Table of Contents

2. Background and Related Work

The following chapter presents the scientific and technical background relevant to the project, as well as an overview of existing solutions. It begins with describing the relationship between smartphone usage and mental health, highlighting the negative effects of excessive screen time and the need for innovative approaches to support healthier digital behavior. Moreover, current digital solutions are analyzed, with a focus on their design principles, functionality and limitations. The chapter then outlines the physical domain by introducing hydroponics, plant cultivation methods and smart farming technologies, which form the foundation for integrating biological systems into the project. Finally, existing products and systems are compared in order to identify gaps and opportunities. This analysis helps justify the design direction of the smart plant pot called Screen2Green, which connects the plant pot to the users' screen time, and establishes the basis for the following chapters.

2.1 Smartphone Usage and Mental Health

The rapid increase in smartphone usage has raised significant concerns regarding its impact on mental health, particularly among young people and students. Numerous studies have found a consistent association between excessive screen time and negative psychological outcomes such as anxiety, depression and stress. For example, a study on university students found that as daily screen time increased, levels of anxiety and depression also increased significantly. In particular, screen use above approximately 6.5 hours per day was associated with a higher risk of mental health problems **[1]**. Several mechanisms help explain the relationship between smartphone use and mental health. One important factor is sleep disruption. Screen exposure, particularly before bedtime, can interfere with sleep quality, which is strongly associated with increased stress and emotional instability.

Another important aspect is the addictive nature of smartphone use, particularly in relation to social media. Studies have shown that compulsive smartphone use is associated with higher levels of psychological distress, including anxiety and depression **[2]**. This is often explained by reward mechanisms in apps, such as notifications and social feedback, which reinforce habitual checking behavior and make it difficult for users to regulate their screen time.

Importantly, research also suggests that reducing smartphone usage can lead to measurable improvements in mental health. A randomized controlled trial demonstrated that lowering screen time resulted in improved well-being and reduced psychological distress among participants **[3]**.

Overall, existing research indicates a clear relationship between excessive smartphone use and negative mental health outcomes. While smartphones offer many benefits, their overuse can contribute to stress, anxiety, depression, and reduced well-being. These findings underline the importance of developing tools and systems that help users manage their screen time more effectively.

2.2 Existing Digital Solutions

The increasing use of smartphones has raised concerns about distraction, reduced productivity and digital addiction **[4]**. In response, many mobile applications have been developed to help users reduce screen time and improve focus. While it may seem contradictory to use a smartphone-based app to reduce screen time, the app functions not as a source of distraction, but as a tool for awareness and behavior change. Smartphones are an essential part of our life, used for

communication, education, navigation, work and social interaction. Because of this, completely avoiding smartphone use is unrealistic in today's society, as most people depend on their devices for daily tasks, meaning that the goal cannot simply be to stop using phones altogether. Instead, a more realistic approach is to develop healthier usage patterns that reduce unnecessary or excessive screen time while still allowing essential use. This makes tools that help regulate smartphone behavior particularly relevant. **[5]**

Mobile applications typically rely on behavioral design strategies such as gamification, timers and reward systems to encourage users to stay away from their phones **[6]**. One of the most widely known examples is the app Forest, which has popularized the concept of visualizing focus time through the growth of virtual plants.

2.2.1 Applications

2.2.1.1 Forest

The application Forest represents one of the most successful examples of this concept. The app was released in 2016 and is available on both mobile platforms and web browsers. Forest encourages users motivation and productivity by using a simulated forest that's maintained by the user. With every productive session, the user grows a virtual tree and when that tree is fully grown, the user starts growing another one. With this, the user is growing a virtual forest, taking care of it by studying, working or being off the phone in general.

When the user stops the session midway, the current tree dies and the user's forest doesn't grow, countering the user's tendency to open social media during their focus session. Alternatively, when the user enters a focus session, all notifications are blocked, minimizing the user's tendency to get distracted by notifications **[7]**.

2.2.1.2 Liven

This app focuses on countering dopamine deficit and procrastination by creating a personal guide with the user during app usage. Liven uses a balance of teaching, self exploration, experience. The user gets taught on dopamine, procrastination and stress-related topics. Inbetween lessons, the app asks the user questions in order to understand the user better, leading to more personalized guidance. While using the app, the user can log their personal thoughts and feelings, which in turn lead to generated affirmation phrases and even more personalized guidance. Lastly, the user receives exercises regarding mental and physical health.

Liven focuses on personalizing the journey to improve, leading to every user having a unique journey fitting their needs and personality. Using animations that are soft to the eyes, phrases throughout the user's journey for affirmation and the option to personally log thoughts and feelings, Liven allows users to guide themselves to learn about their flaws and how to work with them **[8]**.

2.2.1.3 Minimalist Phone

This app minimizes distractions by turning the phone into a screen with a timer and no apps. The user downloads the Minimalist Phone launcher app in their preferred application store. Using the launcher,

the user locks away all forms of distraction including notifications, access to apps and even overwhelming colors such as the user's wallpaper.

The app includes a timer to display the remaining time of the current focus session, a display of the current time of day and the phone's battery percentage. The app offers various ways of displaying this to fit the user's taste, all keeping minimalism in check **[9]**.

2.2.2 The Pomodoro Technique

The Pomodoro Technique is a time management method designed to improve focus and productivity by breaking work into short, structured intervals.

It typically works as follows:

1. Work for 25 minutes (called one “Pomodoro”)
2. Take a 5-minute break
3. After four Pomodoros, take a longer break (15–30 minutes) **[10]**

This cycle makes it easier for users to focus and maintain concentration for a defined period without feeling overwhelmed.

2.2.3 Key Characteristics

- Timer-based focus sessions that limit phone usage during work periods
- Gamified rewards, such as points, coins or visual progress
- Visual representations of productivity, such as growing plants or characters
- Statistics and tracking systems that allow users to monitor their focus habits

These design strategies rely on behavioral psychology principles, particularly positive reinforcement and goal visualization. The visual representation of progress can make abstract productivity goals more concrete and motivating for users **[11]**.

2.2.4 Design

Before starting to make a wireframe and user test it, the app developer of the team researched several applications in the field of productivity and mental health. The following apps were researched: Forest, Liven and Minimalist Phone

These apps were researched on their purpose, functionality, design and ease of use. On the topic of design, all of the researched apps share one thing in common, minimalism. These apps are minimilastic in movement, color choice and design. There are no overwhelming colors or animations and there are no uncomfortable design choices, meaning the layout is simple to understand and the amount of info that's portrayed on the screen is logical. One thing to note is how little the user needs to scroll. Due to the low attention span that's noticeable in today's society, users can't stay on a page that only contains large blocks of text **[12]**.

Firstly, these apps use pages. Forest and Liven have different pages for different purposes, for example a page to see your personal journey and one for your personal profile. Minimalist phone has

different pages as well, but this app doesn't show personal progress. Since this app's purpose is to remove all distractions using timers and blocking notifications, it doesn't show any information or progress. The user only sees their timer, battery percentage and the time of day.

Secondly, these apps use smooth and light animations. By keeping animations locked to their reserved space on the phone, there are no uncomfortable shifts of text or other content which brings the user out of their flow. Using transitions however, the app can show more expressive animations (for example an animation when the user completes a lesson in Liven) that don't hinder the rest of the app's content. This is because the content is shown after the animation is done. Even so, these animations follow the rules of smooth and slow movement in order to keep the user's eyes and brains relaxed **[13]**.

Thirdly, these apps use low amounts of color to no color at all. Forest and Liven make use of white and green. In the case of dark mode, white gets replaced with a very dark tone of blue. Green calms the mind and keeps the user's eyes relaxed. It is also suggested that the color reduces stress and boosts health **[14]**. In the case of Forest, it expresses the feeling of nature and matches with the purpose of the app, being virtue tree growth. Minimalist phone uses no colors because this app focuses purely on turning the user's phone into a minimalistic screen with only platonically important information. However, the user can set a preset that shows more color.

In general, using simple colors and animations keeps the user relaxed and takes away stress. By ensuring that the user sees the right information without any distracting information or that which is outside of the current topic, the app avoids any chance of overwhelm.

2.2.5 Ease of use

In order to help a user solve their problems, an app needs to be easy to use so the user doesn't lose motivation. To be easy to use, an app needs to have a simple layout, a logical hierarchy of information, a logical focus order, focus on accessibility and fast performance **[15]**.

All the researched apps are simple to use by applying one of two techniques. Firstly, Liven and Forest guide the user throughout the app and its features using text blocks that pop up during app usage. To ensure this doesn't hinder the focus order and user's flow, these text blocks are shown between transitions. Secondly, apps can focus on solely one purpose, removing the need for a user journey. Minimalist phone uses this approach. Instead of having a personalized journey or several goals that the user can achieve, it only shows the current time of day, battery percentage and focus session timer. There are no pages with separate topics, nor are there mutliple topics on pages individually. There is only one page. There are presets of design, but these don't change any of the information shown.

Minimalist phone's layout is simple, showing only 3 items. Liven and Forest use a completely vertical layout, setting a simple user journey where the user only goes down the screen. This simple layout and the usage of pages for separation of concern enhances the focus order because the user only has 2 ways of navigation, top to bottom and page to page. Because these apps go from top to bottom, it's also accessible for users who use screen readers, for example users with impaired vision. There is no extravagant order of information, meaning the screen reader will always read in the right order. On the topic of accessibility, deaf users have a similar experience because there are no ground-level defining functions using sounds. Liven for example only uses background music that the user can turn on by choice. Sounds don't define the experience, they only enhance it.

There are 2 ways these apps ensure their light weight and fast performance without overloading the

phone's processor. Firstly, Forest and minimalist phone have only a handful of features which are very lightweight. Minimalist phone only shows 3 items on the screen and has the option to swap between screen savers. Forest only has features regarding focus sessions and personal profile feedback. Forest also uses animations and art that show the user their virtual forest, but it uses a simple art style and minimal animations. Secondly, Liven has an abundance of features and more animations than Forest. To counter graphical and computational overload, Liven generates information throughout usage of the app. Since Liven focuses on giving the user a personalized journey, most of the data gets generated at the moment, making the application very lightweight out of the box and throughout usage.

In general, these apps have several ways of ensuring a simple, fast and reliable user journey for various kinds of users.

2.2.6 Limitations of Existing Solutions

Despite their popularity, existing focus applications remain entirely digital. The reward mechanisms, such as virtual plants or characters, exist only within the app interface. While these visual systems can motivate users, they may lose effectiveness over time because they do not create a tangible or physical connection to real-world outcomes. Furthermore, users can often bypass the restrictions of such apps simply by closing the application or ignoring the virtual consequences. As a result, the behavioral impact may be limited in the long term. This limitation highlights an opportunity for new approaches that connect digital behavior with real-world feedback. By linking smartphone usage to physical outcomes, such as the growth of a real plant, future systems could create a stronger emotional connection and a more meaningful feedback loop.

2.2.7 Summary

The current market has several apps that boost the user's motivation, productivity and mental health. These apps share a simple design and fast performance. Another thing they have in common is that they are all designed to be accessible, making the journey as simple as possible for various types of users. Using the color green, some of these apps help boost mental health and keep the user relaxed and calm. Using light and smooth animations, these apps don't overwhelm the user and assist the user in maintaining their focus while keeping the experience fresh and lively. Lastly, these apps have a noticeably flat learning curve due to in-app guidance or due to a small amount of features that are easy to find thanks to their simple layout.

2.3 Growing Media

Determining the most efficient method for indoor herb cultivation is necessary to first understand how growth environments affect plant development. In the context of Screen to Green, the medium must act as a responsive bio-indicator of a user’s digital habits while remaining clean and practical for a modern desk environment.

Traditionally, plants are grown in soil (geoponics), where organic matter acts as a reservoir for water and nutrients. However, soil is often unsuitable for desk-side IoT devices due to its bulk, the potential for mess, and its tendency to harbor pests like fungus gnats **[16]**. Crucially, soil’s high moisture retention creates a “buffer” that delays visible wilting. For our project, this is a major disadvantage, as

we need the plant to show relatively quick visual feedback when a user exceeds their screen time limit.

An alternative is Hydroponics, specifically Deep Water Culture (DWC). DWC suspends roots directly in an oxygenated, nutrient-rich water solution. While DWC is very efficient and clean, it can be technically demanding to maintain in a small, portable pot. This led our team to research a “middle ground” known as Semi-Hydroponics.

2.3.1 Hydroponics

Hydroponics is a method of growing plants without soil, using water that contains all the necessary nutrients. The roots are supported by materials like clay pellets or coconut fiber, making it ideal for indoor farms, greenhouses, or small urban spaces. Because it doesn’t rely on soil, it allows people to grow plants even where space or ground quality is limited.

The idea has existed for a long time, with early examples like the Aztec Chinampas, where crops were grown on floating platforms. Modern hydroponics was developed in the 20th century and popularized by William Frederick Gericke, who showed that plants could grow using only water and nutrients **[17]**.

In hydroponic systems, plants receive nutrients through water, along with oxygen and light. This controlled environment helps plants grow efficiently. It works especially well for herbs because they grow quickly and don’t need large root systems. Common examples include basil, mint, parsley, cilantro, chives, oregano, thyme, and dill, with basil being one of the most popular choices.

Hydroponics has several advantages. Plants often grow faster, use less water due to recycling, and can be grown year-round indoors. There are also fewer pests since no soil is used. However, the system can be expensive to set up, depends on electricity, and requires careful monitoring. If something goes wrong, plants can be affected quickly **[18]**.

There is also an interesting connection between plants and productivity. Apps like Forest help users stay focused by growing a virtual tree while they avoid distractions. This works because it rewards focus instead of just blocking phone use. Research shows that smartphones are a major source of distraction, with people checking them frequently and losing concentration for long periods.

If this idea is applied to a real plant, the effect could be stronger. A real plant creates a sense of responsibility, which may motivate people more. In addition, having real plants nearby can reduce stress, improve mood, and increase concentration **[19][20]**.

Overall, combining hydroponics with focus-based systems could help people be more productive while also bringing the benefits of plants into their daily environment.

2.4 Semi-Hydroponics

Semi-Hydroponics uses inorganic mineral substrates like Lechuza Pon or Seramis **[21]**. They are specialized growing media made of stones like pumice, zeolites, and volcanic rock, or baked clay granules. Unlike soil, these “grains” are sterile, meaning they don't have worms or attract bugs. They act like a sponge: they soak up the exact amount of water the plant needs and leave plenty of space for air, which prevents root rot.

The general advantages of these soilless and mineral systems include:

Controlled Nutrition: Nutrients are delivered directly to the roots in a water-soluble form for faster absorption **[22]**.

Cleanliness: Removing organic soil eliminates dirt spills and indoor pests, which is a priority for a student's workspace **[23]**.

Water Efficiency: These systems use much less water than soil because the moisture is held within the inorganic grains or a small reservoir rather than evaporating into the dirt **[24]**.

Visual Responsiveness: Because these substrates don't have the heavy “water-holding” mass of thick soil, they allow the basil to react more quickly to our automated watering schedule.

While pure DWC is an excellent scientific tool, the use of inorganic substrates like Lechuza Pon or Seramis offers a slight advantage for Screen to Green. They provide the “grainy” look of soil that users are familiar with, but with the high-tech, clean, and responsive benefits of a hydroponic system and the water reservoir can be smaller than in DWC system.

2.5 Comparative Growth Analysis: The Case of Basil

To make our Screen to Green project work, we needed to look at how specific plants behave in different environments, and basil turned out to be the perfect choice for our “biological mirror.” We found a very important study by Saha et al. **[25]** that focused exactly on what we are trying to do: comparing common basil grown in traditional soil versus soilless environments. Basil is a great herb for this project because it is very visually-responsive, meaning you can actually see it change based on how much water it has. In the study, the researchers showed that basil in a soilless setup grows much faster and looks much healthier than basil growing in regular dirt. While some systems use only water, our research also points toward “semi-hydroponic” methods using inorganic substrates like Lechuza Pon or Seramis. These are essentially clean, sterile grains that act like a high-tech version of soil without the mess or the bugs. This is really important for our goal of helping people with phone addiction because we want the user to see a “reward” for their hard work. If person is not exceeding their screen time limits or a student is staying focused and studying without their phone, a soilless system allows the basil to grow big and green very quickly. However, because these inorganic substrates and water-based systems don't have the heavy “buffer” of organic dirt, the plant becomes more sensitive to our watering schedule. This is actually a huge benefit for our project; it means that if a user spends too much time scrolling and our system stops the optimal watering, the basil will start to droop and wilt much faster than it would in thick soil. This creates a quick and clear “physical warning” that tells the user to put their phone down and get back to real life.

The following are the key scientific findings based on this research:

- Faster Growth Height: The researchers found that basil in soilless systems grew taller than the soil-grown plants in the same amount of time. This helps our users see the results of their good study habits almost immediately **[26]**.
- More Leaves to See: The study showed that these plants have a much higher leaf count and a bigger total leaf area. This makes the plant look “extra lush,” which is the exact visual reward we want to give our users for staying off their phones **[27]**.
- Better Root Development: Because the roots in water or loose grains like Seramis don't have to push through hard, compacted dirt, they grow longer and more efficiently. This makes the plant more sensitive to the water levels we control with our system **[28]**.
- Lower Water Waste: Even though it seems like it uses a lot of water, soilless methods actually save water compared to soil because the moisture is targeted at the roots and doesn't just

evaporate into the dirt **[29]**.
- Cleanliness for Apartments: Unlike soil, which was found to be messy and can attract bugs like gnats, using inorganic grains or water stays clean and sterile, which is much better for a student's desk **[30]**.

2.5.1 Growing herbs

Herbs are plants commonly used in cooking due to their distinctive aromas and flavors. Examples include basil, thyme, oregano, rosemary, and cilantro. These plants can be cultivated in soil or through hydroponic systems. Propagation is possible either from seeds or from cuttings, with cuttings generally providing faster results.

The cultivation process begins with either sowing seeds or preparing cuttings. Seed sowing involves placing seeds in an environment suitable for germination. This environment must provide sufficient nutrients to support early root and shoot development, as well as optimal levels of water, oxygen, and temperature. Seeds may be sown in soil or in hydroponic systems, often within smaller, controlled environments that allow for easy transplantation after germination. Certain seeds, such as those of licorice or lemon balm, require scarification—a process in which the seed coat is slightly nicked to facilitate nutrient absorption.

An alternative propagation method involves the use of cuttings. In this approach, a stem is removed from an existing herb plant and placed directly into a growing environment. This method accelerates growth since the cutting already has an established structure. Over time, roots develop, and the stem becomes a fully independent plant. This process can be repeated by taking additional cuttings from the newly grown plant. Even commercially purchased herbs can serve as viable sources for cuttings, making this method particularly advantageous for hydroponic systems.

Successful growth requires adequate sunlight to enable photosynthesis, allowing the plant to produce compounds necessary for development. Most herbs require approximately 6 to 8 hours of sunlight per day, although light intensity requirements vary between species **[31]**. For example, basil typically requires more intense sunlight than bay leaves. In addition to light, proper airflow, temperature, and humidity levels are essential. Adequate airflow helps prevent fungal growth, while optimal temperatures generally range between 18 °C and 24 °C. In hydroponic systems, maintaining the correct pH level is also critical, with most herbs thriving in a range between 5.5 and 6.5.

These environmental factors remain important throughout the maintenance phase. Poor regulation of these conditions can lead to plant diseases, often indicated by discoloration. Common issues include downy mildew and, in the case of mint, mint rust. Infected plants can often be treated by removing affected leaves to prevent further spread.

Under optimal conditions, most herbs reach a harvestable stage within 6 to 8 weeks. However, plants grown from cuttings may require only half that time. Growth rates vary among species, with herbs such as basil developing more quickly, while others, such as rosemary, require a longer cultivation period.

2.5.2 Vertical gardening

Vertical gardening is a way of growing plants upward instead of letting them spread across the ground. Rather than using large horizontal areas, plants are supported on walls, trellises, towers, or

stacked containers. This makes it especially useful in cities or small spaces where there isn't much room for a traditional garden, but people still want to grow plants or food.

Even though it might seem like a modern idea, vertical gardening has been around for a long time. People have always used supports to grow climbing plants such as beans or grapes. What's different today is how this idea has developed, especially in urban environments. In recent decades, vertical gardening has become more popular as cities look for greener solutions. A big influence on this trend is Patrick Blanc, who introduced the concept of living walls **[32]**. These are walls covered with plants, often built into buildings, showing that greenery can be added even where there is no ground space.

There are different ways to create a vertical garden. One of the simplest methods is using a trellis, where plants grow upward along a wooden or metal frame. This works well for crops like peas, beans, and cucumbers. More advanced systems include green walls, where plants grow directly on specially designed panels with built-in watering systems. There are also vertical planters, such as stacked pots or hanging containers, and tower gardens, which allow plants to grow in layers and are often used with hydroponics.

There are several reasons why vertical gardening has become so popular. It saves space, which is important in small homes or apartments. It can also improve air quality, since plants absorb carbon dioxide and release oxygen. On top of that, vertical gardens make spaces look more attractive and can even help cool buildings by providing insulation. Another advantage is that people can grow their own food, like herbs or vegetables, even if they don't have a traditional garden.

However, vertical gardening isn't always easy. Some systems, especially living walls, can be expensive to install. They also need regular maintenance, including watering, pruning, and checking that everything is working properly. The weight of the system can be an issue too, so the structure needs to be strong enough to support it. Choosing the right plants is also important, since not every plant can grow well in vertical conditions or in limited sunlight.

The plants used in vertical gardens are usually lightweight and easy to manage. Herbs like basil, mint, and parsley are common choices, along with leafy greens such as lettuce and spinach. Strawberries are also popular, and climbing plants like beans and peas naturally grow well in vertical systems. For decoration, plants like ferns and ivy are often used because they create a full, green look **[33]**.

Overall, vertical gardening is a practical way to grow plants in places where space is limited. It combines older gardening techniques with modern ideas and makes it possible to bring more greenery into urban areas while also supporting small-scale food production.

2.5.3 LED vs natural light for plant growth

In modern plant production, artificial light is no longer treated as simple utility but as a critical nutrient source that can be tailored to drive specific biological responses **[34]**. While natural sunlight is the traditional baseline, it is often insufficient in intensity and duration, particularly during winter months in northern climates **[35][36]**.

Sweet basil is widely used in advanced lighting research, where studies show that tuning LED-light to key absorption wavelengths (around 435 nm (blue) and 665 nm (red)) can significantly improve plant growth and yield **[37]**. Utilizing a blue wavelength of 435 nm instead of the industry-standard 450 nm can result in a 20 % increase in yield for basil. Furthermore, a ratio of 1.5 blue to 1.0 red has been found optimal for boosting both biomass and the concentration of essential oils **[38][39]**. In contrast, generic white LED light can lead to "leggy", structurally weak plants that are unmarketable **[40][41]**.

2.5.3.1 Light in relation to DWC, soil, and water growth

The choice of cultivation system has a direct impact on lightning requirements and overall plant growth.

In DWC specifically, plant roots are submerged in oxygen-rich water, making temperature control essential. For this reason, LED lighting is often preferred, as it produces very little heat and helps prevent the water temperature from rising, which could otherwise lead to root damage or rot. In these systems, roots tend to grow more efficiently because nutrients are readily available, resulting in compact, healthy root structures **[42][43][44]**.

In contrast, soil-based cultivation leads to a different root development pattern. Roots must spread out in search of nutrients, creating a more extensive but less dense root system **[45]**. While growing in soil is generally more accessible and requires fewer initial resources, it offers less control over environmental factors such as light intensity. Compared to hydroponic systems, it is therefore more difficult for growers to precisely optimize conditions in soil-based setups **[46]**.

2.5.3.2 Reasons to delay LED implementation

Although LED technology is often described as the future of plant growth, there are several reasons to delay its implementation in the early stages of a project.

First, the initial investment cost is relatively high, as specialized LED systems are significantly more expensive than traditional lighting or simple soil-based setups **[47]**. Second, the system introduces a level of operational complexity, since optimizing plant growth requires knowledge of Photosynthetic Photon Efficiency and Daily Light Integral **[48]**. Incorrect settings can negatively affect plant health, leading to issues such as light stress or poor development.

In addition, energy efficiency can become a concern if the system is not properly optimized. Using non-specialized or generic LED lighting may increase electricity costs without providing meaningful benefits for plant growth **[49]**.

Also, natural light intensity is typically much higher in southern countries compared to northern European countries **[50]**. Because Portugal has a higher DLI year-round, it is not necessary with artificial light as a sole-source for photosynthesis, which is often required in windowless «plant factories» or warehouses in darker climates **[51][52]**. The project will focus on apartments where it is natural to have access to natural lighting. This highlights how geographic location influences the feasibility and cost-effectiveness of LED-based systems.

Finally, successful use of LED technology often depends on integrating multiple systems, including lighting, climate control, and nutrient delivery. Starting with a simpler grain-based approach allows the project to develop gradually, requiring fewer resources while avoiding unnecessary technical challenges in the early phase **[53]**.

2.6 Products

2.6.1 Aerogarden harvest

The AeroGarden Harvest is a compact indoor hydroponic system that allows users to grow plants without soil. It is designed for countertop use and supports year-round cultivation of herbs, vegetables, and flowers. The system uses full-spectrum LED lights to simulate sunlight and includes automated light cycles and a control panel that alerts users when water or nutrients need to be added.

Plants grow in a nutrient-rich water solution instead of soil, and the system can hold up to six seed pods. Each pod contains seeds and a growth medium. The automated lighting and reminder functions make the system easy to use, even for users with little experience in plant care **[54]**.

2.6.1.1 Advantages and limitations

One key advantage of the AeroGarden Harvest is its ease of use. The system automates lighting and basic maintenance, which lowers the barrier for users who struggle to care for plants **[55]**. In addition, plants grow quickly, often sprouting within 7–14 days, which can increase motivation and engagement.

Hydroponic systems also use space and resources efficiently. Research shows that soilless systems can support high plant density while using less water and fewer resources through recirculating nutrient systems **[56]**.

However, the system has clear limitations. Users must still manually refill water and add nutrients **[57][58]**. More importantly, the system focuses only on plant growth and does not influence user behavior. It does not connect plant care to user habits or provide meaningful behavioral feedback.

2.6.1.2 Gaps and opportunities

The AeroGarden Harvest lacks a connection between plant care and user behavior. It provides reminders but does not actively influence habits **[59]**.

This creates an opportunity to improve the concept by adding full automation, stronger feedback systems, and a link between digital behavior and plant health. By connecting user habits to a living system, it is possible to create emotional engagement and encourage more responsible behavior.

2.7 Home Smart Farming

Home smart farming is basically about using technologies like sensors, automation, and simple data systems to make growing plants at home easier. It can be used in different places, such as a balcony, a small backyard, or even indoors. By combining normal gardening with technologies like IoT and hydroponics, people can manage plant growth in a more controlled way.

The main idea is to reduce the uncertainty that usually comes with traditional gardening. Normally, people have to rely on experience or guess when to water plants or how much light they need. However, in smart farming systems, sensors are used to continuously monitor conditions such as soil moisture, temperature, and light levels, which helps improve accuracy and consistency in plant care **[60]**.

In these systems, the data collected by sensors is sent to a central system or a mobile application.

Based on this data, the system can either provide feedback to the user or react automatically. For example, irrigation systems can be activated when soil moisture drops below a certain level, and lighting can be adjusted depending on environmental conditions. Studies on small-scale hydroponic systems show that this type of monitoring and control can also be applied effectively in home environments **[61]**. Because of this, people do not need to check their plants all the time, and the growing conditions can remain more stable. Some studies suggest that maintaining controlled conditions can improve consistency in plant growth and resource use, although the results still depend on system design and maintenance **[62]**.

2.7.1 Key Technologies

2.7.1.1 Internet of Things

One of the most important parts of home smart farming is the Internet of Things (IoT). It basically allows different devices to connect and share data with each other. In this kind of system, sensors like soil moisture sensors, temperature sensors, and light sensors are used to keep checking the environment around the plant. The data collected from these sensors is usually sent to a central system or a mobile application. This makes it possible for users to check the condition of their plants in real time and control the system even when they are not at home. According to recent research, IoT helps improve how accurately these conditions are monitored and supports better decision-making by providing continuous data **[63]**. It has also been used in small hydroponic systems to monitor things like pH, temperature, and water quality, which shows that it can work well even at a home scale **[64]**.

2.7.1.2 Automation Systems

Automation is another key part of home smart farming because it reduces the amount of manual work needed. Instead of checking plants all the time, the system can react automatically based on certain conditions. For example, if the soil becomes too dry, the system can turn on the irrigation automatically. In the same way, lights can be controlled depending on how much natural light is available or based on a set schedule. Studies on smart irrigation systems show that this kind of automation can help manage water more efficiently and keep growing conditions more stable **[65]**. However, these systems still need to be set up properly and checked regularly to make sure everything works as expected.

2.7.1.3 Artificial Intelligence and Data Analytics

Artificial intelligence (AI) is also starting to be used in smart farming systems, mainly to help analyze data and support decision-making. For example, AI can be used to look at plant images and detect early signs of disease, or to find patterns in environmental data. However, in most home smart farming systems, AI is still quite basic. Instead of fully controlling everything automatically, it is usually used to give simple suggestions or alerts to the user. This means that people still need to be involved in managing the system, especially in smaller setups **[66]**.

2.7.1.4 Soilless Growing

Home smart farming is often used together with soilless growing methods, especially hydroponics. In hydroponics, plants are grown in nutrient-rich water instead of soil. This method is commonly used in indoor systems because it allows better control over the growing conditions. According to the U.S. Department of Agriculture (USDA), hydroponics makes it easier to control how nutrients are delivered to plants. Some studies also suggest that these systems can use water more efficiently compared to traditional soil-based methods, especially in controlled environments **[67]**. Because of this, hydroponics is considered a good option for small indoor farming setups.

2.7.2 Benefits

One of the biggest advantages of home smart farming is that it allows people to grow fresh food at home, even in places where space is limited. For example, people living in apartments can still grow vegetables on a balcony or indoors. This can be useful for those who want more control over the food they eat or prefer growing it themselves.

Another benefit is that it can help use resources more efficiently. Instead of watering plants based on guesswork, the system can supply water only when it is actually needed. Research on smart irrigation systems shows that this kind of approach can help manage water more carefully compared to manual watering **[68]**.

It also reduces the amount of time people need to spend taking care of plants. Since the system can monitor conditions and respond automatically, users do not have to check everything all the time. This makes it easier to maintain plants, even for people who have busy daily schedules.

In addition, keeping the environment more stable can help plants grow in a more consistent way. Some studies suggest that controlled conditions can support more reliable growth, although the results still depend on how the system is set up and maintained **[69]**.

2.7.3 Limitations

Even though home smart farming has several advantages, there are also some limitations to consider. One of the main issues is the initial cost. Setting up a system usually requires buying sensors, lighting, and other equipment, which can be expensive at the beginning.

Another limitation is that the system depends on electricity and sometimes an internet connection. If there is a power cut or a network problem, the system may stop working properly, which can affect plant growth.

There are also limits on what kinds of plants can be grown. Most home systems are better suited for simple and fast-growing plants like leafy greens or herbs. Growing larger or more complex crops can be more difficult, especially in small indoor setups. This trend is also mentioned in studies on controlled-environment agriculture, where leafy greens are commonly the main crops **[70]**.

Finally, even though the system is automated, it still needs regular maintenance. Things like pumps, irrigation lines, and nutrient systems have to be checked and cleaned. Research shows that issues such as clogging or biofilm formation can reduce system efficiency if they are not properly managed **[71]**.

2.8 Comparative Analysis

As shown in Table 1, existing smart growing systems such as AeroGarden and other home smart farming solutions focus primarily on optimizing plant growth through automation and environmental control. These systems use technologies such as sensors, automated lighting, and irrigation to reduce user effort and improve efficiency. While this makes plant care more accessible, particularly for inexperienced users, the systems remain limited to functional support. They do not incorporate mechanisms that influence or reflect user behavior beyond basic maintenance reminders. Additionally, factors such as relatively high cost and required physical space may limit accessibility for some users.

Table 1: Table comparing different products on the market

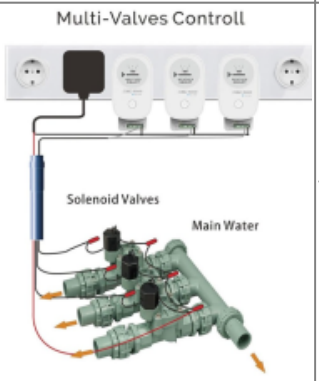
Photo	Product	Purpose	Automation level	Space	Sensors & technology	User effort	Price	Key limitation
	AeroGarden Harvest [72]	Indoor hydroponic plant growth	Semi-automated (light + reminders	Medium	LED lights, water system, basic alerts	Medium	99.95 $	Expensive over time (pods)
	Smart farming systems [73]	Efficient agriculture or home food production	High (sensors + automation)	Medium - Large	IoT sensors, automated irrigation	Low - medium	69.90 $ ++	Relies heavily on Wi-Fi, basic monitoring for being “smart”
	Traditional plant pot [74]	Manual plant care	None	Small	None	High	21.99 $ (5-pack)	Requires constant user attention

Table 2 illustrates that existing focus and screen-time applications rely heavily on digital feedback mechanisms, including timers, gamification, and statistical tracking. Applications such as Forest, Flora, and Focus To-Do aim to improve productivity and reduce smartphone usage by visualizing progress and rewarding focus. While these solutions are generally low-cost and easily accessible, their impact may be limited due to their entirely digital nature. The consequences of excessive phone use remain abstract, and users can often bypass or ignore the system without significant repercussions. This highlights a key limitation in current approaches, as they lack a tangible connection between digital behavior and real-world outcomes.

Table 2: Table showing different applications/systems already on the market

Application	Feedback type	Strength
Forest **[75]**	Visual (virtual trees)	Highly engaging
Flora **[76]**	Visual + social	Social motivation
Focus To-Do **[77]**	Data/statistics	Productivity features
Screen time (built-in)	Data only	Easy access

2.9 Summary

This chapter showed that while digital solutions can help reduce screen time, their impact is limited by their virtual nature. At the same time, physical systems enable plant growth but do not influence user behavior. This highlights a gap between digital behavior tracking and physical feedback systems and demonstrates the need for the Screen2Green project by linking smartphone usage to a real-world element. These findings provide the foundation for the next chapter, which outlines the project management and development process.

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