". After that, he/she can ultimately submit the previously entered amount to their compost by clicking the button "Submit" (3).

(1) Using the calculator and clicking "Calculate" triggers a simple *Action* that calculates the value of the local variable "Weight" with the following formula (Figure 29):

```
Round((Weight + Volume*(1-ProportionKitchenYard)*DensityYard + Volume*(ProportionKitchenYard)
*DensityKitchen),2)
```

*Figure 29: Formula - Value variable "Weight"*

This formula adds the sum of the share of yard and kitchen waste to whatever was previously stored in the variable "Weight" (by default 0) and rounds the result to two decimal places. The respective weight shares (for yard and kitchen waste) are calculated by multiplying the volume with the respective proportion, provided by the user through the proportion slider (a value between 0 and 1 determined by the UI element, whose position is set by the user) and the respective density. The two respective densities are calculated in a previous action as follows (using the example of the yard waste density) (Figure 30):

```
GetYardWasteDensityRange.List.Current.WasteDensities.MinDensity + (GetYardWasteDensityRange.List.
Current.WasteDensities.Range * (YardSliderSetting))
```

*Figure 30: Formula - Product of density range*

This formula sums the product of the density range of the yard waste and the yard slider setting (a value between 0 and 1 determined by the UI element, whose position is set by the user) with the density minimum. The range and minimum of the corresponding densities are previously fetched from the static *Entity* "WasteDensities".

(2) Directly entering a custom weight triggers an *Action* that simply assigns the inputted weight to the local variable "Weight".

(3) Most of the work of the input tracking happens when the user clicks the "Submit" button. This triggers the *Action* "SubmitOnClick" (Figure 31), which firstly validates the inputted weight. If the input is over 22 kg, a message prompts the user to double check. The *Action* then calls the server *Action* "UpdateCompostingProfile". After "UpdateCompostingProfile" is executed, the user XP point *Aggregate* is refreshed, which necessary for the input streak logic (not explained here). Finally, the user is redirected to the Main Dashboard.

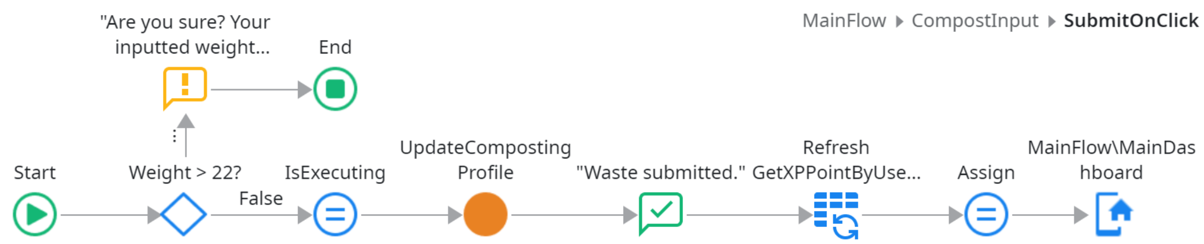


*Figure 31: SubmitOnClick Action*

The *Action* "UpdateCompostingProfile" (Figure 32) firstly updates the "UserCompostInputSettings" *Entity* if the input settings have changed (meaning the volume and/or the slider settings). This is followed by four server *Action* calls. "CreateUserCompostingInput" adds another row to the "UserCompostInput" *Entity*, with a unique Id and the current “UserId”. The $CO_2$ attribute is calculated by multiplying “Weight” with 2.80477, as explained in Subchapter 6.2. Two additional important attributes, which are used for the input history graph, are “EntryYearPlusWeek” and “EntryCalenderWeek”. “EntryYearPlusWeek” stores an integer, composed of the current year and current calendar week, i.e., 202245, for calendar week 45 of year 2022. By grouping, summing up, and sorting the inputs with the same “EntryYearPlusWeek”, we get the weekly input history, visualized in the history graph of the impact report. “EntryCalenderWeek” additionally stores the current calendar week and year in text format (i.e., ‘45/22’) used as the x-axis label in the history graph.

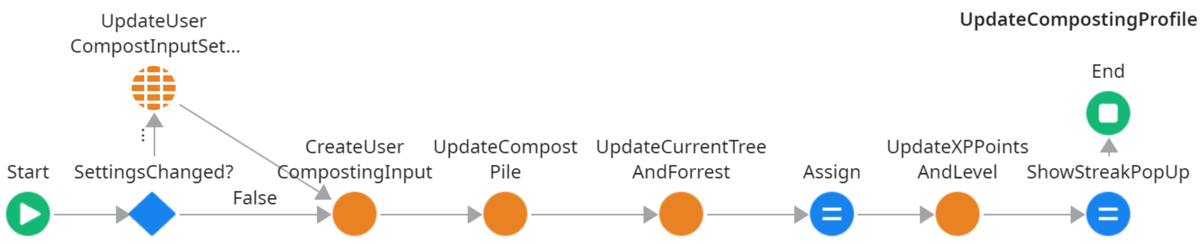


*Figure 32: UpdateCompostingProfile Action*

The *Actions* “UpdateCurrentTreeAndForrest” and “UpdateXPPointsAndLevel” will be explained in the next subchapter.

### 8.2.2 Impact Tracking Implementation Logic

For the impact tracking we must distinguish between the impact of Mudatuga as a company and each user’s individual impact.

The former is rather a side product of the app and its database than a feature. As mentioned previously, we store each user’s amount of composted food waste and consequent $CO_2$-eq savings in the *Entity* “UserCompostPile”. Since these values are stored in the Compostuga database, Mudatuga can simply retrieve and aggregate this data using SQL queries. Since we also collect meta data about the user during the sign-up process and store it in the “AppUser” entity, Mudatuga may cluster the composting data in different ways. They could, for instance, measure the amount of composted waste by city or by composting method. This could be a valuable insight for municipalities and other organizations.

*$CO_2$-eq and* equivalents

Each user can track his/her total individual $CO_2$-eq savings since he/she started tracking their waste with Compostuga. Firstly, users can track their total $CO_2$-eq savings and total weight of waste on the Main Dashboard. For this, the app simply fetches the corresponding database entry from "UserCompostPile" and displays it on the page. Secondly, they can track their $CO_2$-eq savings as six different equivalents on the Impact Report. The equivalents are calculated by dividing the user's total composted weight with a specific factor for the respective equivalent. In *OutSystems* the formula for EU household's daily electricity equivalent is for example calculated as follows (Figure 33):

```
Round(GetUserCompostPileByUserId.List.Current.UserCompostPile.TotalWeight/2.299247913,fractionalDigits:0)
```

*Figure 33: Formula - EU household's daily electricity equivalent*

Here, for the household daily electricity, 2.299247913 is the specific factor. The result is then simply displayed as a number below the respective equivalent's icon on the impact report.

*Tree and forest implementation logic*

The individual impact is additionally presented to the users through the trees and his/her forest, as one tree in the app represents $CO_2$-eq savings of 22.5 kg.

The tree and forest logic entails the algorithm that calculates the new state of the current tree and the forest size displayed on the main dashboard, after a user makes a composting input. The second aspect is the logic of the tree and forest animations, which intend to make progressing in the app pleasant and gratifying experience (this aspect can also be seen as part of the Gamification logic).

The algorithm that calculates the new state of the current tree and the new forest size is implemented in the "UpdateCurrentTreeAndForrest" *Action* (Figure 34). It is called by the "UpdateCompostingProfile" *Action* (Figure 32), which in turn runs after the user clicks on "Submit" on the Input Page.

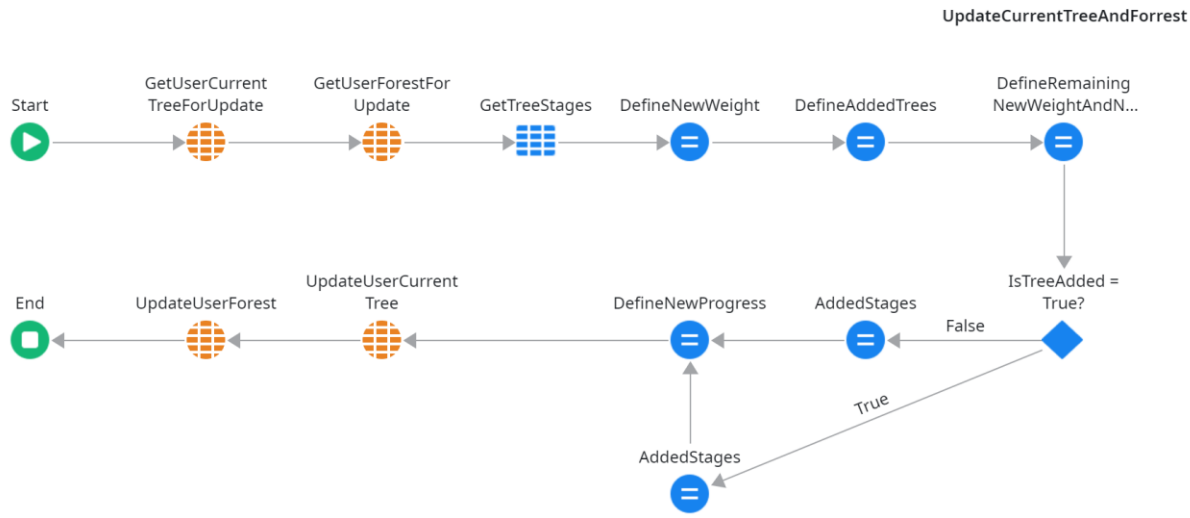


*Figure 34: UpdateCurrentTreeAndForrest Action*

"UpdateCurrentTreeAndForrest" has one input parameter "InputWeight" (the inputted weight) and two output parameters. The two output parameters are "AddedStages", containing the number of stages that were added as a result of that input, and "IsTreeAdded", convoying the information if a tree was added. These two output parameters are necessary for both the animation of the tree and forrest growth and the XP system.

The *Action* starts with three database requests, fetching the "UserCurrentTree" and "UserForrest" with the current "UserId" and the static *Entity* "TreeStages", which stores the different tree stages with their respective step sizes and upper weight limits. For example, "Stage4" has a step size of 9 kg and the upper limit 22.5 kg. The *Action* then calculates the new current tree weight ("NewWeight"), by adding the "InputWeight" and the "Weight" attribute of the "UserCurrentTree", which is the old weight of the current tree before the input.

With the new weight of the current tree, three values can be calculated successively: (1) The number of added trees ("NewTrees"), (2) the new tree stage ("NewStage"), (3) and the new progress (in %) of the current tree stage ("NewProgress").

(1) The number of added trees ("NewTrees") is calculated as follows: If "NewWeight" is greater or equal to the upper weight limit of tree stage 4, one tree is added, else zero trees are added. Note, that the inputted weight is limited to 22 kg (refer to Subchapter 8.2.1), so that with an upper limit of 22.5 kg, one input cannot result in more than one new tree (Figure 35).

```
If((NewWeight >= GetTreeStages.List[4].TreeStages.WeightUpperLimit), 1,0)
```

*Figure 35: Formula - Number of added trees*

(2) If a tree is added, the "NewWeight" would exceed the upper weight limit of stage 4. In that case, to calculate the new weight of the new current tree, the upper weight limit of stage 4 must first be subtracted from the "NewWeight".

The "RemainingNewWeight" is therefore calculated as follows (Figure 36):

```
(NewWeight-(NewTrees * (GetTreeStages.List[4].TreeStages.WeightUpperLimit)))
```

*Figure 36: Formula - Remaining new weight*

With the help of "NewRemainingWeight" the "NewStage" can be determined using a nested if statement, which basically compares the "RemainingNewWeight" with the upper and lower limits of all tree stages and outputs the correct stage. Since this expression is too long and not really readable, we will leave it out here and instead add a screenshot to the Appendix 2.

The new progress of the new tree stage is determined in a similar fashion, with a nested if statement. Except that in this case the value for the new progress (in %) must also be calculated. Dividing the difference between the "RemainingNewWeight" and the lower limit of the correct stage with the step size of the correct stage and multiplying it with 100 yields the new progress (in %). The following visualization (Figure 37) might give a better understanding:

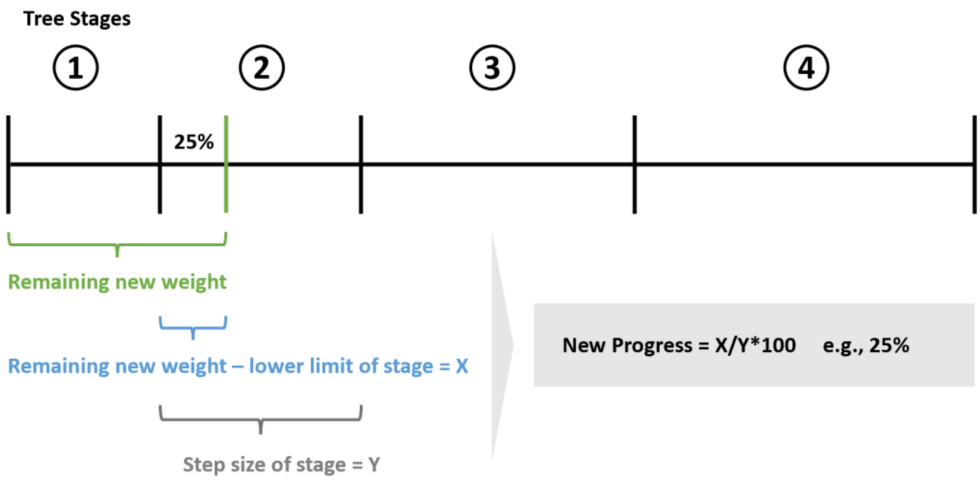


*Figure 37: New progress calculation*

As the entire expression is again too long and not really readable, a complete screenshot is added to the Appendix 3. For exemplary purposes, the part of the nested if statement for tree stage 2, looks as follows (Figure 38):

```
If(RemainingNewWeight >= (GetTreeStages.List[1].TreeStages.WeightUpperLimit) and RemainingNewWeight <
(GetTreeStages.List[2].TreeStages.WeightUpperLimit),(RemainingNewWeight-(GetTreeStages.List[1].TreeStages.
WeightUpperLimit))/(GetTreeStages.List[2].TreeStages.WeightStepSize)*100,
```

*Figure 38: Formula – New progress algorithm (tree stage 2)*

The two output parameters "IsTreeAdded" and "AddedStages" were also calculated but shall not be explained further here. The last step of the “UpdateCurrentTreeAndForrest” *Action* is then to update the respective database *Entities* with the newly calculated values.

We have now explained how the new state of the tree and forest are determined and updated after a user makes a composting input. However, this is only the first part of the overall tree and forest logic. To achieve a smoother user-experience this progress must be animated in the main dashboard. Since the animation logic is too extensive and would go beyond the scope of this report, we will not explain it further. For the sake of completeness, a screenshot of the “AnimateTreeForestAndPopUpsAfterFetch” *Action* is added in the Appendix 4. As the name suggests, this action also contains the logic that triggers the corresponding popup windows that communicate the progress (e.g., gaining a new tree or new ninja level) to the user.

### 8.2.3 Gamification Implementation Logic

The Gamification logic essentially includes the XP system logic (although the tree and forest logic can also be seen as part of the Gamification).

*XP System implementation logic*

The XP System includes the XP points as well as the ninja level system. The underlying concept behind the XP points and ninja level system has been explained in Chapter 7.3. To summarize, the user has four ways to earn XP points:

- By reaching another tree stage [+125 XP]
- By gaining a new tree [+500 XP]
- By being on a streak (inputted multiple at least 2 weeks in a row) [+200 XP for each week]
- By having composted the most out of all users in a week [+400 XP]

In terms of the implementation, the first three ways are checked and calculated right after the user makes a composting input in the *Action* “UpdateXPPointsAndLevel” (Figure 39). Once again, this *Action* is called by the *Action* “UpdateCompostingProfile” (Figure 32), which in turn runs after the user clicks on “Submit” on the Input Page. “UpdateXPPointsAndLevel” has the two input parameters “IsTreeAdded” and “LevelAdded”, which were the output parameters from “UpdateCurrentTreeAndForrest”, as we have seen in the previous section. With these values we can easily calculate the XP points for gaining another tree and/or tree stage(s). The XP points for being on a streak are calculated in the “CheckAndUpdateStreak” *Action*, which is a bit more complicated. We shall not explain it further here but instead provide a screenshot of the *Action* in the Appendix 6.

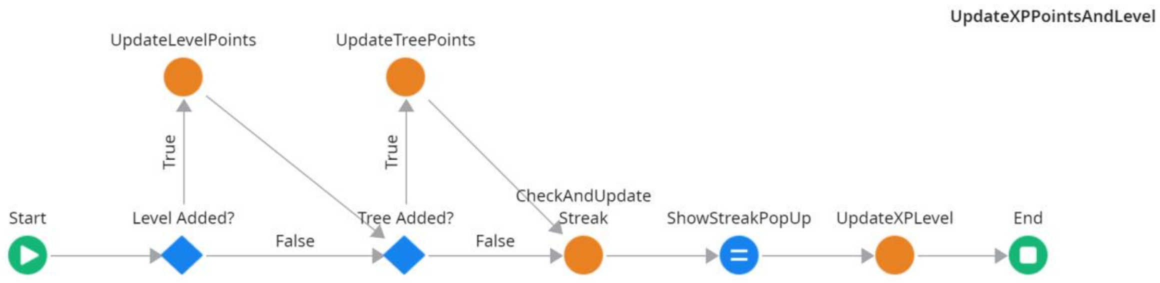


*Figure 39: UpdateXPPointsAndLevel*

Now that we have calculated all the XP points that the user might have gained, we need to determine if a new ninja level has been reached and update the database accordingly. This is done in the "UpdateXPLevel". The new XP level is calculated by comparing the total XP points with the point range of each XP level and then determining the correct one (Appendix 5). The point ranged of the XP levels are previously fetched from the static *Entity* "XPLevel". Finally, the users "UserXPProfile" is updated with the right XP level.

The weekly leader logic is independent from the input tracking. We therefore had to find another place in the program where we could define the *Action* "UpdateWeeklyLeader" (Figure 40). The solution was to run the *Action* inside a timer, which we timed to run every Sunday at 23:45. Notice that in this *Action* we had to call database queries with custom SQL queries. The reason for that is that the "UpdateWeeklyLeader" is called only once on the server and is independent from a user session. We therefore had to make a database call that updates many database entries at once, which was only possible using custom SQL queries. The first query is to reset the weekly leader from the previous week. We then determine the current weekly leader by fetching all "UserCompostInputs" of that week, grouping them by "UserId", summing up "Weight" to "WeightSum", and sorting by descending "WeightSum". The first entry of that *Aggregate* is then the weekly leader. After we determine the "UserId" of the weekly leader, we update his/her total XP points and calculate if a new XP level was reached. As the last step his/her "UserXPProfile" is then updated accordingly.

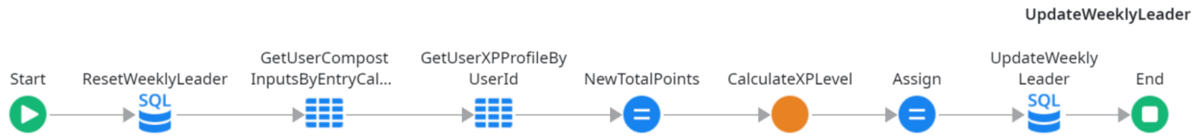


*Figure 40: UpdateWeeklyLeader Action*

Despite the length of the previous subchapters, there are many more aspects that we could not describe due to the limited length of the report, such as the implementation of the front-end (user facing interface). Nevertheless, have we now explained how we implemented the most important aspects of the Compostuga App. One key aspect of the implementation is however still missing, which is the deployment.

## 8.3 Deployment

During the development of an app, it must be continuously deployed and tested by the developers. However, during an external user testing, the app should not be updated or changed to ensure a consistent experience and not confuse the testers.

In order to enable simultaneous testing and development we worked with two separate environments. First, we developed the app on the "development" environment and later deployed the finished MVP on a separate "testing" environment. For a public rollout of the app in the future an additional third environment ("production") may be added.

As of now the app was published mainly as a progressive web app (PWA), which is basically a website optimized for mobile devices. Additionally, to the PWA, we generated the app as an Android-package (.apk file) that can be installed natively on Android devices. A native iOS app was not generated due to Apple's added complexity and security requirements for installing third party files. In the future, the app may also be published as an iOS app. The Android app has not been published in the Google Play store but was distributed with a download link to Mudatuga and testers.

# 9. Strategic Recommendations

So far, this report has covered our project in terms of its overall context, problem definition, the final solution (Compostuga MVP), as well as deep dives into the solution finding process, implementation, and testing of the app. It hence comprehensively covered the core of our project, which was the development of the MVP.

To conclude this report, we would like to provide Mudatuga with some strategic recommendations that leverage and build upon this MVP and could realize some of Mudatuga's untapped potential in the future, both in terms of business and environmental impact. Those recommendations will not only cover future app developments (additional features, improved UI, etc.) but also discuss core strategic issues such as commercialization or competitive advantage in an integrative fashion with Mudatuga's overall product offering.

The chapter will begin with a strategic vision, continue with the main objectives, focus areas, and concrete measures, and conclude with specific key performance indicators (KPIs) to monitor the strategies' implementation and progress.

## 9.1 Strategic Vision

To start off our strategic recommendations, it is important to align on a common vision. We hence wanted to summarize Mudatuga's strategy with a vision statement that combines Mudatuga's existing vision with the goals that we have set for the Compostuga app. We ultimately identified three main strategic goals for Mudatuga:

1. They aim to be a fully self-supporting business that in the long run is not reliant on external funding.

2. They want to spread the practice of composting throughout Portugal by directly helping people to compost.
3. They aim to influence and support the Portuguese government and municipalities to deeply anchor composting within Portugal's society.

Taking into account those three goals we created the following vision statement:

*"Mudatuga works to be a self-sustaining impact venture that empowers the people of Portugal to compost all their biowaste. In addition, Mudatuga works to mainstream the practice of composting in Portuguese society by representing its interests to the Portuguese government and municipalities and helping to develop data-driven and evidence-based programs and policies."*

## 9.2 Strategic Objectives

From the strategic vision we reformulated the goals into the following three tangible objectives, whereas each is meant to help reach its respective strategic goal from the previous section:

1. Revenue growth and identification of new revenue streams
2. Increased overall reach and growth of costumer / user base
3. Increased political influence and building of data-based political lever

## 9.3 Focus Areas and Concrete Measures

To work towards the aforementioned objectives, we identified four focus areas. The focus areas with a mapping to their corresponding objectives are as followed:

1. App development (objectives 1, 2 and 3)
2. Business development (objective 1)
3. Promotion (objective 2 and 1)
4. Lobbying and public relations (objective 3)

In the following sections, we will address all four focus areas in more detail and briefly introduce concrete measures that we recommend for each area.

### 9.3.1 App Development

App development is an important focus area because it has the potential to impact all three objectives. With the help of an outstanding app Mudatuga could significantly grow its user base, increase its revenue by tapping into potential monetarization opportunities, and massively grow its data collection efforts. We categorize our concrete recommendations for the further development of the app into short- and long-term measures.

*S*hort term

In the coming months we recommend Mudatuga to implement quick fixes that should be derived from the feedback of the user testing. With quick fixes we mean, the elimination of any further bugs to get the application ready for roll-out as well as small, requested features or improvements, that do not require much development effort.

In that sense we also want to highlight that the most important point of modern app development is what Brikman (2018) of Y combinator calls “MVP-as-a-process, in action”. In that logic, an MVP is not something “that you build once, and then consider the job done” but rather a process “that you repeat over and over again”. We hence recommend Mudatuga to quickly set up a process to frequently collect user feedback and to continue to improve the application accordingly.

As we are currently only testing the PWA and native Android app, the native iOS app should also be tested and if necessary debugged. Finally, developer accounts for both Google and Apple need to be created and the application rolled out to the Google Play and the Apple Appstore.

*L*ong term

The remaining paragraphs of this subchapter will deal with a selection of features that could be very beneficial to implement into the app in the long run but would also require significantly more technical exploration and development effort. These potential directions come not only from internal discussions, but also from ideas of the founder team and other experts. It is important to note that these are mere recommendations that are in no form prioritized yet.

*1) Social network features*: One idea that is already partly represented in the current version of the app but could be greatly extended is the social aspect. We have already implemented a leaderboard with a league-based ranking system, but there are still various potential directions that the app could evolve in. The general idea is to integrate components of a social network. As shown by the success of apps like Strava, social network components have been proven to work greatly in helping users to uphold new habits (Craft 2018).

Firstly, Compostuga could implement profile pages, which would give users the opportunity to see each other's profile information, like current ranks, composting history, and composting level. It could then support users to connect with each other through a friendship and chat feature. A social feed would allow users to share achievements, pictures, or stories about composting and to interact with each other through likes or comments.

*3) Validated and user-friendly input tracking:* Another feature that can be extended in the future is the input tracking. In the MVP we trust users to input the correct weight of their composting waste without any form of validation. Accurate and valid user inputs are however crucial in several ways. Firstly, they are necessary for the social component to work, as truthful users might get discouraged by falsely high inputs from cheaters. Secondly, accurate inputs are necessary to have valid composting data. If the data of Compostuga ought to be used for any kind of political decision making, it most likely must be validated. Thirdly, future features that would connect composting achievements with real life awards (later explained in more detail), could encourage cheaters to make false inputs. These issues are not that critical in the beginning when the app has a small and trusted user base and does not yet implement the features mentioned above. However, they would certainly become an issue in the future, especially with a growing user base. We therefore strongly recommend that some form of input validation should be implemented in later iterations of the app. Here, the focus should be on a user-friendly experience, as a lengthy input process could lead to a significant drop in usage and ultimately to the failure of the app. We came up with two possible methods:

a) One option would be to develop a weight sensor that is connected to the app via Bluetooth or WIFI. The sensor would either be built into the composter or come as a component, compatible with traditional composting bins. The sensor could then automatically measure the weight of the added waste, making a user input into the Compostuga redundant. Such a solution could, at the same time, serve as a unique selling point for Compostuga's own composting bin, which they are planning to develop.

b) A second option would be to use a computer-vision based validation. This option would require the user to take a photo of their waste with which the inputted weight could be validated using a machine learning algorithm. The disadvantages of the method are that it is most likely not as accurate as option a) and that the process would become slightly more tedious for the user as a photo and an input are required. On the other hand, this method is notably cheaper and less risky to implement than option a) since no special hardware would be required.

*4) Reward system:* A feature that could significantly increase users' motivation to track their compost and use Mudatuga is a reward system that is not only based on virtual XP points but also on real-life prizes. These prizes could range from discounts on items in the Mudatuga store, to discounts in partner stores that reach the same clientele, such as organic food stores, to planting real trees. Such a reward system would, however, require an input validation mentioned in point 3) to prevent users from cheating the system. It would also require Mudatuga to form partnerships with other businesses or reforestation initiatives.

### 9.3.2 Business Development

Next to app development, another important focus area in Mudatuga's strategy should be its business development, particularly regarding objective 1 and the goal of becoming a self-sustaining venture. In order to reach that goal, Mudatuga needs to grow their existing revenue, which currently mainly comes from the store sales, and to additionally identify new revenue streams. Increasing store sales could, in the best case, simply be a byproduct of a successful app attracting a larger user- and subsequent customer base, but could also be the result of product innovation, such as the development of a smart composting bin that integrates with the app or store discounts that are rewards within the app. In addition to growing the existing revenue, new potential revenue streams could be developed. We came up with the following two ways to monetize the app:

a) The most obvious one would be to add ad placements within the app. Advertisement always somehow negatively impacts the user experience, however if banners or clips are smartly placed and the content is relevant for the user, it could be a great option for monetization. ( Tang 2016)

b) The second option is to move the app from an MVP to an MMP, meaning a minimal marketable product, or in other words a product that users would be willing to pay money for (Angermeier 2019). This could be done by offering premium plans, which would give users access to exclusive content or discounts in the app or the option to remove ads (if there are any). Exclusive contents could entail, educational videos or articles, additional features like an extended and more advanced composting history graph, or access to a smart-watch version of the app. Additionally in-app purchases could be offered, which would include special customization options for profiles or ninja avatars.

Another aspect that we highly recommend Mudatuga to consider within their business development is a further refinement of their target segments. As mentioned before the current target costumers of Mudatuga are young and middle-aged women that are environmentally conscious. Mudatuga should therefore think about what steps they could take to further specialize the app for their existing target group. In addition to that, as the objective is to expand its user base, Mudatuga should investigate what other target groups could be approached and in what way the app needs to be adapted. For example, a second target group could be less environmentally conscious and unexperienced in composting, in which case an additional tutorial and more fundamental explanations would have to be added to the app.

A crucial aspect to take into account is how Mudatuga can protect itself against competition by asking questions like: What could be a sustainable competitive advantage? What economic moats could protect the business in the future?

One moat that immediately comes to mind in connection with a social-network-like app such as Compostuga are network effects. Network effects describe the change in utility of a user of a specific platform if the amount of total user changes. In the case of Compostuga the more user the platform has, the more interesting it is for other users to use the app (Dietl and Royer 2000). Compostuga will have the first mover advantage, by being the first app of its kind, but needs to make sure to quickly grow its user base to a critical mass.

Another moat could be product innovation, specifically in the form of a complementary hardware like a smart composting bin. This would also lead to ecosystem effects, making a switch to a competitor more costly. Furthermore, Compostuga should differentiate itself through the quality of its UI/UX and features, especially its gamification, as a gratifying and maybe even addictive experience is one of the most effective ways to ensure user retention (Anderson, McRee, and Wilson 2010).

Competitive advantage could also be achieved by forming exclusive partnerships. As Compostuga will be the first product of its kind, contracts with municipalities could be concluded, i.e., stating the exclusive endorsements or promotion of Compostuga, and ultimately rendering a market entry for competitors more difficult.

### 9.3.3 Promotion

Having a great application with sophisticated features and a solid monetarization model, is, however, only part of the equation. The best features and smartest strategy for turning a profit are useless if nobody or only a few people use the app. Hence, Mudatuga should focus a significant part of their time on a good promotion strategy. Especially nowadays, where users have a vast number of apps to choose from, getting a new app adapted can be extremely difficult. The fact that Compostuga is the first in its product category, namely a habit tracker for composting, is both an advantage and a disadvantage. The advantage being that there are not many competitors, at least in the beginning, with which Compostuga must battle for new users. On the other hand, new users might first need to be convinced about the utility and usefulness of such an app. In either case, a solid promotion strategy is indispensable.

Developing a full promotion strategy could be a thesis of its own and would therefore go beyond the scope of this report. We instead want to provide Mudatuga with two ideas how to smartly promote the app, without spending millions on performance marketing.

The first way, which we already briefly mentioned, would be to form contracts with municipalities to have Compostuga exclusively endorsed, maybe even as part of official composting initiatives. This option could however take some time, as work with governments can be a lengthy process. Another option that would be less dependent on third parties and could be utilized from the beginning on is a costumers-recruit-costumer approach. This approach is used by many other B2C mobile apps such as Bolt and Uber and has proven to be a very effective method to grow a user base (Jung et al. 2021). Compostuga could implement a similar mechanism, by offering benefits for costumers that recommend the app to other people. Those benefits would be "paid out" as soon a new user would register to Compostuga using the sign-up link, that the existing user had shared. This approach, however, would require some tangible compensation within the app that would serve as benefits for the recommending user (and possibly the newly registered user as well). One idea could be the planting of trees (through partnerships with reforestation initiatives) or gift cards for the Mudatuga store.

#### 9.3.4 Lobbying and Public Relations

Lobbying can be a substantial lever for scaling social entrepreneurial impact and hence presents one of the Mudatuga's core strategic goals. We will use the definition from Bloom and Chatterji (2009) stating the capability of lobbying "to mean the effectiveness with which the organization is able to advocate for government actions that may work in its favor." Motivations for lobbying for social ventures might be to obtain desired laws, regulations, budget allocations, and taxes.

As stated by Bloom and Chatterji (2009) successful lobbying might be achieved by "hiring engaging talented lobbyist and public relation firms who have connections and the political acumen to be persuasive with influential policy makers". Especially the latter would present Mudatuga with high costs, that they might not be able to bear – at least not in the beginning.

We nonetheless recommend hiring or seeking consultation from a public relations or lobbying expert at a later stage to get external expertise.

But there might be another and cheaper way that could prove to be even more effective in reaching political advocacy. Presenting well-researched, credible evidence demonstrating that what is being advocated clearly has substantial benefits, plays a big role in winning over political support. In addition to that, a significant head start can be achieved by cultivate a grass-roots social movement (Bloom and Chatterji 2009), which could further convince politicians in collaborating with Mudatuga. Both methods, namely collecting well researched evidence (data from Compostuga) and building grass-root support (composting community), are already being pursuit by Mudatuga. This further highlights the importance of focusing on these objectives due to their interdependency to the objective of gaining political support.

### 9.4 Key Performance Indicators

We have now presented the four focus areas and recommended concrete measures for each. We finally want to conclude the strategic recommendations by providing Mudatuga with some key performance indicators (KPIs) that could be used to monitor the progress of the strategies' implementation.

We differentiate between KPIs related to the success of the app, Mudatuga's commercial success, and the environmental impact. These KPIs mainly relate to the focus areas 1. App development, 2. Business Development, and 3. Promotion, as the success of lobbying can hardly be measured in granular KPIs but is rather determined by large successes, like passed policies or laws.

*App success:* To measure the app's success, we recommend focusing on the following, widely used KPIs:

- Retention rate and churn rate
- Monthly active user (MAUs) and Weekly active user (WAUs)
- Average session length

*Commercial success:* For the commercial success we recommend the following key metrics:

- Revenue from store sales
- Revenue from in-app purchases / premium plans
- Costumer acquisition cost (CAC)
- Costumer Lifetime Value (CLC)
- Cash burn rate (CBR)

*Impact measures:* To measure Mudatuga's impact the following metrics could be used, as they can be pulled from the Compostuga database:

- Composted weight per user
- $CO_2$ savings per user
- Total $CO_2$ savings

The accuracy of the impact metrics obviously depends on the truthfulness of the users input (or, in the future, the effectiveness of a validation method) and should therefore be viewed with caution – at least in the beginning.

# 10. Conclusion

The presented thesis was primarily motivated to answer the two following questions:

1. What are Mudatuga's main objectives and how can they be achieved with an app while securing a good end-user experience?
2. How can an app be implemented within the given time frame and scope?

To address the questions, we began by gaining a comprehensive understanding of Mudatuga and the practice of composting. Subsequently, we refined the scope, objectives, and challenges for the development of the app. We agreed that the app, in its MVP form, should be a mobile composting habit tracker that incentivizes households to the continuous practice of composting through gamification and tracking of $CO_2$ emission reductions. Following this, we proceeded to define and specify all necessary features through benchmarking, conception, and design. These efforts formed the prerequisites for the implementation the app in *OutSystems*. After the completion of the first draft, user testing of the app was conducted and the resulting feedback was integrated into the app. Lastly, strategic recommendations were provided about further development possibilities of Compostuga and Mudatuga as a company.

The creation of the app can play a significant role for Mudatuga. With the app, the company is now able to increase its visibility and promote the practice of composting by enabling individuals to develop a habit. Besides, the app allows the company to collect data about user's composting behavior to measure and communicate the positive impact composting has on the environment (especially its impact on $CO_2$ emissions). This is of great interest regarding future funding and potential lobbying efforts of Mudatuga, that would help to anchor composting more deeply into society.

The app not only offers added value to the company, but also to its users. Users can benefit from the app by finally being motivated to uphold their composting habits thanks to a gamified experience and the tangibility of their individual impact. Those factors as well as an added sense of community through social features, have the potential to increase the enthusiasm for composting.

Moreover, the app also supports composting in general. Through the development of the app, a new platform was created to increase the promotion of composting and to encourage users to start composting and consequently making it a habit. These factors led to composting becoming more widespread, people learning more about it, and therefore resulting in a higher positive impact on $CO_2$ emissions.

It is now crucial for Mudatuga to focus on the next steps in order to fully capitalize on the potential of the MVP and realize its maximum value. First, the company should focus on achieving short-term quick wins, such as fixing final bugs, improving the interface based on feedback from the testing and deploying the app to the Apple Appstore and Google Play Store. In the long-term Mudatuga's focus should be on extending the app with social network features and an input validation. The app could then be monetized using a freemium model. In combination with solid promotion and lobbying strategies Mudatuga could take not only its environmental impact but also its business value to the next level.

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# Appendix

## *Appendix 1: XP Logic*

The overall XP Logic is based on a best practice example. It refers to a user, who uses the app in a frequent manner.

| Categories | Level | Ninja Name | Total Points<br>in XP | Time<br>in weeks | Tree Points<br>500 per tree | Tree Stage Points<br>125 points per level | Streak Points<br>First time 100 points 200 per streak | Leader Points<br>400 per leader |
|---|---|---|---|---|---|---|---|---|
| White Belt | 1 | Junior | 0 | 0 | / | / | / | / |
| | 2 | Genin | 325 | 1 | 0 | 125 | 200 | 400 |
| | 3 | Jonin | 650 | 2 | 0 | 250 | 400 | 400 |
| | 4 | Chunin | 1800 | 4 | 500 | 500 | 800 | 400 |
| Yellow Belt | 5 | Junior | 2450 | 6 | 500 | 750 | 1200 | 400 |
| | 6 | Genin | 3600 | 8 | 1000 | 1000 | 1600 | 400 |
| | 7 | Jonin | 4250 | 10 | 1000 | 1250 | 2000 | 400 |
| | 8 | Chunin | 5400 | 12 | 1500 | 1500 | 2400 | 400 |
| Orange Belt | 9 | Junior | 6375 | 15 | 1500 | 1875 | 3000 | 400 |
| | 10 | Genin | 7525 | 17 | 2000 | 2125 | 3400 | 400 |
| | 11 | Jonin | 8175 | 19 | 2000 | 2375 | 3800 | 400 |
| | 12 | Chunin | 9325 | 21 | 2500 | 2625 | 4200 | 400 |

### Categories

There are currently three leagues implemented (**bolt**) with the option of additional leagues in the long term:

- **White Belt**
- **Yellow Belt**
- **Orange Belt**
- Green Belt
- Blue Belt
- Purple Belt
- Red Belt
- Brown Belt
- Black Belt

### Total Points

The Total Points are measured in XP points. In our XP Logic, the total points are calculated as followed:

<u>Example (White Belt Category, Level 4):</u>

Total Points (1800) = Tree Points (500) + Tree Stage Points (500) + Streak Points (800)

→ Assuming the user already collected 500 Tree Points and 500 Level Points. In addition, we assume that the user composted every week and therefore collected Streak Points.

**Time**

The fixed timetable to reach the next level was set based on our research. We therefore decided to achieve the first levels quickly (1 week), which extends to 2 and 3 weeks after the first few levels. The timeline (in weeks) was a crucial factor in calculating the overall XP points needed.

**Tree Points – 500XP**

The Tree Points were assigned after the first 3/4 weeks, assuming it takes a user around three weeks to generate a tree. We then calculated with an additional tree in week 8, 12, 17, and 21.

**Tree Stage Points – 125XP**

A user can earn 500XP Tree Points when completing one tree and additional 125XP per Tree Stage completed. Consequently, the achievement of a new tree and the timeline of the Tree Points as well as the Tree Stage Points are equivalent. The Tree Stage Points are calculated as followed:

Example (White Belt Category, Level 4):

Tree Stage Points (500) = Time in weeks (4) x 125XP

→ Assuming the user reached Level 4 after four weeks.

**Streak Points – 100XP / 200 XP**

The user gets 100XP for composting in general. If the user decides to compost every week consecutively, she/he gets additional 100XP. This results in 200XP. The streak points are calculated as followed:

Example (White Belt Category, Level 4):

Streak Points (800) = Time in weeks (4) x 200XP

**Leader Points – 400XP**

If a user has the highest composted amount in a week, he/she gets rewarded with 400XP. These points were not included in our calculations, as those points represent an individual case.

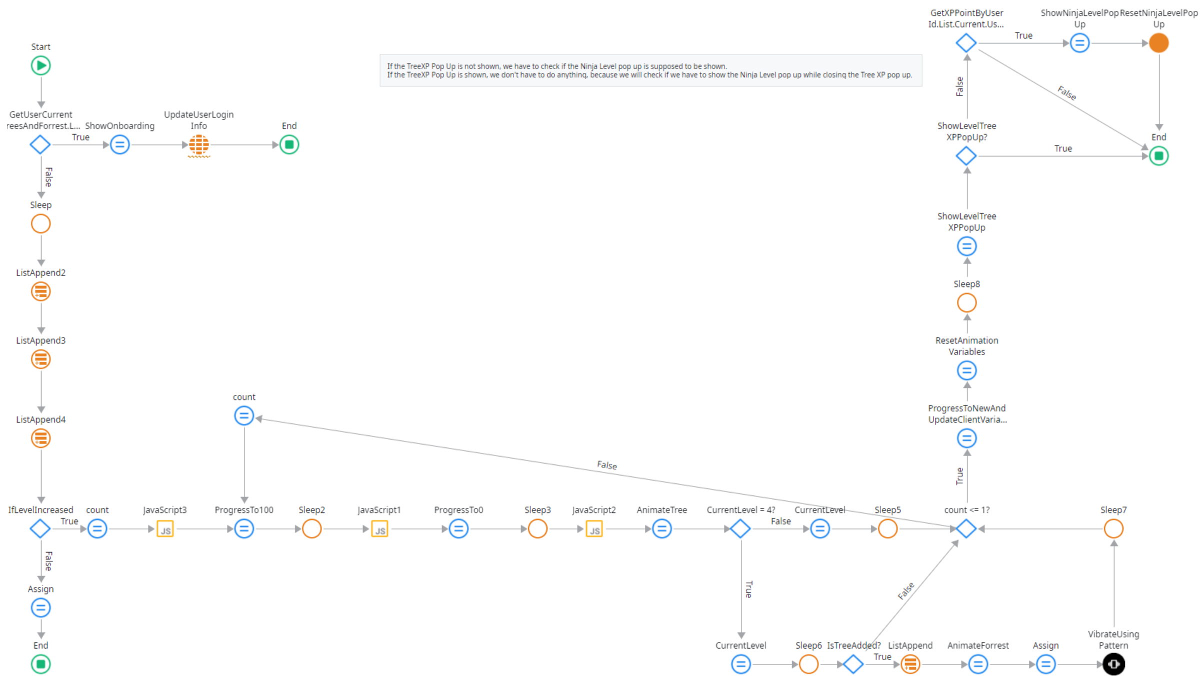
## *Appendix 2: New tree stage algorithm*

```
If(RemainingNewWeight<(GetTreeStages.List[1].TreeStages.WeightUpperLimit),
(GetTreeStages.List[1].TreeStages.Stage),
If(RemainingNewWeight >= (GetTreeStages.List[1].TreeStages.WeightUpperLimit)
and RemainingNewWeight < (GetTreeStages.List[2].TreeStages.WeightUpperLimit),
(GetTreeStages.List[2].TreeStages.Stage),
If(RemainingNewWeight >= (GetTreeStages.List[2].TreeStages.WeightUpperLimit)
and RemainingNewWeight <(GetTreeStages.List[3].TreeStages.WeightUpperLimit),
(GetTreeStages.List[3].TreeStages.Stage),
If(RemainingNewWeight >= (GetTreeStages.List[3].TreeStages.WeightUpperLimit)
and RemainingNewWeight < (GetTreeStages.List[4].TreeStages.WeightUpperLimit),
(GetTreeStages.List[4].TreeStages.Stage),-1))))
```

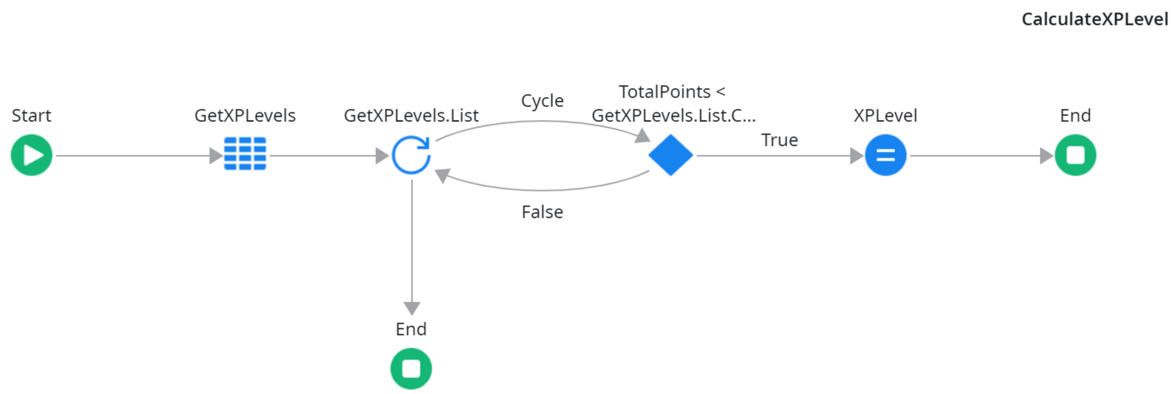
## *Appendix 3: New progress algorithm*

```
If(RemainingNewWeight<(GetTreeStages.List[1].TreeStages.WeightUpperLimit),RemainingNewWeight/(GetTreeStages.List
[1].TreeStages.WeightStepSize)*100,
If(RemainingNewWeight >= (GetTreeStages.List[1].TreeStages.WeightUpperLimit) and RemainingNewWeight <
(GetTreeStages.List[2].TreeStages.WeightUpperLimit),(RemainingNewWeight-(GetTreeStages.List[1].TreeStages.
WeightUpperLimit))/(GetTreeStages.List[2].TreeStages.WeightStepSize)*100,
If(RemainingNewWeight >= (GetTreeStages.List[2].TreeStages.WeightUpperLimit) and RemainingNewWeight <
(GetTreeStages.List[3].TreeStages.WeightUpperLimit),(RemainingNewWeight-(GetTreeStages.List[2].TreeStages.
WeightUpperLimit))/(GetTreeStages.List[3].TreeStages.WeightStepSize)*100,
If(RemainingNewWeight >= (GetTreeStages.List[3].TreeStages.WeightUpperLimit) and RemainingNewWeight <
(GetTreeStages.List[4].TreeStages.WeightUpperLimit),(RemainingNewWeight-(GetTreeStages.List[3].TreeStages.
WeightUpperLimit))/(GetTreeStages.List[4].TreeStages.WeightStepSize)*100, If(RemainingNewWeight >= (GetTreeStages.
List[4].TreeStages.WeightUpperLimit),-1,-1)))))
```

## *Appendix 4: Tree animation / Main dashboard Action*




## *Appendix 5: CalculateXPLevel Action*



### *Appendix 6: CheckAndUpdateStreak Action*