Groene Boat Project Report

ES/SO360 - Designing the Sustainable City

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I. Introduction

As Americans spending the semester in Amsterdam, it can be easy to see the city as a utopia where solutions to uniquely American issues cross our eyes immediately when we step outside. After spending two months delving into what the city is missing, our focus landed on food insecurity and water usage. A city with its canal identity so intertwined in its culture that the two are rather inseparable, we challenge the city to find new uses for the canals and to consider untapped potential from the water itself.

One area we saw with a lot of room for improvement was the area of the canals themselves. While Amsterdam combats a looming housing crisis due to its limited space, instead of suggesting we convert yet another public park or square into a multi-level building, we turned to the widest canals and the unused space along the banks. By creating a project that uses existing dead space instead of compromising common space, we hope that our boat will turn a few square meters of unused water into a flourishing community hub.

II. Problem Definition

As women in Amsterdam, Sylvia and Emma often find themselves in a sticky situation when they need to pee yet don't want to buy something from a cafe in order to use their bathroom, which isn't the case for Da'juantay. While Amsterdam has begun to combat this issue by installing some public restrooms around the city, these restrooms are almost always accompanied by a small 1-euro fee. Even though that is cheaper than buying a coffee, the solution presents itself as an equity and accessibility issue when comparing these paid restrooms

to the male urinal infrastructure installed around the city without an associated cost. When also considering the sporadic placement of clean drinking water across Amsterdam, we knew we wanted our project to offer both free drinking water and a free public restroom that welcomes all genders. After selecting a location, we were intentional about ensuring we are in an area that is dense in population and lacks access to green space.

The Amsterdam-Centrum borough, which encompasses the historic Canal Belt with its popular canals like the Singel, Herengracht, Keizersgracht, and Prinsengracht, is a highly populated urban area. As of January 1, 2019, Amsterdam-Centrum had a population of 86,862 inhabitants within an area of 8.04 km^2 (3.10 sq mi). This results in a population density of approximately 10,804 inhabitants per km^2 (27,980 per sq mi), which is significantly higher than the overall Amsterdam average of around 5,277/km^2 .

Living in Amsterdam-Centrum means being in a dense, lively urban environment with abundant activity. Even with the historic design, access to fresh produce remains strong as a network of local shops, markets, and supermarket chains supports it, all of which can be easily accessed within walking or biking distance. Amsterdam-Centrum presents a challenge regarding accessible green spaces for cultivation and hands-on learning, particularly for students. There's a lack of traditional garden plots or extensive green areas where children can directly engage with growing food. This creates a disconnect for urban children from understanding where their food comes from and the principles of sustainable cultivation.

This is where our boat, the 'Groene Boot', directly addresses these needs. By transforming a used houseboat into a floating community hub, we can bring green space and educational opportunities directly to the dense areas of the canals. Our project will feature a vertical garden

utilizing hydroponics and aquaponics, demonstrating innovative food production methods that are ideal for limited urban spaces. This hands-on garden will provide students with a unique chance to learn about growing their produce, understanding sustainable food systems, and connecting with nature in an otherwise concrete environment. This is an opportunity to fill a critical gap in experiential food education for children in Amsterdam's most populated core.

Coming full circle, we also liked the idea of collaborating with schools to teach students how to garden and giving them a community center where they feel safe spending time after school. After all, what would be the purpose of implementing such sustainable measures if they aren't advertised as such? This brought us to the idea of having an education center on board our boat. This education center would explain the design and rationale behind all of the systems on the boat and would serve to increase awareness about these issues in Amsterdam. It will also be a space for kids to hang out after school, and can even be a classroom for people to learn about our gardening systems.

III. Design Approach

To approach our problem, we first decided it would be best to tackle each issue separately and then bring them all together at the end. Independently, we researched drinking water, public restrooms, education centers, sustainable gardening (with a focus on water conservation), and the demographics of Amsterdam and its layout.

A. Drinking Water

One offering we knew we wanted to incorporate into our project was having drinking water available on board our boat. Ideally, we aimed to use water from the canals for this

solution. After researching whether this would be feasible, we came across multiple initiatives that had done the same thing in the past.[1]

Founded in 2016, AquaBlu is a water tech company that works to increase water access in the world and focuses on purification.[2] According to them, every year, over 60.000 kg of plastics, 700 dead animals, and 12.000 bikes are fished from the water. Although the quality of the canal water continues to improve - especially during the COVID-19 lockdown - it has never been drinkable before.[3] During this initiative, Aquablu decided on a day when they drew water from the Keizersgracht, Herengracht, and Prinsengracht. After pumping out this water, they purified it, mineralized it, and bottled it on the spot.[4] They then sold and distributed these to locals who claimed that they would never have been able to tell that it was canal water.[5]

Another company we researched is LifeStraw, which focuses on drinking water access for developing countries and remote places.[6] Lifestraw usually operates on a smaller scale, such as a personal straw or water bottle, however, they have a community-scale purifier for sale on their website as well.[7]

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[1] Anton Hein, "Yes, You Can Drink Water from the Canals of Amsterdam," Amsterdam Tourist Information, July 20, 2020, https://www.dutchamsterdam.nl/2297-yes-you-can-drink-water-from-the-canals-of-amsterdam.
[2] "Amsterdams Grachtenwater - Drinking Water from the Canal, That Is.," Home, accessed April 17, 2025, https://www.aquablu.com/stories/amsterdams-grachtenwater-8211-drinking-water-from-the-canal-that-is.
[3] "Dutch start-up turns Amsterdam canal water," accessed April 17, 2025, https://www.eur.nl/media/88560.
[4] Ibid.
[5] Ibid.
[6] "Water Filters & Water Purifiers: Lifestraw," LifeStraw Water Filters & Purifiers, accessed April 17, 2025, https://Lifestraw.com/.
[7] "Lifestraw Community," LifeStraw Water Filters & Purifiers, accessed April 17, 2025, https://lifestraw.com/products/lifestraw-community.

Figure 1: Lifestraw community purifier [8]

Unfortunately, we were unable to get in contact with Aquablu to discuss the feasibility of using their technology for our project. However, after this setback, we landed on a multifaceted solution. First, we planned to use a simple pump and a homemade filtration system to get the water from the canal to the boat and to remove large sediments and some debris. We will also cover the pipe entrance with some sort of mesh to make sure no plastic gets into the system and clogs it. After this, we will install a pump from the simple filtration system into a Lifestraw community purifier, which will be our source of drinking water on the boat.

Some issues this idea brings to mind are the scale of the system and also concerns about the appearance of the system. We want to make sure that our water filtration system can handle filling about 100 bottles per day, which we consider to be a high-end estimate. On the Lifestraw

[8] Ibid.

website, it says that the community purifier has a "total capacity of 50L and lasts 26,000 gallons (100,000L) before needing to replace the filter. The product reliably serves 75-100 school children or clinic attendees per day, or up to 25 people per day in a survival situation for a span of 3-5 years."[9] We hope that this estimate means that our system should be able to work for 3-5 years before needing to replace the filter. Another issue is the pump mechanism and the homemade filtration system. Since the homemade filtration system is easy to make, we will have an extra system or two on hand at all times in case the system starts failing. If the pump fails, we can always use a bucket to get water from the river in the meantime, as we are waiting for it to get fixed.

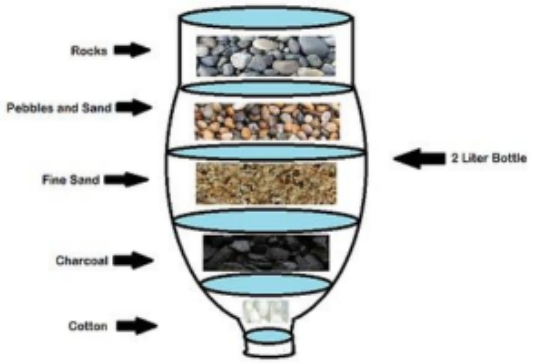

Figure 2: DIY Water Filtration System[10]

In addition to making sure the system works logistically, we also want to make sure that it is safe. Once a day, we will have someone test the water that comes out of the homemade filter and the water that comes out of the Lifestraw purifier to make sure that it meets our standards.

[9] Ibid.
[10] "Filter Your Water," Bell Museum, July 14, 2020, https://www.bellmuseum.umn.edu/activities-for-kids/exoplanet-exploration-grades-7-8/filter-your-water-experiment/.

This test will be conducted with a Varify Complete Drinking Water Test Kit which tests 17 parameters at once.[11]

This in conjunction with our filtration system and Lifestraw community purifier will ensure complete potability of the water and will eliminate the need for a more expensive or advanced water testing system.The homemade filter should remove all debris and most contaminants, whereas the Lifestraw filter will ensure it is completely safe to drink.

Figure 3: Varify Complete Water Test Kit

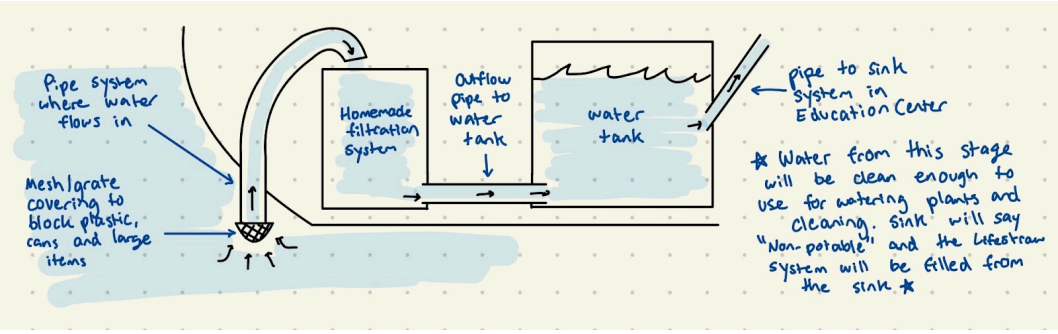

Figure 4: Water Intake and Initial Filtration System

[11] "Complete Drinking Water Test Kit," Varify, accessed May 23, 2025, https://varify.com/products/complete-drinking-water-test-kit.

As for the appearance of the system, we intend to have a pipe running from the lower level filtration system to the upper level classroom. Next to the sink there will be signage explaining how the filtration system works and that the sink water is not potable. The Lifestraw Community Purifier will be filled using this sink and will be located in the hallway next to the restroom so that both the restroom and water station can be accessed during hours where the rest of the boat is closed. The Lifestraw purifier will also have signage next to it explaining the purification process, which we hope will serve as an educational opportunity.

B. Public Restroom

A big factor that contributed to the realization of this project early on was the need for a free public restroom. All too often, women and disabled people in Amsterdam have trouble finding a place to go to the bathroom when they need to, and even if they do, they are faced with a fee. While we cannot eliminate the issue of the quantity of bathrooms, we hope that our strategic placement of our boat will at least provide relief for an area of Amsterdam that is historically underserved.

When researching up-and-coming female restroom solutions, Emma mentioned attending a music festival once, which had female urinals set up in the same way male urinals were. We looked more into this and discovered Peequal. Peequal is a flatpack portable urinal system which uses recycled sea plastics and produces 98% less carbon than traditional portable toilets.[12] The brains behind Peequal want pee equality across the world and to break the taboo around female

[12] TWinFM, "Toilet Equality – Pioneering Female Urinals," TWinFM, accessed April 17, 2025, https://www.twinfm.com/article/toilet-equality-pioneering-female-urinals.

urination.[13] While we loved this solution to an undisputed global problem, we found that this solution wasn't quite tailored to our project. Even though female urination access is a huge issue, we also wanted to address disabled restroom access, and also having public restrooms for all situations, not just peeing.

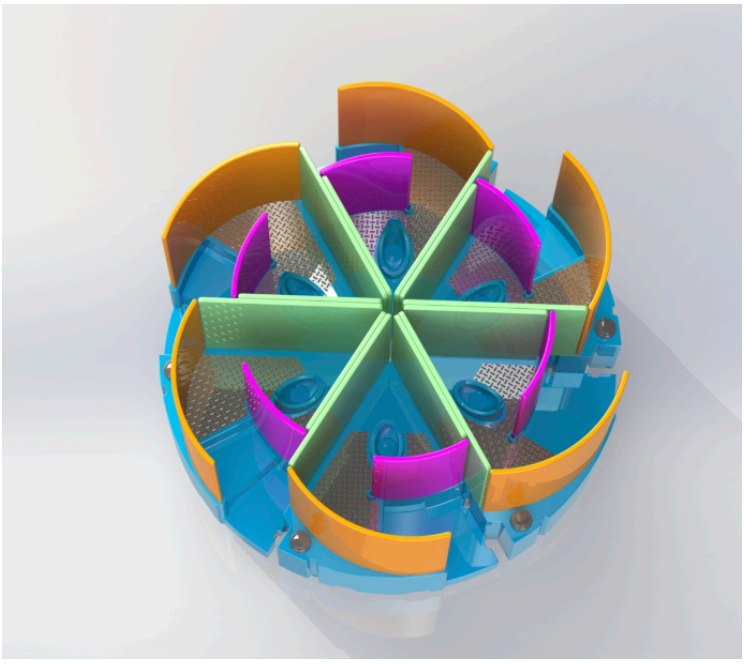

Figure 5: Peequal Female Urinals[14]

Composting toilets on boats have been a viable solution in the past, but as we look toward the future in Amsterdam, most of the bathrooms on houseboats have been connected to the sewer system.[15]

[13] Ibid.
[14] Ibid.
[15] "Marine Composting Toilets for Houseboats," All About Houseboats, accessed April 17, 2025, https://www.all-about-houseboats.com/marine-composting-toilets-for-houseboats.html.

Figure 6: A typical Composting Toilet on a Boat [16]

Since we anticipate our boat stationing in one place for months at a time, we thought that our best bet would be to connect to the sewer system in the same way houseboats do. [17] As our project progressed, we began to think about how best to approach the boat infrastructure from a sustainability standpoint. We decided that repurposing an old houseboat would be preferable to building a new one. The houseboat we have chosen to renovate for this project has a pre-existing plumbing system that can be easily connected to Amsterdam's sewer system.

C. Education Center

Mission

The education center represents an innovative approach to addressing the growing disconnect between urban children and their food systems. As a mobile educational platform navigating Amsterdam's historic canal network, our mission centers on cultivating

[16] Ibid.
[17] Anton Heinhttps://www.dutchamsterdam.nl/author/citydesk-editor, "All Amsterdam Houseboats Connected to Sewer System," Amsterdam Tourist Information, January 6, 2025, https://www.dutchamsterdam.nl/564-houseboats-amsterdam.

comprehensive food literacy among primary school students throughout the city. The initiative aims to bridge critical gaps in children's understanding of food production, nutrition, and sustainability through hands-on experiential learning.

Our core objectives encompass three interconnected domains. First, we provide practical instruction in diverse food cultivation techniques, including both traditional soil-based gardening and modern hydroponic and aquaponic systems[18]. Second, we promote nutritional education and equitable access to fresh produce, addressing food security concerns in urban environments. Finally, we emphasize food literacy beyond mere consumption, teaching students how to meaningfully incorporate nutritious ingredients into their existing cultural and culinary practices.

Rendering 1: Created by Google Gemini. Prompt: uploaded project proposal and requested an image of the interior of the education center with tables for kids, big windows, gardens, and educational posters.

[18] Sensorex, "Aquaponics vs Hydroponics: Which One Is Best for You?," Sensorex Liquid Analysis Technology, March 1, 2023, https://sensorex.com/aquaponics-vs-hydroponics/#:~:text=Aquaponics%20involves%20growing%20fishes%20and,without%20the%20use%20of%20soil.

Additionally, the program serves as a vessel for integrating sustainability science and climate education into primary school curricula. By positioning these critical subjects within the accessible framework of food systems, we create meaningful entry points for young learners to engage with complex environmental challenges. This approach fosters ecological awareness while simultaneously developing practical skills that students can apply throughout their lives.

Furthermore, research supports our educational approach, with Dorothy Blair's comprehensive review in the Journal of Environmental Education demonstrating that garden-based learning programs significantly improve science achievement, environmental awareness, dietary choices, and practical life skills among primary school students[19]. This evidence validates our focus on experiential food literacy education, suggesting that our floating education center's hands-on approach to hydroponic, aquaponic, and traditional gardening will foster meaningful learning outcomes. Blair's findings indicate that children who engage directly with food production develop more sustainable attitudes and behaviors, precisely the transformation our Amsterdam Canal Education Center aims to catalyze throughout the city's diverse school communities.

Recent research by Kluczkovski et al.[20] demonstrates the value of integrating aquaponic systems into primary school settings as a vehicle for hands-on, interdisciplinary learning. Their study of UK schools found that aquaponics-based programs not only enhanced students' understanding of healthy eating and sustainable food systems but also effectively embedded

[19] The child in the garden: An evaluative review of the benefits of School Gardening: The Journal of Environmental Education: Vol 40, no 2, accessed April 17, 2025, https://www.tandfonline.com/doi/abs/10.3200/JOEE.40.2.15-38.
[20] Kluczkovski, Alana, Ulrike Ehgartner, Emily Pugh, Imogen Hockenhull, Rachel Heaps-Page, Abigail Williams, Jens M. H. Thomas, Bob Doherty, Maria Bryant, and Katherine Denby. 2024. "Aquaponics in Schools: Hands-on Learning About Healthy Eating and a Healthy Planet." Nutrition Bulletin 49 (3): 327–44. https://doi.org/10.1111/nbu.12689.

complex scientific and environmental concepts within an accessible, experiential framework. By aligning aquaponics activities with national curriculum standards, the initiative fostered engagement across STEM subjects while nurturing ecological literacy and practical food production skills. These findings validate our decision to feature aquaponic systems as a core component of the Groene Boat's curriculum, underscoring their potential to inspire environmental awareness and behavioral change among urban youth.

Additional evidence supporting our experiential model comes from the "Gardens to Bellies" program in Denmark, examined by Stage[21] et al. (2025). Their study highlights how garden-based education initiatives can significantly enhance children's food literacy, climate change awareness, and overall school engagement. Through a combination of surveys, physical activity tracking, and qualitative interviews, the researchers found that students involved in hands-on gardening activities demonstrated improved understanding of food systems, increased physical activity levels, and greater enthusiasm for school participation. These findings reinforce the value of our curriculum's emphasis on integrating food production with environmental and nutritional education. By embedding similar hands-on components into our Groene Boat residencies, we aim to foster not only cognitive development but also a deeper, lasting connection between students and the ecological systems that sustain them.

Implementation Strategy

Our operational model involves strategic three-month residencies at different Amsterdam primary schools. The boat will dock near each participating school for this duration, establishing

[21] Stage, Anna, Marie Caroline Vermund, Mads Bølling, Camilla Roed Otte, Alberte Laura Oest Müllertz, Peter Bentsen, Glen Nielsen, and Peter Elsborg. 2025. "The impact of a school garden program on children's food literacy, climate change literacy, school motivation, and physical activity: A study protocol." PLoS ONE 20 (4): e0320574. https://doi.org/10.1371/journal.pone.0320574.

a temporary yet impactful learning hub. This time frame allows for sustained engagement with students, moving beyond one-off demonstrations toward meaningful project-based learning experiences.

During each residency, students participate in structured daily programming designed to build cumulative knowledge and skills. The curriculum emphasizes long-term projects that extend beyond the classroom and continue after our departure. A signature initiative involves the installation of hydroponic and aquaponic garden systems within school classrooms, transforming ordinary learning spaces into living laboratories. These installations serve as permanent legacies of our residency while providing ongoing opportunities for students to practice and expand their food production skills.

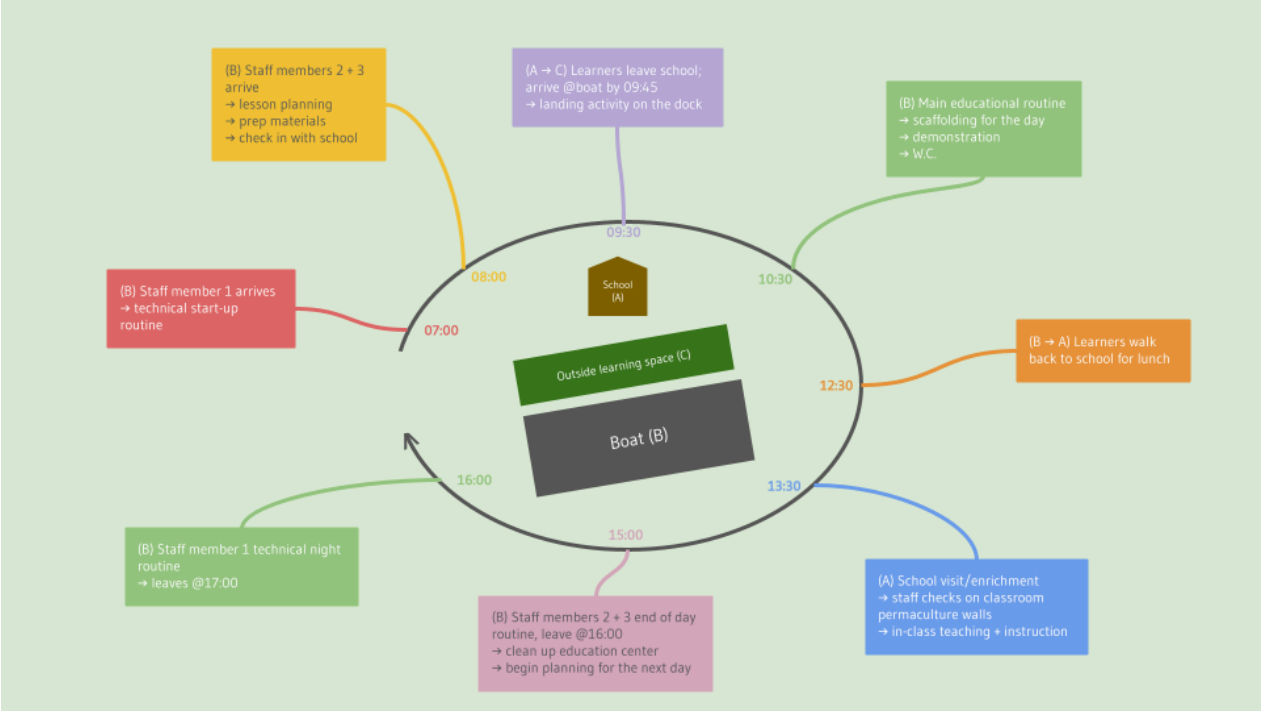

Figure 7: A day in the life on the Groene Boat.

The programming integrates seamlessly with existing school curricula, offering teachers valuable resources for addressing mandated educational standards through engaging, hands-on activities. Our specialist educators collaborate with classroom teachers to develop customized learning experiences that respond to the specific needs and interests of each school community. This adaptive approach ensures relevance across diverse educational contexts while maintaining programmatic coherence.

The initiative will incorporate extensive hands-on learning experiences across multiple disciplines. Students will conduct water quality testing, study canal ecosystems, and explore the maritime heritage of Amsterdam. These activities connect food production to broader environmental systems while leveraging the unique educational opportunities presented by Amsterdam's waterways. By integrating arts and cultural elements, we create a holistic learning environment that appeals to diverse learning styles and interests.

We are exploring strategic partnerships with established organizations to enhance our educational impact. Our programming will benefit from collaboration with Reclaim the Seeds Amsterdam[22], whose expertise in seed sovereignty and biodiversity conservation aligns perfectly with our curriculum goals. Additionally, a partnership with the NEMO Science Museum[23] would provide valuable resources for developing rigorous STEM programming related to food systems and sustainability.

[22] "Reclaim the Seeds Amsterdam," Nederlands, March 9, 2025, https://reclaimtheseeds-amsterdam.nl/en/.
[23] "Home - Nemo Science Museum," NEMO Science Museum in Amsterdam, accessed April 17, 2025, https://www.nemosciencemuseum.nl/nl/.

Facilities

Recognizing the physical limitations of the boat, our programming model extends beyond the vessel itself. While small groups can engage in specialized activities aboard the boat, most educational sessions occur within the partner school's facilities. The boat thus functions as a resource hub rather than the exclusive learning environment. This approach maximizes our impact while accommodating full classroom participation.

The vessel incorporates several features that serve as educational tools themselves. A water filtration system demonstrates the process of converting canal water into potable drinking water, illustrating principles of water cycles and purification. Additionally, the boat's various growing systems—from vertical hydroponic and aquaponic walls to traditional container gardens—showcase diverse approaches to food production in limited spaces.

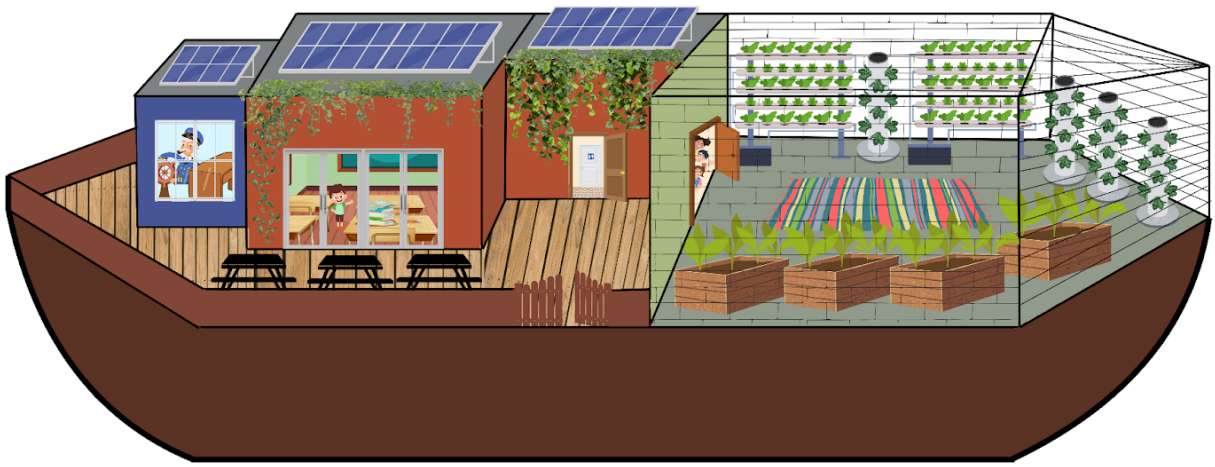

Figure 8: A visual mockup of the Groene Boat

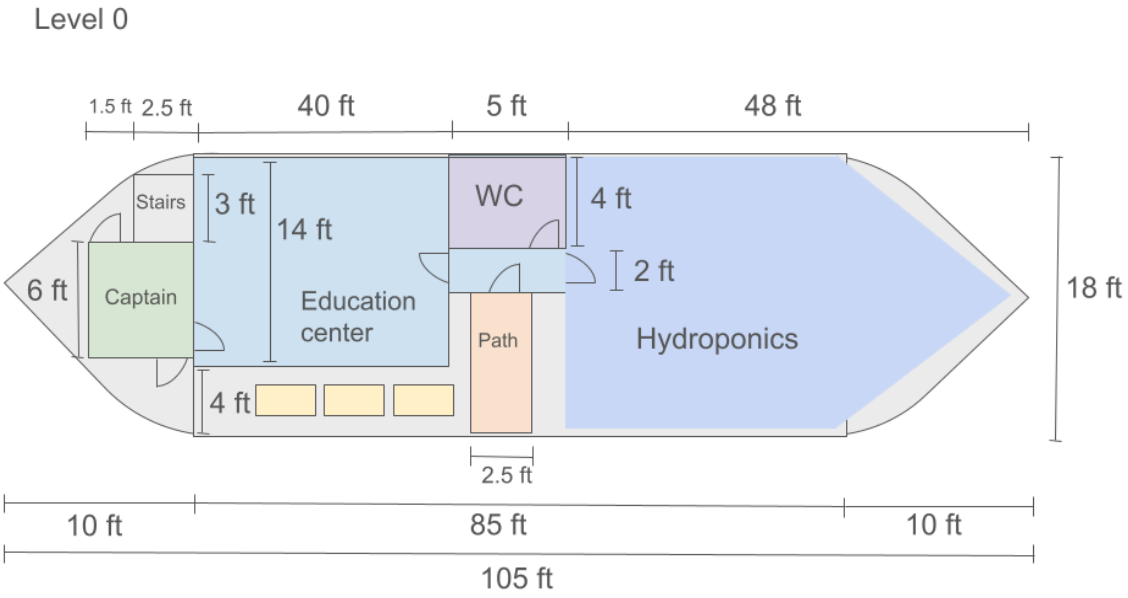

Figure 9: Floor plan of level 0 of Groene Boat

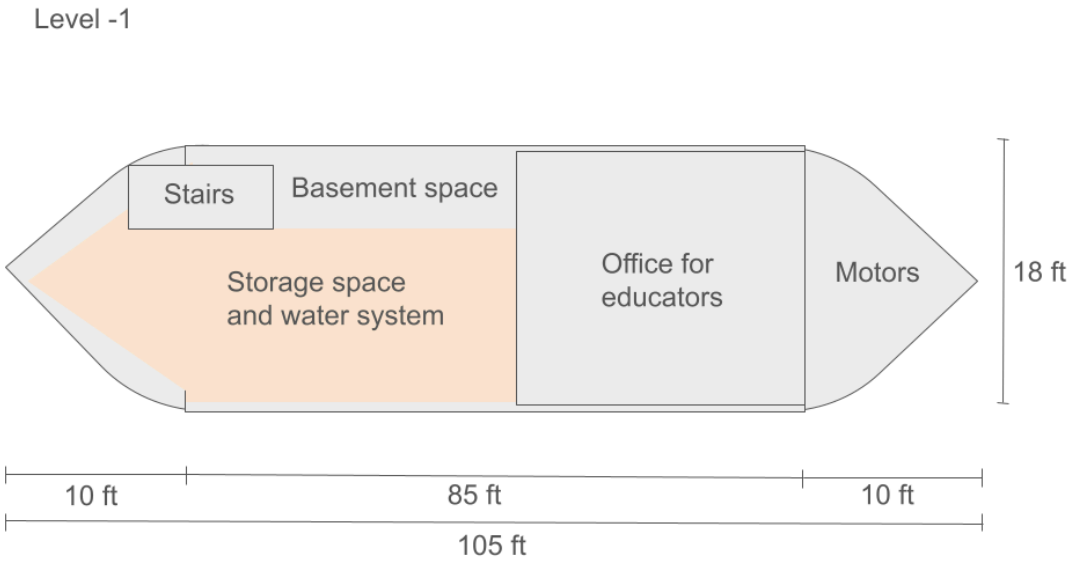

Figure 10: Floor plan of level -1 of Groene Boat

Beyond its primary educational mission, the boat will function as a mobile information center, providing resources on city initiatives, community events, and public services to

Amsterdam residents along the waterways. This outreach component enhances community engagement while creating potential revenue streams through guided tours and special events during non-school hours. These supplementary activities help ensure the financial sustainability of the project without compromising its core educational purpose.

Our concept draws some inspiration from the Science Barge[24] in Yonkers, New York, a pioneering floating environmental education center developed by NY Sun Works. Their successful model of transforming a vessel into a sustainable farm and educational space has informed our approach, though we've adapted the concept to Amsterdam's unique urban context and educational needs.

Figure 11: Science Barge located in Yonkers, New York

[24] "Home - Nemo Science Museum," NEMO Science Museum in Amsterdam, accessed April 17, 2025, https://www.nemosciencemuseum.nl/nl/.

Potential Challenges

Ensuring project continuity after our departure presents a potential challenge, requiring robust transition planning and ongoing support for school staff. Aligning our three-month residency with existing school schedules and curriculum demands, flexible programming that adapts to each institution's calendar. Classroom space limitations will necessitate customized hydroponic system designs that maximize educational value while respecting physical constraints. Strong collaborative relationships with school administrators should be established well before each residency to successfully navigate these interconnected challenges.

D. Physical Infrastructure

As envisioned, the boat will be approximately 105 feet long and 18 feet wide. This length is distributed across its main decks: the forward section spans 40 feet, a central area of 5 feet, and a substantial 48-foot aft section for the hydroponics area. Level 0, the main deck, will feature a 6-foot captain's area at the bow, accessible via stairs. Adjacent to this will be the education center, measuring 14 feet by approximately 18 feet. A public restroom (WC), about 4 feet by 5 feet, and a 2.5-foot-wide path will connect the education center to the expansive hydroponics section, which occupies the remaining 48 feet of the deck. Below deck, Level -1, will house crucial operational components. This lower level, also 105 feet long, includes a basement space and a dedicated storage area for the water system, spanning approximately 85 feet. An office for educators will also be located on this level, with the motors situated at the stern. The design incorporates a modular interior, allowing for reconfiguration to accommodate various activities and group sizes.

The educational vessel itself represents a thoughtful balance between spatial constraints and functional versatility. Given the narrow dimensions necessitated by Amsterdam's canal system, the boat features a modular interior design that can be reconfigured to accommodate varying activities and group sizes. Primary spaces include a compact demonstration garden, a hydroponic and aquaponic growing area, and a multipurpose instruction zone.

E. Hydroponics and Aquaponics

Aquaponics

Our educational initiative studied two growing systems: classroom-based hydroponics and boat-based aquaponics. The result of our research will provide students with a comprehensive understanding of sustainable food production while addressing practical space constraints within schools.

Classroom Hydroponics Implementation

The centerpiece of our school integration strategy involves installing vertical hydroponic systems directly within classrooms.[25] These systems feature:

- Water-based nutrient delivery that eliminates soil-related waste runoff
- Sustainable water sourcing through rainwater collection or filtered canal water
- Closed-loop water recirculation systems minimizing consumption
- Vertical design maximizing growing capacity within limited classroom space

[25] Sensorex, "Aquaponics vs Hydroponics: Which One Is Best for You?," Sensorex Liquid Analysis Technology, March 1, 2023, https://sensorex.com/aquaponics-vs-hydroponics/#:~:text=Aquaponics%20involves%20growing%20fishes%20and,without%20the%20use%20of%20soil.

These installations transform everyday learning environments into living laboratories where students engage with food production throughout their school day. Daily monitoring of these systems becomes integrated into classroom routines, reinforcing responsibility while providing continuous opportunities to observe plant development.

For schools lacking traditional greenhouse facilities, these vertical hydroponic installations offer accessible alternatives that require minimal spatial footprint while delivering maximum educational impact. Their prominent placement ensures that food production becomes visibly embedded within students' daily educational experience.

Vessel-Based Aquaponics Demonstration

The education center houses a demonstration aquaponics system[26] that showcases a more complex ecological approach:

- Integrated fish and plant cultivation within a symbiotic environment
- Bacterial conversion of fish waste into plant-available nitrates
- Complete nitrogen cycle demonstration with water purification benefits
- Sustainable protein production alongside vegetable cultivation

While more complex than hydroponics, this system would provide a comprehensive model of circular ecological systems. Though requiring approximately six months to reach full biological equilibrium, the established system demands less frequent maintenance (weekly rather than daily) and operates more efficiently than separate growing systems once established. The

[26] Ibid.

cost advantage of fish feed over specialized hydroponic nutrients offers another practical demonstration of system efficiency.

Implementation Considerations

Our implementation strategy reflects careful attention to practical concerns:

1. Minimizing Institutional Burden: Systems are designed for minimal maintenance requirements and include comprehensive staff training. We prioritize schools with appropriate facilities and demonstrated commitment.
2. Accessibility and Maintenance: Modular components enable easy reconfiguration and repair when needed. External access points are incorporated where possible to facilitate maintenance without classroom disruption.
3. Customization: Each installation follows our established requirements framework while allowing adaptation to specific classroom environments and teaching objectives.
4. Sustainability: Both systems emphasize resource efficiency, teaching fundamental conservation principles through daily operation.

These growing approaches provide students with tangible interaction with sustainable food systems. The classroom-based hydroponics ensure continued engagement after our departure, while the more complex aquaponics system aboard our vessel demonstrates advanced ecological principles during our residency period. Together, they create a comprehensive educational experience connecting students directly to food production processes.

F. Location and Timeline

Amsterdam is a city beaming with roads, trams, metros, and, of course, our beautiful canals. The Groene boat will have a home base and serve schools that are in the city centre, as the deepest canals are located here, which can fit the needs of our boat. The boat will follow an intentional path that allows it to comfortably go through the city, but more importantly, meet the needs of residents in this area.

The canal system is one of a kind. By looking at using the resources provided through canals of Amsterdam, we were able to intentionally and strategically identify which canals we hope to use. This map also cross-referenced with information on population density and accessibility to fresh produce in our neighborhoods, as mentioned in our needs section. The path of the “Groene Boat” is created not only for navigability but also to maximize visibility and accessibility for our target users. Understanding the nuances of each canal, as mentioned in the preceding paragraph, including potential width restrictions or bridge clearances, has been crucial in finalizing both the home base location and the operational routes.

Our operational model involves strategic three-month residencies at different Amsterdam primary schools. This time frame allows for sustained quality engagement with students, moving beyond one-off demonstrations to building a meaningful project-based learning experience. During these three months, schools within walking distance of the boat will be able to use the boat. The boat will also adhere to the school schedule, which is as follows: Spring Break: February 22 - March 2, 2025, May Break: April 26 - May 4, 2025, Summer Break: July 19 -

August 31, 2025, Autumn Break: October 18 - October 26, 2025 and finally Christmas Break: December 20, 2025 - January 4, 2026.

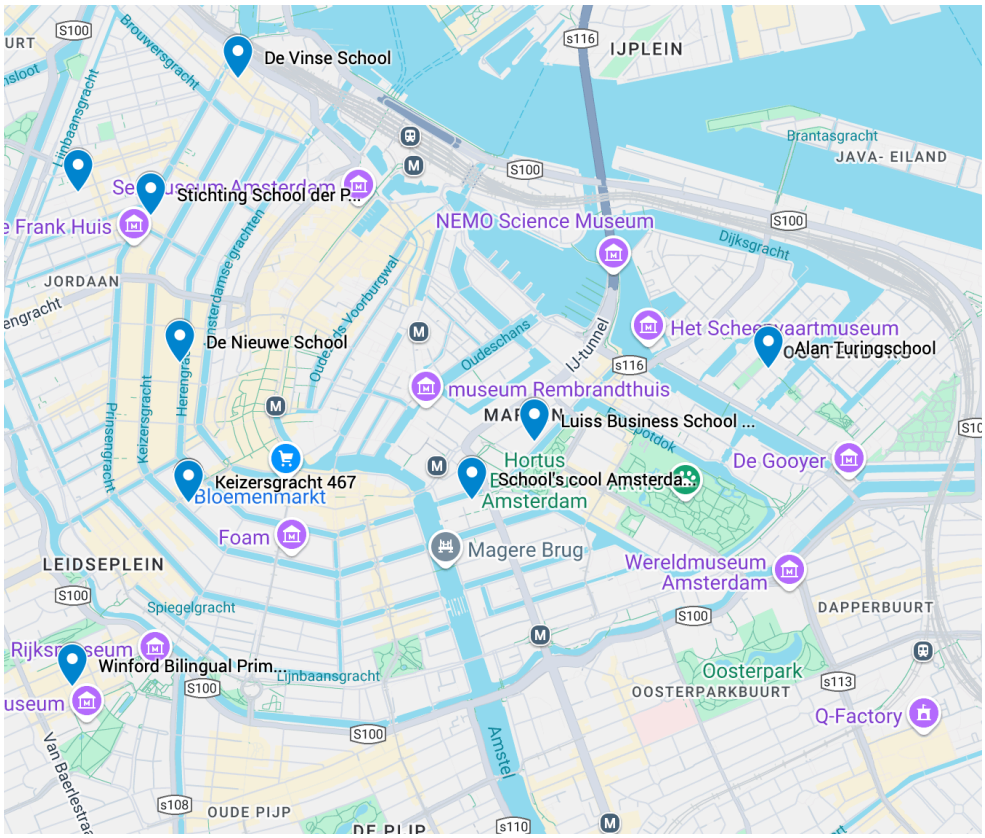

Figure 12: Map of schools along proposed route[27]

The Boat will rotate between schools every three months. Starting in March and May, the boat will be stationed in Central Grachtengordel, which hosts the Herengracht & Nieuwe canals. During this cycle, the schools that will have access to the boat for the three months are De Nieuwe School (Herengracht 274, 1016 BW Amsterdam), School's cool Amsterdam (Nieuwe Herengracht 18, 1018 DP Amsterdam), and Luiss Business School Amsterdam (Nieuwe

[27] Marcoskreenz. "Map of the Canal District in Amsterdam - Canals of Amsterdam." Canals of Amsterdam, September 2, 2022. https://canalsofamsterdam.com/map/.

Herengracht 103, 1011 RZ Amsterdam). As this is in the Spring, the activities will be focused around spring planting, providing an introduction to hydroponics and aquaponics, and water quality testing. As Spring is a popular tourist season, the boat will continue to host a public restroom and drinking water facilities.

During the summer session of June & August, the boat will transition to be hosted at Prinsengracht and the Haarlemmestraat area. The schools that will be hosted this season are De Vinse School, Theo Thijssen School, and the Foundation school. During this season, the boat will be open for the public and allow individuals to learn more about the sustainable system that is on board the canal, workshops for children and family and an emphaize on fall planting, As this is the summer, majority of students will not in courses but we will aim to serve the students who are partaking in summer session.

The canal in the fall will transition into the Southern Canal Belt, floating between the canals of Jan Luijkenstraat. During this time, we will serve The Consciousness School as well as Winford Bilingual Primary School. During this fall season, curriculum and programming will be focused on teaching the skills of harvesting, gardening, and waste management through the composting toilet system.

For the final season of the boat, it will be hosted in the Eastern City Centre, serving the Alan Turingschools. This will be hosted on the Nieuwe Vaart, and our activities will allow students to partake in indoor workshops on plant circles, nutritional education, and interactive learning experiences with the education center. As always, the public restroom and water will remain accessible.

With this rotating schedule, we can ensure that the Groene Boat serves a wide population of the Amsterdam community to maximize its impact and fulfill its mission of enhancing the educational experience for students, as well as increasing equity through the other services on our boat. The Port of Amsterdam publishes tariffs for mooring and reservation schemes, which will inform our planning for long-term docking agreements. Additionally, private marinas like Kempers Watersport offer berthing options that could be explored for the boat's home base or for maintenance periods.

G. Cost Estimation

To understand the price of our project, we performed a simple cost estimation to get a sense of what our opening and annual costs would be. For our opening costs, we planned to buy a used houseboat that meets our size and utility goals. The cost of this boat is estimated to be 274,900 euros.[28] While the houseboat is functional in many aspects, to meet our usage goals, we estimate renovations will be needed. Based on Dutch estimates, typical house renovations cost around 750 euros per square meter.[29] Since our boat is 173 square meters, the renovation costs amount to around 130,000 euros. The rest of the annual estimations performed were based on established mooring fees[30] or costs associated with features previously discussed in this report.

Opening costs	
Used houseboat	**€274,900.00**
Renovation costs (750 euros)/ m^2)	**€129,840.00**
Total opening costs	€404,740.00

[28] 1924 Luxe Motor 32.00 wad en sontvaarder, 274 900 EUR, accessed May 23, 2025, https://www.boat24.com/se/motorbatar/luxe-motor-3200-wad-en-sontvaarder/detail/641536/.
[29] Afzetbak.nl, "Costs for House Renovation per M2 and M3," Afzetbak.nl, accessed May 23, 2025, https://www.afzetbak.nl/en/huis-verbouwen-kosten.
[30] Mooring fees - city of Amsterdam. Accessed May 23, 2025. https://www.amsterdam.nl/en/municipal-taxes/mooring-fees/.

Annual Costs	
Mooring fees (Euros per m^2)	€16.70
Area of boat (m^2)	173.12
Mooring annual fee	**€2,891.10**
Annual maintenance	**€2,000.00**
Employee hourly salary	€20.00
Hours worked per week by all 3 staff	130
Annual hours worked by staff	6760
Annual employee costs	**€135,200.00**
Lifestraw purifier (yearly cost)	**€133.33**
Water test strips (1 strip per day)	**€120.00**
Total yearly fees	€140,344.44

Table 1: Operating cost estimations

IV. Concerns and Limitations

Developing a project as ambitious as the Groene Boat, while rooted in sustainable ideals, inevitably presents a series of significant challenges and limitations that require proactive planning and strategic partnerships. Foremost among these are the logistical and financial hurdles associated with securing suitable mooring locations within Amsterdam's intricate canal system. Mooring fees are known to be substantial, particularly for prime spots that offer the accessibility crucial for reaching our target demographics of students, families, and schools. To mitigate this, securing a long-term mooring agreement with the city government is essential for the project's sustained viability and consistent delivery of services. This will require intentional and persistent engagement with municipal authorities, advocating for the project's unique community benefits and educational mission.

Beyond the financial implications, the competitive nature of Amsterdam's canal spaces poses another considerable challenge. There is significant demand for canal-side locations, and the Groene Boat will face competition from commercial ventures, residential houseboats, and other initiatives vying for similar positions. Our advocacy for the necessary space must be robust, emphasizing the vital role the Groene Boat plays in providing free drinking water, accessible public restrooms, and hands-on educational opportunities in sustainable gardening—services that directly address identified community needs and contribute to the city's broader sustainability goals. We must clearly articulate how the boat's presence will create a flourishing community hub by utilizing existing "dead space" along the canals, rather than compromising other valuable common areas. Overcoming these challenges will demand strong negotiation skills, clear communication of our project's value proposition, and a demonstrated commitment to working collaboratively with all stakeholders to ensure the Groene Boat can truly become a trusted and readily available resource for the Amsterdam community.

V. Conclusion

The Groene Boat project is aimed at transforming a repurposed houseboat into a dynamic, floating community hub that addresses many key urban challenges in Amsterdam Centrum, such as limited access to green space for educational purposes and inequitable access to public bathrooms. To paint a clear picture of the scarcity of garden plots for hands-on learning about food systems, Amsterdam city center is densely populated, with around 10,804 inhabitants per square kilometer.

The Groene boat will aim to bridge this gap by transforming an average boat into a multifaceted mission. This boat features a vertical garden, utilities, hydroponics, and aquaponics to show students the innovative, space-saving food production methods that they otherwise would not learn. Our integrated education center on board will provide students with experiential learning opportunities in food literacy, sustainability science, and environmental awareness, cultivating a deeper connection to their food sources and ecological systems through a strategic rotating schedule that ensures widespread community reach and sustained engagement with students.

In addition to its educational mission, the Groene Boat will offer essential public services, including a free drinking water station, purified from canal water using a multi-stage filtration system including a LifeStraw purifier, and a free, all-gender, wheelchair-accessible public restroom connected to the city's sewer system.

VI. Bibliography

Bibliography

Afzetbak.nl. “Costs for House Renovation per M2 and M3.” Afzetbak.nl. Accessed May 23, 2025. https://www.afzetbak.nl/en/huis-verbouwen-kosten.

“Amsterdams Grachtenwater - Drinking Water from the Canal, That Is.” Home. Accessed April 17, 2025. https://www.aquablu.com/stories/amsterdams-grachtenwater-8211-drinking-water-from-the-canal-that-is.

The child in the garden: An evaluative review of the benefits of School Gardening: The Journal of Environmental Education: Vol 40, no 2. Accessed April 17, 2025. https://www.tandfonline.com/doi/abs/10.3200/JOEE.40.2.15-38.

“Complete Drinking Water Test Kit.” Varify. Accessed May 23, 2025. https://varify.com/products/complete-drinking-water-test-kit.

Dutch start-up turns Amsterdam canal water. Accessed April 17, 2025. https://www.eur.nl/media/88560.

“Filter Your Water.” Bell Museum, July 14, 2020. https://www.bellmuseum.umn.edu/activities-for-kids/exoplanet-exploration-grades-7-8/filter-your-water-experiment/.

Hein, Anton. “All Amsterdam Houseboats Connected to Sewer System.” Amsterdam Tourist Information, January 6, 2025. https://www.dutchamsterdam.nl/564-houseboats-amsterdam.

Hein, Anton. “Yes, You Can Drink Water from the Canals of Amsterdam.” Amsterdam Tourist Information, July 20, 2020. https://www.dutchamsterdam.nl/2297-yes-you-can-drink-water-from-the-canals-of-amsterdam.

"Home - Nemo Science Museum." NEMO Science Museum in Amsterdam. Accessed April 17, 2025. https://www.nemosciencemuseum.nl/nl/.

interactive.com, CYCLE Interactive LLC - cycle-. "From the Science Barge to over 300 Schools: Celebrating 20 Years of Sustainability Science and Climate Education." New York Sun Works. Accessed April 17, 2025. https://nysunworks.org/from-the-science-barge-to-over-300-schools-celebrating-20-years-of-sustainability-science-and-climate-education/.

Kluczkovski, Alana, Ulrike Ehgartner, Emily Pugh, Imogen Hockenhull, Rachel Heaps-Page, Abigail Williams, Jens M. H. Thomas, Bob Doherty, Maria Bryant, and Katherine Denby. 2024. "Aquaponics in Schools: Hands-on Learning About Healthy Eating and a Healthy Planet." Nutrition Bulletin 49 (3): 327–44. https://doi.org/10.1111/nbu.12689.

"Lifestraw Community." LifeStraw Water Filters & Purifiers. Accessed April 17, 2025. https://lifestraw.com/products/lifestraw-community.

Marcoskreenz. "Map of the Canal District in Amsterdam." Canals of Amsterdam, September 2, 2022. https://canalsofamsterdam.com/map.

"Marine Composting Toilets for Houseboats." All About Houseboats. Accessed April 17, 2025. https://www.all-about-houseboats.com/marine-composting-toilets-for-houseboats.html.

Mooring fees - city of Amsterdam. Accessed May 23, 2025. https://www.amsterdam.nl/en/municipal-taxes/mooring-fees/.

1924 Luxe Motor 32.00 wad en sontvaarder, 274 900 EUR. Accessed May 23, 2025. https://www.boat24.com/se/motorbatar/luxe-motor-3200-wad-en-sontvaarder/detail/641536/.

"Reclaim the Seeds Amsterdam." Nederlands, March 9, 2025. https://reclaimtheseeds-amsterdam.nl/en/.

Sensorex. “Aquaponics vs Hydroponics: Which One Is Best for You?” Sensorex Liquid Analysis Technology, March 1, 2023. https://sensorex.com/aquaponics-vs-hydroponics/#:~:text=Aquaponics%20involves%20growing%20fishes%20and,without%20the%20use%20of%20soil.

Stage, Anna, Marie Caroline Vermund, Mads Bølling, Camilla Roed Otte, Alberte Laura Oest Müllertz, Peter Bentsen, Glen Nielsen, and Peter Elsborg. 2025. “The impact of a school garden program on children’s food literacy, climate change literacy, school motivation, and physical activity: A study protocol.” PLoS ONE 20 (4): e0320574. https://doi.org/10.1371/journal.pone.0320574.

TWinFM. “Toilet Equality – Pioneering Female Urinals.” TWinFM. Accessed April 17, 2025. https://www.twinfm.com/article/toilet-equality-pioneering-female-urinals.

“Water Filters & Water Purifiers: Lifestraw.” LifeStraw Water Filters & Purifiers. Accessed April 17, 2025. https://Lifestraw.com/.

“Canals of Amsterdam Map.” Canals of Amsterdam. Accessed April 17, 2025. https://canalsofamsterdam.com/map/

“Google Maps of Amsterdam.” Google. Accessed April 17, 2025. https://www.google.com/maps/place/Canals+of+Amsterdam/@52.3736079,4.8873051,16z/data=!4m6!3m5!1s0x47c609c05b1b1103:0x21067a7298a3961a!8m2!3d52.3720805!4d4.8886558!16s%2Fm%2F03cdmdg?entry=ttu&g_ep=EgoyMDI1MDQxNC4xIKXMDSoASAFQAw%3D%3D

Kempers Watersport. "Marina." Accessed April 17, 2025. https://www.kemperswatersport.nl/en/marina/

Port of Amsterdam. "2022 Tariffs for Port of Amsterdam and Municipality of Zaanstad Reservation Scheme." PDF. Accessed April 17, 2025. https://www.portofamsterdam.com/sites/default/files/2022-01/2022%20Tariffs%20for%20Port%20of%20Amsterdam%20and%20Municipality%20of%20Zaanstad%20Reservation%20Scheme%20EN.pdf.

Cardozo, T. a. Lopes. “Walking the Talk: Autoethnographic Reflections on Co-creating Regenerative Education Within International Development Studies.” *Third World Quarterly* 44, no. 7 (April 10, 2023): 1625–42. https://doi.org/10.1080/01436597.2023.2197206.