FROM USE TO END-OF-LIFE: A SYSTEMIC DESIGN APPROACH TO AGRICULTURAL PLASTIC WASTE IN GHANA

Graduation thesis

Nova Meijer





PREFACE

The reacurring photo's have been shot by me. These photo's tell a story. They try to give an impression of the context in which the design project has found place, namely, in Kumasi, Ghana. With the emphasize on try. The only way of truly getting to know the context is by visiting it.

One of my goals for this project was to immerse myself within the context of the design project. During a previous project, we needed to create designs for refugee camps in Uganda without actually visiting the context. But how can we understand the true design challenge if we don't know the context of it. How can we find a suitable design intervention when we have little contact with the target group and don't listen to their values, habits, opinions.

An overall underlying requirement in this project has been to get to the core of the design challenge by listening to and engaging with the context. To find design opportunities together with the target group.

Most likely, this requirement has not been completely met. For that, the time spend in Ghana was too short and I was lacking previous experience in projects in low-income countries. This project learned me a lot about the difference in designing in a western and a non-western context. It also learned me a lot about myself as a designer, and myself as a person. I am very gratefull to have had the opportunity to take on this design challenge.

I would like to thank my supervisors Laurens and Frans for providing me with very valuable tips and steers in the right direction, coming from true experience and knowledge. Your confidence in me helped with continuing when I sometimes lost the overview.

Also, I'd like to thank Esther and Charlotte for the guidance from out ACHI. Charlotte welcomed me with open arms when I arrived in Ghana and tried to make me feel at ease right away. Esther has shown so much enthusiasm about the project which kept the value of it alive.

Furthermore, thank you Sam and Prince. It has been a nice experience working together with you. You've showed me what hard work really looks like. I had the pleasure of staying with Sam's family who took care of me: Josefine, Kelvin, Josefine; and Erica, with whom I had a special connection. Prince went with me to field visits, helped with engaging the participants of focus groups and was truly interested in the topic of the project and constantly showed me the importance of it.

I am very thankful for all the people that I have had the chance to meet and get to know during my time in Ghana. Especially Nele and Ruben, with whom I spend most of my time during the last two months. You will be deeply missed.

Focusing on maintenance practices and recycling systems

Thesis report
From use to end-of-life: a systemic design approach to agricultural plastic waste in Ghana

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ABSTRACT

Agriculture plays an important role within Ghanaian society and economy, yet many farming activities remain dependent on seasonal rainfall. Drip irrigation systems offer opportunities for year-round farming, but also introduce new challenges related to maintenance, accessibility, costs and agricultural plastic waste. Plastics such as drip tapes and plastic mulch increasingly contribute to waste-related challenges, as sustainable disposal alternatives currently remain inaccessible or unsuitable within the practical realities of the Ghanaian farming context. At the same time, the research revealed that economic value plays an important role in the motivation of farmers for adopting new systems.

The project was conducted in collaboration with the ACHI program, an educational farming program for Ghanaians established through a collaboration between Kwadaso Agricultural College (KAC), Holland Greentech (HGT) and Delft University of Technology. Through literature research and various design activities, the research explored the broader system surrounding drip irrigation and agricultural plastics in Ghana.

Using systems thinking and iterative system mapping, the research revealed both the complexity of the issue and opportunities for intervention. The findings demonstrated that challenges surrounding drip irrigation systems are interconnected and influenced by maintenance behavior, communication, educational structures, infrastructural limitations, financial accessibility and waste management systems. As the project progressed, the focus shifted from solving isolated challenges towards identifying broader systemic opportunities for intervention. Based on these insights, three design goals were established: reducing drip tape damage at KAC, developing sustainable alternatives for agricultural plastic waste disposal and creating accessible maintenance guidance for drip irrigation systems.

The project resulted in two final design interventions: a set of recommendations for KAC focused on reducing drip tape damage, and the GreenPoints app concept, a mobile-based platform focused on irrigation maintenance support, agricultural plastic recycling, farmer communication and reward-based engagement through economic incentives.

Overall, the project demonstrates how systems thinking and design research can contribute to developing more sustainable and practical approaches towards irrigation maintenance and agricultural plastic waste management within the Ghanaian context.

EXECUTIVE SUMMARY

Agriculture plays an important role within Ghanaian society and economy. Farming activities often remain dependent on seasonal rainfall, resulting in farmers often requiring secondary sources of income to sustain their livelihoods. Drip irrigation enables year-round farming. At the same time, agricultural plastics such as these drip tapes and plastic mulch increasingly contribute to waste-related challenges due to limited recycling infrastructure and unclear end-of-life systems.

This graduation project was conducted in collaboration with the ACHI program, an educational farming program for Ghanaians created by Kwadaso Agricultural College (KAC), Holland Greentech (HGT) and the TU Delft. Through interviews, observations, focus groups, surveys and system mapping, the research explored the broader system surrounding drip irrigation, agricultural plastic waste, maintenance practices and farming education in Ghana.

The research demonstrated that the challenges surrounding drip irrigation systems are not isolated technical problems, but part of a larger interconnected system involving farming practices, educational structures, communication, maintenance behavior, infrastructural limitations and waste management. In addition, the findings revealed that there is currently a lack of standardized and accessible maintenance guidance for drip irrigation systems, while recycling opportunities for agricultural plastics remain limited.

Three central design goals were established:
1. Preventing and reducing damage to irrigation drip tapes at KAC.
2. Enabling sustainable and practical alternatives for agricultural plastic waste disposal.
3. Developing clear and accessible maintenance guidelines for drip irrigation systems.

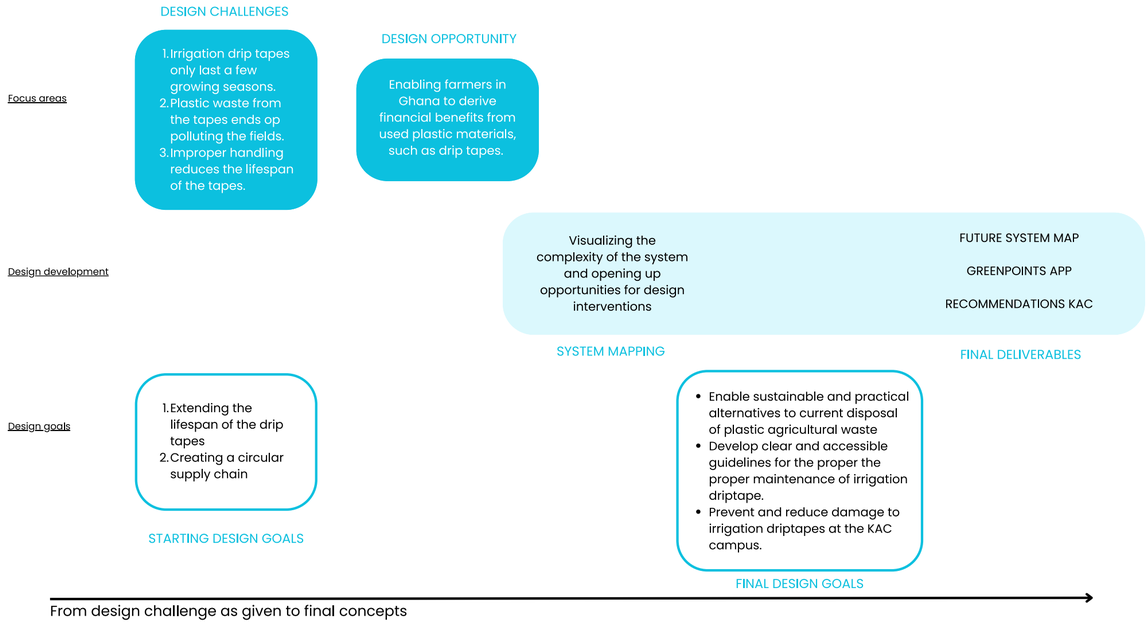
The research further showed that farmers are primarily motivated by practical and economic value. Reward systems, discounts, maintenance reminders and peer-to-peer communication were perceived positively during focus groups and concept testing. Existing communication structures such as WhatsApp groups, farmer field days and lead farmer networks appeared highly valuable for future implementation.

Based on the research findings, two final design interventions were developed:
1. A set of recommendations for KAC focused on reducing drip tape damage through improved communication, supervision, practical training, student involvement and alternative weeding practices.
2. The GreenPoints app concept, a mobile-based platform focused on irrigation maintenance support, agricultural plastic recycling, farmer communication and reward-based engagement.

The GreenPoints app was designed around simplicity, low-data usage and practical accessibility within the Ghanaian farming context. Through a points-based reward system, farmers receive short-term value for performing tasks related to maintenance, recycling and farmer support.

Validation of the concepts demonstrated that successful implementation depends strongly on sensitization, accessible communication, practical education and gradual adoption strategies. The project highlights the importance of combining behavioral, educational, infrastructural, and digital interventions when addressing sustainability challenges within agricultural systems.

Overall, this project demonstrates how systems thinking and design research can contribute to creating more sustainable and practical approaches towards irrigation maintenance and agricultural plastic waste management within the Ghanaian context.



GLOSSARY

Quotes are highlighted orange.
Green indicates intermediate topics.
Blue indicates conclusion.

DRIP TAPES
Thin irrigation tubes

PLASTIC MULCH
Thin plastic sheet

DEMOFIELD
Demonstration field

KAC
Kwadaso Agricultural College

HGT
Holland Greentech

PC
Project Coordinator ACHI

PM
Project Manager ACHI



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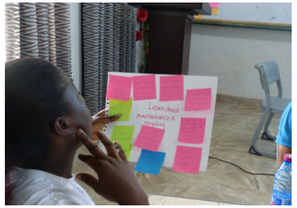

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1. THE OVERARCHING PROJECT



The ACHI project

The ACHI project is a collaborative initiative between KAC, TU Delft, and HGT. The project aims to address youth unemployment in Ghana through a four-month training programme titled “Farming as a Business.”

The programme has been running for approximately five years. It began with ‘batches’ of 20 participants and has since expanded to around 40 participants per batch, with a total of 10 bachets having completed the programme to date. Participants are typically young professionals with an interest in the agricultural sector.

The primary objective of the ACHI project is to foster a new generation of farmers who adopt modern and climate-smart agricultural practices. The programme emphasizes an incremental approach to entrepreneurship, encouraging participants to start small and scale their activities over time.

At the conclusion of the programme, ACHI students take part in a graduation ceremony that includes a pitching competition. During this event, student groups present their agricultural business ideas, demonstrating the knowledge and skills acquired throughout the training.

Upon completing the ACHI course, alumni gain access to a broad alumni network where they can connect with fellow farmers and exchange knowledge and expertise.



The main stakeholders in the ACHI project

TU Delft

TU Delft, through the Delft Centre for Entrepreneurship and the Delft Global Initiative, aims to contribute to global sustainable development by sharing its knowledge and expertise. Knowledge exchange and capacity development are central to this mission, which is realized in initiatives such as the ACHI project.

Within the ACHI project, TU Delft focused on strengthening local capacity by enhancing practical education in horticulture and introducing entrepreneurial skills. These activities are coordinated from the The Green Village at TU Delft.

Holland Greentech

Holland Greentech (HGT) is an agricultural equipment distributor operating in Africa, with a team in Ghana. In addition to supplying agricultural inputs and technologies, the company provides farmers with technical expertise and practical support.

HGT serves a broad client base across Ghana and actively facilitates knowledge exchange through initiatives such as farmer field days and community garden training sessions. These activities create opportunities for farmers to connect, share experiences, and develop their skills.

The company offers training on various aspects of agriculture, including farm management as a business, seed selection, irrigation systems, and other climate-smart practices. Organizationally, HGT operates with a management team based in Accra, supported by regional representatives who maintain direct relationships with farmers and clients in different parts of the country.

HGT contributes practical horticultural knowledge and hands-on skills to the ACHI project. Through this collaboration, ACHI students are connected to farmers and lead farmers within Holland Greentech's network, enabling them to gain real-world experience and apply their learning in practice.

Kwadaso Agricultural College

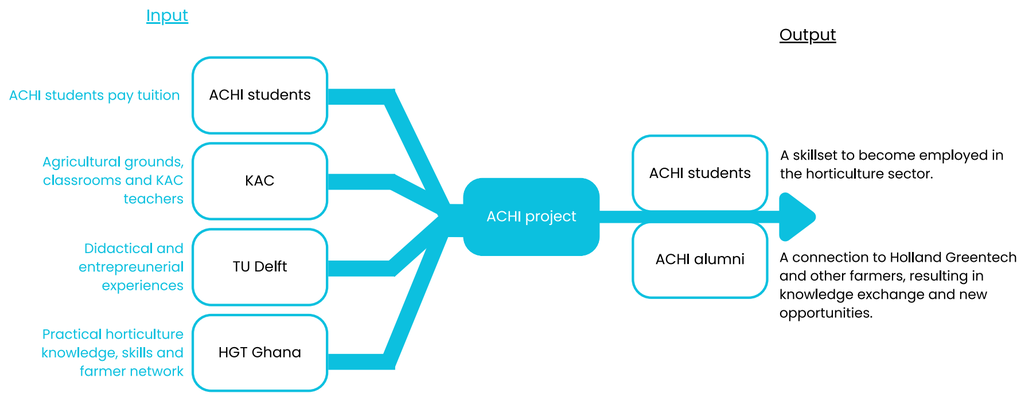
Kwadaso Agricultural College (KAC) is an educational institution located in Kumasi, Ghana, and is the oldest agricultural college in the country. The college offers a three-year programme focused on agricultural education and practice.

Students at the college are each assigned a small plot of land, which they cultivate as part of their training. The curriculum combines theoretical instruction with practical fieldwork, conducted during both morning and afternoon sessions.

In addition to technical agricultural training, the college places a strong emphasis on "farming as a business." As part of a business-oriented course, students are required to develop their own agricultural business concepts, encouraging an entrepreneurial mindset.

The college accommodates approximately 1,200 students, all of whom reside on campus, creating a fully immersive learning environment.

The KAC agricultural grounds are used in the ACHI program and KAC teachers teach the various ACHI modules.





Mission and vision statements of stakeholders

TU Delft

Vision
TU Delft contributes to solving complex and urgent societal challenges through the education of highly qualified engineers who are creative, innovative and responsible, by pushing the boundaries of technical sciences, by developing innovative applications, and by fostering entrepreneurship.

Mission
We conduct research at a world-class level by combining groundbreaking science, pioneering technologies and human-centred designs in a socially responsible manner. This enables us to make a real impact towards building a sustainable society. (Delft University of Technology, n.d.)

We educate people to prepare them for a career as professional, highly qualified and reputable engineers, and develop and enhance the expertise of technical leaders throughout their careers.

We develop technology-based innovations for some of our society's biggest challenges. We encourage entrepreneurship and proactively interact with leading national and international institutions, companies and societal partners, while also keeping our close ties to the Delft region.

We continuously work towards improving our collective effectiveness, performance and organisational resilience by applying the following values as our guiding principles.

HGT

Vision
Our vision is to meet the increasing demand for vegetables in growing urban markets in Africa. We aim to increase food production, enhance food safety and use natural resources more efficiently. Think of sustainable investments in horticulture.

We call our vision 'the next step in horticulture' – where environmental consciousness is key.

We are dedicated to promoting sustainable practices, reduce post-harvest losses, improve soil health, reduce use of chemical pesticides and promote efficient use of water, energy and inputs.

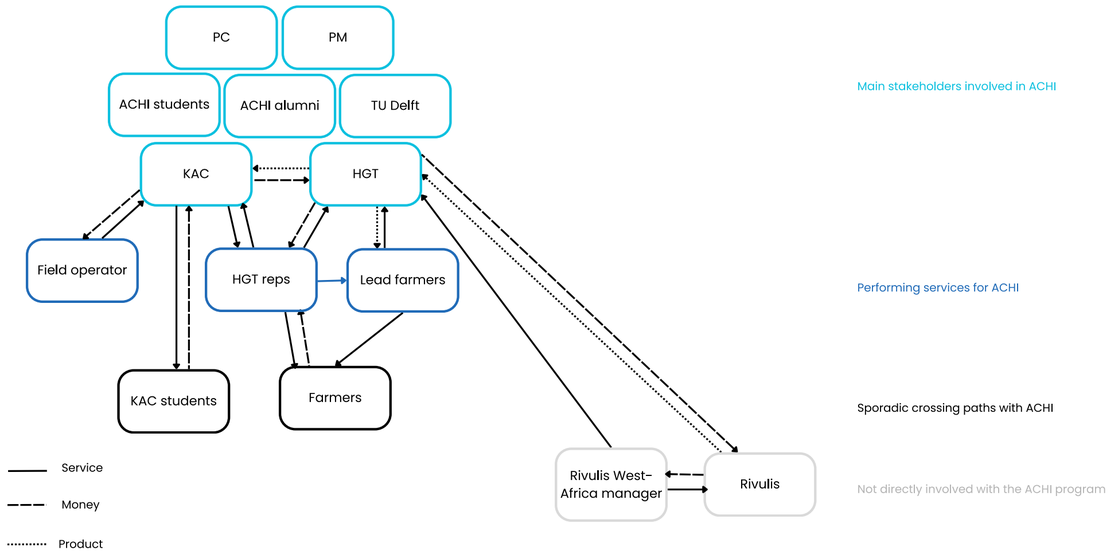
Mission
Holland Greentech empowers African small commercial farmers. The company provides an integrated package of innovative products, knowledge, and market & finance connections. This helps developing the supply of sustainable healthy vegetables to the African cities.

We empower farmers by providing comprehensive knowledge in technical and business skills. We ensure environmental stewardship. We also facilitate their access to market and finance opportunities. (Holland Greentech, n.d.)

KAC

Vision
A center of excellence with dynamic, flexible and demanddriven training programmes where staff and the youth build careers that make them transformational leaders in agriculture and agribusiness in Ghana, Africa and beyond

Mission
We attract and train young minds and staff to offer innovative and transformational leadership to deliver practical agricultural solutions in a sustainable manner that brings value to all stakeholders and meet national agricultural, agribusiness and gender needs (Kwadaso Agricultural College, n.d.).



Stakeholder map ACHI

Additional stakeholders in the ACHI project

This stakeholder map outlines the key actors involved in the ACHI project. All identified stakeholders are considered relevant to the research and have been consulted to obtain valuable insights and to construct a comprehensive understanding of the broader system in which the project operates.

Local project coördinator
The project coordinator (PC) at KAC is responsible for managing the organisational aspects of the ACHI batches and also teaches several modules. The PC has been closely involved in the execution of this graduation project, for example by coordinating farmer participation in sessions and contributing to discussions on key insights.

Local project manager
The project manager (PM) oversees the schools participating in the ACHI project as well as its scale-up. The PM has also been actively involved in this graduation project by providing context and clarifying key aspects of the programme.

Field operator
The field operator is a member of the KAC team and is primarily responsible for field maintenance.

HGT reps
The regional representatives act as the primary point of contact with HGT's clients. They facilitate product installation and conduct on-site visits to support clients in addressing field-related challenges.

Lead farmers
A lead farmer is selected based on specific criteria established by HGT. These farmers function as role models within the farming community and demonstrate the effective use of provided products. In return, they receive products from HGT and serve as promotional and educational reference points. Their farms are accessible to other farmers seeking to acquire practical knowledge and expertise.

Farmers
In this research, the term "farmers" refers to all farmers in Ghana, regardless of their affiliation with ACHI, KAC, HGT, or any other organization.

Rivulis
This stakeholder is the producer of irrigation materials. These products are distributed by HGT and are utilized within the ACHI network, including by KAC, lead farmers, and a broader group of farmers.

Rivulis West-Africa manager
The manager serves as the point of contact between HGTand Rivulis.

PROJECT KICKOFF

Design challenge as given

TU Delft regularly develops design challenges within the ACHI project, which are assigned to students to address. In this particular case, however, the challenge is uniquely initiated from within the local context itself. The PC of ACHI, introduced the issue based on firsthand experiences in Ghana. The design challenges are defined as follows:

1. The irrigation tubes typically last only a few growing seasons due to the hot climate and the fragility of the material.

2. Once discarded, large amounts of plastic waste from these tubes end up polluting the fields.

3. Improper handling further accelerates damage, significantly reducing the lifespan of the irrigation tubes.

Aligned design goals

Based on the defined design challenges, a set of initial design goals was formulated to guide the direction of the research. The research started with the following 2 goals in mind.

1. Extending the lifespan of the driptape

2. Creating a circular supply chain

TARGET GROUP

Every Ghanaian who is using, or will use, the irrigation driptape and other agricultural plastics.

Farmers

Lead farmers

ACHI students

ACHI alumni

KAC students

The overall design approach evolves in a learning-oriented and iterative manner. The design challenge calls for a systemic approach, meaning that the challenge is understood as part of a broader, inter-connected system.

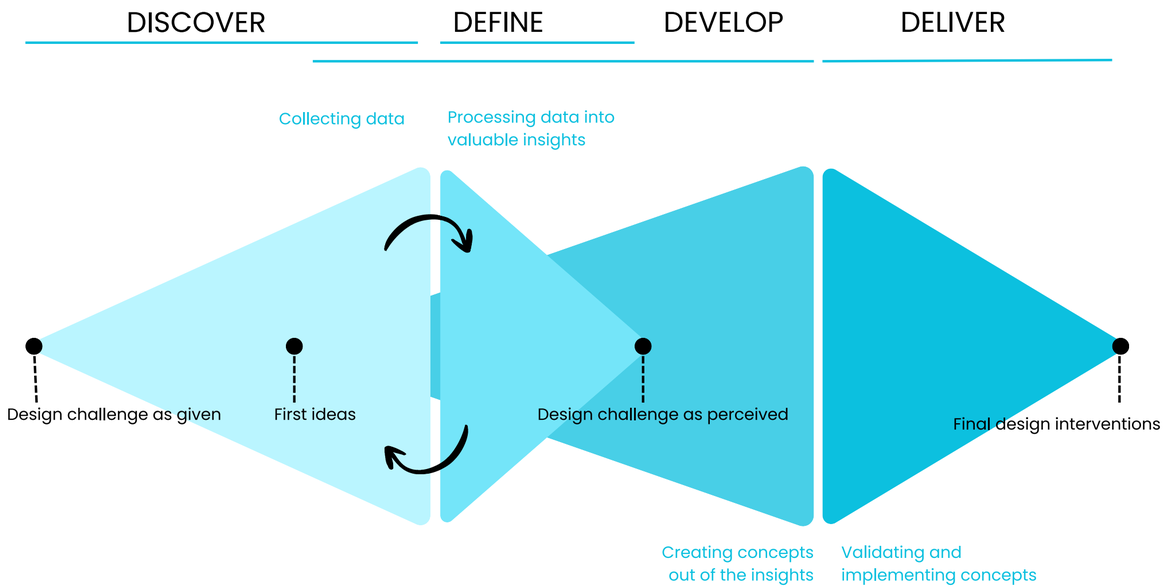
2. THE DESIGN METHOD

The design process

The process consists of four main phases: Discover, Define, Develop, and Deliver. The Discover and Define phases are closely interconnected and continuously inform one another. Data collected during the Discover phase is analysed and refined in the Define phase, often revealing the need for additional data to validate or expand upon initial insights. As a result, the project develops through a continuous cycle of reflection and decision-making based on previously gathered information.

After collecting and processing the necessary data using various analytical frameworks, these frameworks are critically examined to draw informed conclusions. The initial design challenges, as defined by the ACHI project, are reframed based on insights gained through engagement with the context. Notably, the conceptualisation phase begins early in the process, during data collection. Capturing ideas throughout the project is essential, as it allows for a structured understanding of what works, what does not, and why.

Following the Discover and Define phases, the large volume of collected data and the diversity of insights led to the development of a system map. This system map serves as a tool to identify gaps and potential areas for improvement. These insights are then further explored and elaborated upon in the Develop and Deliver phases. The design interventions evolved through an iterative process, ultimately leading to the development of a final concept



The double diamond

Design activities

Discover and define

- Online meeting PC to prepare first HGT meeting
- Meeting HGT in Accra: management meeting and leadership training with time for questions
- Bopinc: gaining expertise about design projects in low-income settings
- Interview KAC student
- ACHI class and PC giving a tour and explanation of the program
- 2nd interview with the KAC students
- ACHI graduation event
- KNUST phd'er plastic chemistry and recycling lecture
- Interview PC ACHI
- Interview plastic waste initiative TrashSmart
- Interview and field visit lead farmer
- Interview and field visit farmer
- Interview field operator
- KNUST phd'er physics recycling lecture
- Survey 1 ACHI alumni
- Meeting with HGT team Ghana
- Interview other KAC student
- HGT opening event Kumasi
- Field observation with ACHI PM during replacement of driptapes
- Online meeting plastic waste initiative Mckingtorch

Develop and deliver

- KCARP factory tour
- Focus group 1 with ACHI alumni
- Meeting with HGT founders
- Tour with ACHI PM on campus
- Contact with Rivulis West-Africa manager
- Contact with other KAC student
- KCARP 2nd visit: conversation with research and quality manager
- Interview and field visit to lead farmer
- Campus visit from RVO and orange corners, meeting with farmes and ACHI alumni, presenting the project
- Focus group 2 with ACHI alumni and farmers
- Survey 2 KAC students
- Field observations with field operator
- Meeting 2 HGT founders
- Meeting project coordinator and project manager ACHI about results survey
- First app test session with lead farmer and PC
- Call with Dutch entrepreneur in Ghana
- Visit of ministry of food and agriculture Ghana at the Green village
- Second app test with farmer
- Survey 3 and validating the app with farmers

A contextual design project in Ghana

A design project in Ghana differs significantly from one in the Netherlands, and therefore requires an adapted design strategy. Differences in norms, values, habits, desires, cultural practices, and communication styles all shape the context in which design takes place.

Halme et al. (2024) propose the importance of contextualizing research in low-income settings. They say that low-income settings haven't received separate methodological attention for qualitative research, thus stress on the importance of getting to know the context of the research. For a western designer working in Ghana, it is essential to develop an understanding of this broader context, not only the design environment itself, but the social and cultural landscape as a whole. These factors strongly influence both the research process and the types of insights that can be generated.

For example, in interview settings, cultural awareness can foster mutual respect and trust. Even small efforts, such as learning basic words in Twi, are appreciated and signal a willingness to engage with the local culture. This can contribute to a more open and comfortable interview environment, ultimately leading to richer and more meaningful responses.

Therefore, when engaging in a design challenge within a different cultural context, it is crucial for designers to immerse themselves in that context over an extended period. In this case, immersion was achieved by living in Ghana for three months. Engagement with the community took place through everyday activities such as using public transportation, taking Bolt rides, visiting markets, living with a Ghanaian host family, and collaborating with Ghanaians. The organisation of focus groups and co-creation sessions is essential for the validation of assumptions and concepts, and for data collection.

This design project is primarily grounded in real-life insights gathered through design activities conducted within the context:

- Conversations with experts in design, recycling, plastics and farming in Ghana
- Field visits to farmers
- Visits to plastic waste initiatives in Ghana
- Observations
- Focus groups
- Events

POSITIONALITY REFLECTION

It is important as a foreign researcher to stay aware of your own role and position within the research context. The ACHI PC in Ghana explained that both ACHI and KAC students, as well as farmers, often saw me as part of the ACHI team. In Ghana, hierarchy plays a significant role, especially within formal institutions like KAC. Because of this, my perceived connection to ACHI may have influenced how comfortable students felt sharing their honest opinions, particularly when talking about the school.

This became clear early on in my fieldwork. On one of my first days on campus, I approached a group of students working in the field and asked about their activities. Their answers were short, and the conversation quickly felt reserved. After a while, they asked for permission to leave the conversation. At first, this surprised me, but it also showed how they positioned me within a hierarchical structure.

Another moment that shaped my understanding of my position happened during an Uber ride. The driver mentioned that Ghanaians often look up to "white people," sometimes even seeing them as "angels." Although this made me uncomfortable, it gave me insight into how foreign researchers can be perceived, and how this can influence interactions and power dynamics in the field.

During research sessions, I tried to reduce this distance by using simple Twi phrases, as a way to show respect and engage with the local culture. Still, language remained a challenge. In one instance, I was reading a text out loud in English during a focus group, and a participant offered to read it instead. When they did, the group seemed to understand it much better. This showed that even when a common language is used, differences in how it is spoken and understood can still affect communication and participation.





Before initiating the research, an expert was consulted and preliminary research was conducted on designing for low-income countries. The insights gained serve as guiding principles throughout the process, helping to continuously monitor and align the work.

3. RESEARCH ON DESIGN APPROACHES IN LOW-INCOME CONTEXTS

Contextual research in low-income settings

In their discussion of contextualization, Halme et al. (2024) identify three central challenges.

Contextualization of:

1. The research process and methods

Risks:
In academic research, significant value is typically placed on recorded interviews, transcriptions, and coded data. However, participants in low-income settings are often unfamiliar with or uncomfortable with such methods. The use of recordings can evoke distrust or feelings of intimidation, which may hinder open communication. As a result, participants may provide socially desirable responses, thereby compromising the validity and reliability of the research findings.

Solutions:
To address these challenges, researchers can complement interview data with observational methods. Observational notes, as well as visual data such as photographs and videos, can enrich and contextualize insights. While traditional ethnographic approaches often require extended fieldwork (e.g. one year or more), more flexible approaches can be adopted. Combining observations and interviews with participatory methods, such as focus groups, diaries, or self-documentation, can lead to a more nuanced and context-sensitive understanding of the research setting.

2. The research findings

Risks:
In prior research, the challenges of interpretation during data analysis are often underreported, with analysis presented as a straightforward process. However, meaning can be lost due to language differences, cultural gaps, and social distance between researchers and informants. Additionally, there is often limited involvement of local actors in the analysis phase, which can lead to the overlooking of valuable local knowledge. Academic pressures to align findings with dominant Western frameworks further risk distorting context-specific insights.

Solutions:
To mitigate these risks, researchers should preserve local terms and concepts in their analysis, as this maintains authenticity and reduces the loss of meaning through translation. Rather than forcing data into Western theoretical frameworks, researchers should remain open to context-specific interpretations. Iterative interpretation, revisiting and refining insights multiple times, is essential. Furthermore, being transparent about the limitations of the study strengthens its contribution and provides valuable direction for future research.

3. The researcher

Risks:
Conducting research in low-income settings can involve significant emotional strain, role conflicts, and ethical dilemmas. At the same time, researchers' interpretations are often constrained by Western frameworks, which may limit accurate and context-sensitive understanding of the data.

Solutions:
To address these challenges, reflexivity is essential. Researchers should critically reflect on their own positionality and influence within the research process, and remain aware of the differences between themselves and their informants. Actively questioning one's own assumptions is crucial for developing more nuanced, contextually grounded interpretations.

Cross-cultural differences in qualitative interviewing

Au (2019) states multiple guidelines for taking on interviews when there are cross-cultural differences between researchers and participants.

- Interviews should be approached as relational interactions between the interviewer and the participant, in which the interviewer adopts a personal and engaged attitude to demonstrate genuine interest.
- Emphasis should be placed on building trust by avoiding an overly formal approach at the start of the interview. Creating an open and safe environment, in which participants feel that there are no right or wrong answers, is essential.
- The interviewer should remain aware of and sensitive to potential cultural differences, particularly in relation to language use and interpretation, and adjust their approach accordingly.
- A responsive interviewing style should be adopted, allowing the conversation to develop organically rather than strictly following a formal structure, with questions evolving based on participants' responses.

9 principles for design for the developing world

Mattson and Wood (2014) have set up 9 principles related to design for the developing world. These principles are based on engineering literature.

1. Co-design with people from the specific developing world context encourages designer empathy, promotes user ownership, and empowers resource-poor individuals.
2.Testing the product in the actual setting is an essential part of design for the developing world, not merely a final step.
3. Importing technology without adapting it to the specific developing world context is ineffective and unsustainable.
4. Both individuals in urban and rural contexts can benefit from poverty alleviation efforts.
5. Women and children are more affected by poverty alleviation efforts than men.
6. Project management techniques that are adapted to the specific developing world context enable a more effective and efficient design process.
7. Products for the developing world have greater impact when contextualized, developed, and implemented by interdisciplinary teams.
8. Cooperation with governments and local influencers contextualizes and enables poverty alleviation plans.
9. There are existing distribution strategies that can be used to successfully introduce products into developing world markets.

The importance of community engagement and training

'A project by Engineers Without Borders in Rwanda failed because of "their lack of involvement and training of the community during the initial implementation". The NGO World Vision drilled several wells in a region of Senegal but the cleaner water tasted bad, and people went back to drinking contaminated water. In the third case, a Save the Children Fund project in Malawi lacked training on the importance of hygiene and sanitation practices [19].' (Pocock, Steckler, & Hanzalova, 2016)

In this article, the importance of community training during the implementation of a design becomes evident, as well as the need for sensitization to the new design. These aspects are as crucial as the design itself.

A value-driven perspective

During a conversation with an employee from Bopinc, a social innovation consultancy, the recommendation was made to approach the design project from a value-driven perspective. This involves identifying and articulating the value generated by the project, particularly for the primary target group as well as for relevant stakeholders.

A key starting point in this process is the concept of desirability. Before considering feasibility or viability, it is essential to define a clear and specific target group and to understand their needs, motivations, and lived experiences.



For this research, it is essential to develop a foundational understanding of farming practices in Ghana, as well as the use and characteristics of (plastic) materials within this context. A lot of this information is based on field visits, observations and interviews with the stakeholders.

4. FARMING IN GHANA

Farming practices

The Food and Agriculture Organization of the United Nations (FAO, n.d.) reports that approximately 33% of Ghana's active labour force is employed in the agricultural sector, highlighting its central role in the national economy. In addition, agricultural land accounted for 55.39% of the country's total land area in 2022. Farming in Ghana is predominantly characterized by smallholder systems, with a significant proportion of farms being smaller than 2 hectares.

Motivation of becoming a farmer from interview with a KAC student (appendix A1):

'Even if you don't have any money, you eventually get something out of farming: which is food.'

In Ghana, agricultural practices are shaped by a climatic system characterized by alternating rainy and dry seasons, rather than distinct winter and summer periods. Farmers are highly dependent on these seasonal patterns. An irrigation system is highly necessary in the dry season when there is no natural watering of the plants. However, many smallholder farmers lack the financial resources to invest in agricultural technologies such as drip irrigation systems or plastic mulch. As a result, cultivation is often limited to specific crops that can be grown during the rainy season, constraining productivity and flexibility.

Due to the limited and seasonal nature of agricultural income, many farmers engage in additional occupations to sustain their livelihoods. Crop selection and farming activities must be carefully aligned with seasonal conditions. However, increasing climate change has made these patterns less predictable, introducing uncertainty into a system that heavily relies on planning and timing.

Furthermore, entering the agricultural sector often requires initial capital that is not readily available. Aspiring farmers frequently need to work in other sectors, such as transportation or informal services, to save sufficient funds for inputs like seeds and basic materials.

In comparison to highly mechanized agricultural systems such as those in the Netherlands, farming practices in Ghana remain largely labour-intensive. Tasks such as weeding and ploughing are predominantly performed manually. There is a clear need and demand for appropriate mechanization and technological support within the sector, as brought up by the interviewed farmers (appendix A4, A5, A8) and the ACHI PC (appendix A2) themselves.

Ghanaian farmers often exchange expertise among themselves. In a focus group (appendix B1), one participant responded to the question of whether they frequently interact with other farmers by stating:

"Yes, two heads are better than one."



Seasonal climate patterns

A typical day on the farm

During a focus group (appendix B2) with farmers and ACHI alumni, participants were asked the following question: “What does a typical day at the farm look like?” The following responses were gathered:

‘A day at the farm is happy when crops are active and production is going well, it is stressfull when crops are dying, very bad when you are not able to pay your workers’.

‘Go around and check the crops.’

‘A very busy day: making sure the crops on the farm are healthy by checking the crops.’

‘Observing growing crops and their wellbeing, and providing for the crops what they need and if possible, harvesting.’

‘A farm day looks busy. Trying to work that will bring positive influence to the crops.’

‘Cheking on the plants, watering/ irrigating.’

Agricultural fields by stakeholder



Field of a lead farmer: drip tapes buried under plastic mulch



Field of a farmer



ACHI demofield



HGT demofield



KAC field: some sections don't use plastic mulch due to high costs

Irrigation and drip tape use on the farm

In Ghana, there are very few producers of irrigation materials; the market is primarily served by distributors such as HGT. HGT has around 5,000 clients in Ghana, including smallholder, medium-scale, and commercial farmers across all regions. The company sells approximately 500 units of drip tape per year, with about 20% of its clients purchasing these products. The irrigation material distrubed by HGT is from Rivulis.

There are three main types of irrigation: sprinkler irrigation, drip irrigation, and rain tube irrigation. When water availability is limited, sprinkler irrigation is often not feasible due to its high water consumption. In such cases, drip irrigation is a more suitable alternative, as it uses significantly less water.

Drip irrigation works by delivering a continuous, controlled flow of water directly to the root zone of each plant via driptapes. This targeted approach increases water efficiency and supports healthy plant growth.

Irrigation enables year-round farming in Ghana by ensuring that crops remain hydrated and can grow consistently, regardless of rainfall patterns.

A typical irrigation setup for Ghanaian farmers is structured as follows: water is sourced from a borehole, river or stream, reservoir, dam or through rainwater harvesting. An electric pump is connected to this source, which pumps the water into a polytank. The polytank is usually placed on an elevated platform, allowing gravity to help distribute the water across the fields.

Drip tapes are laid out across the fields, either between ploughed rows or underneath plastic mulch. The system is operated manually and can be switched on or off as needed. Additionally, individual drip lines can be controlled separately. This allows farmers to manage water pressure more effectively, for example, by shutting off certain sections when pressure is low so that other areas receive sufficient flow.

Fertilizer can occasionally be added to the polytank, after which it is distributed through the drip irrigation system, enabling efficient fertilization of the crops.

When the water source is a river, sand, dirt and other debris can enter the system and cause blockages. To prevent this, filters are installed, but these need to be cleaned regularly to maintain proper functioning.





Drip tapes must be laid facing the ground, and their ends are typically tied (knotted) to a stick that is fixed into the soil. When the system is flushed, these ends are untied to allow any accumulated dirt or debris to flow out freely from the drip lines.

If a section of drip tape becomes damaged, it can be repaired using couplings. The broken part is cut out, and the remaining ends are reconnected using a coupling, restoring the functionality of the system.

During a focus group (appendix B1) with ACHI alumni and students, participants identified several positive and negative aspects in response to the question: “What do you know and what have you learned about irrigation?”

Positive

‘It helps to farm all year round.’

‘I have learned that irrigation is the key to succesfull farming.’

‘Advantage is that it is really efficient and effective since farmers do not rely on rain water.’

‘Efficient use of water.’

‘Easy to control.’

‘Fertilization application becomes easy.’

‘Irrigation makes farming attractive to me.’

Negative

‘Its disadvantage is that it’s expensive for local farmers.’

‘Difficult to maintain.’

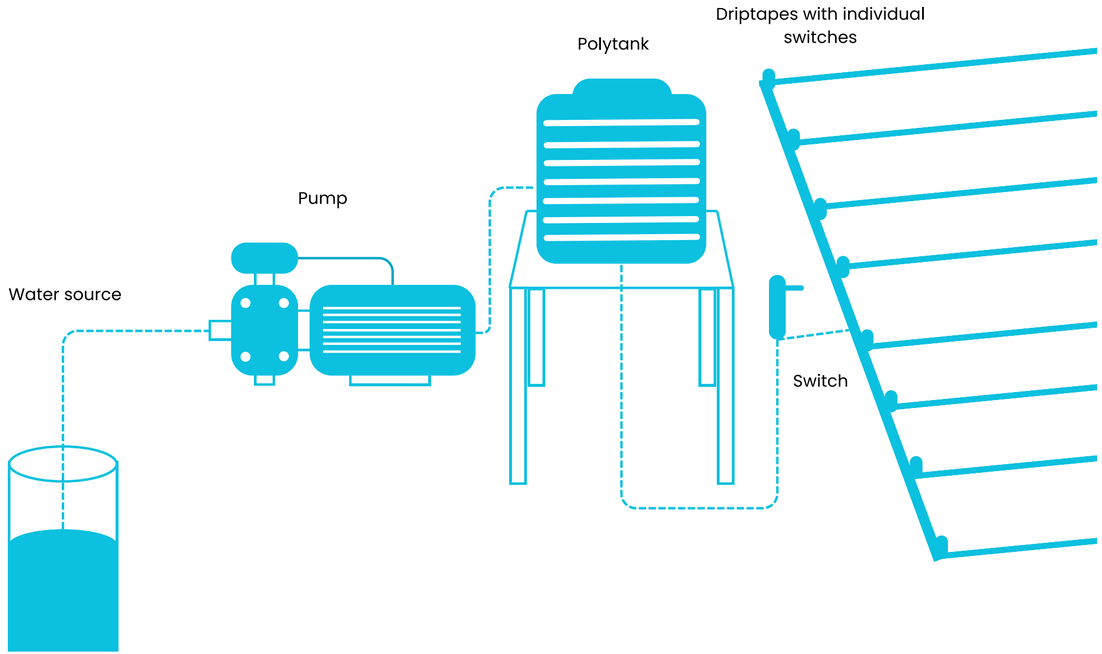
‘Expensive to buy.’

‘Difficult in getting parts.’

‘Irrigation kits are expensive at the initial stage.’

‘Setting up irrigation can be complex.’





Irrigation setup

Additional agricultural plastics

In addition to drip tapes, various other agricultural plastics are used, such as plastic mulch, seed trays, seed sachets, and fertilizer packaging.

Plastic mulch, a big waste contributor in the field, is used to reduce weed growth and minimize water evaporation from the soil, which is particularly beneficial in Ghana's climate. It also helps warm the soil, promoting faster plant growth. Furthermore, it protects the soil and prevents fruits from coming into direct contact with the ground, reducing the risk of rotting.

It is important to understand the cost of agricultural plastics in order to estimate the budget a farmer needs to get started. (1 cedi= 0,077 euro (14-04-2026))

Seed prices vary depending on the crop type and seed brand. For example, sachets containing 500 seeds can range in price from approximately 150 Ghanaian cedis for eggplant seeds to 2800 Ghanaian cedis for cucumber seeds.

Drip tape

Low pressure
500 meters
2500 cedis
5 cedis p/m

15 mil (0.38 mm)
1250 meters
1950 cedis
1,56 cedis p/m

8 mil (0.2 mm)
2300 meters
2200 cedis
0,96 cedis p/m

Plastic mulch

Holland Greentech sells
1000 units a year

600 meters x 1 meter
20% micron
1300 cedis

500 meters x 1.2 meter
40% micron
1300 cedis

Couplings

5 cedis per coupling



Couplings



Seed trays

Conclusion 'farming practices'

Agriculture plays an important role in Ghana. However, many farmers lack the financial capital needed to invest in agricultural technologies such as drip irrigation systems. As a result, many farmers remain dependent on the rainy season for crop production and often require secondary sources of income to sustain their livelihoods. At the same time, Ghanaian farmers frequently exchange agricultural knowledge and expertise within their communities.

Drip irrigation appears to be a suitable technology within the Ghanaian context, particularly because it uses less water compared to other irrigation methods and enables year-round farming. Opinions among ACHI alumni regarding irrigation systems were generally positive, with several participants describing irrigation as a key factor for successful farming. However, farmers also mentioned that irrigation systems can be expensive and difficult to maintain properly.

In addition to drip tapes, other agricultural plastic products commonly used within farming systems include plastic mulch, couplings, seed sachets, and seed trays.



5. THE DESIGN CHALLENGE WITHIN GHANA'S WASTE LANDSCAPE

Waste systems in Ghana

In Ghana, there is no nationwide government-organized waste collection system comparable to that of countries such as the Netherlands. Instead, plastic waste management is still in its early stages and primarily focuses on collection and disposal through a combination of municipal services and the informal waste collection sector (Laryea et al., 2025). The adoption of more advanced waste management strategies, such as recycling and circular systems, remains limited.

A significant role in the current system is played by the informal waste sector. This sector consists of informal waste collectors, defined as individuals or groups engaged in unregistered and unregulated waste management activities (Agyei et al., 2023). These actors are responsible for collecting, transporting, sorting, recycling, and/or disposing of waste. In many cases, they receive financial compensation through initiatives that reward the collection and separation of recyclable materials, such as plastic. This is particularly valuable for Ghana, as the United Nations Development Programme (UNDP) reports that in 2023 youth unemployment and underemployment remain significant challenges.

At the same time, single-use plastics are deeply embedded in everyday life in Ghana. Plastics are widely used for packaging food and other goods; for example, vegetables are often wrapped in plastic. The economic importance of the plastic industry further complicates the transition away from plastic use. On a monthly basis, the industry generates approximately 14.4 million Ghanaian cedi in revenue and contributes around 5.4 million cedi in tax income, creating strong economic incentives to maintain the current system (Agyei et al., 2023).

Although Ghana has introduced policies such as the National Plastic Management Policy, implementation remains limited. This is largely due to the absence of clear guidelines and infrastructure for sorting, recycling, and waste disposal (Agyei et al., 2023). As a result, a significant portion of waste is not properly processed. Instead, waste is often burned locally or accumulates in open dumping sites.

This issue can also be observed at a local scale. For example, at the KAC campus, waste is collected in bins across the campus but is ultimately disposed of in a large, unmanaged waste pile behind the student housing.

The FRESHPPACT project highlights the importance of creating economic incentives to support the adoption of more sustainable plastic waste practices. In particular, it emphasizes that alternatives to the current system must become more accessible and affordable in order to enable large-scale change.

Perspectives from plastic waste initiatives in Ghana

There are, however, several promising plastic waste initiatives in Ghana. For this research, two of these initiatives were interviewed to better understand their operations and to draw inspiration.

Trashsmart

Trashsmart collects plastic waste and transforms it into building blocks used to construct school washrooms. In addition, they educate communities about waste segregation, promote responsible disposal habits, and provide bins to support this behavior. Their riders collect the waste, and part of it is sold to recycling plants to generate a small income that helps pay the riders. The organization currently still depends on external funding to operate.

Mckingtorch

Women in the informal waste sector collect and aggregate plastic for Mckingtorch. The company processes this material in its own facility, where it is transformed into products such as school desks. Revenue is generated through sales, partnerships, in which partners purchase these products, as well as through general funding. In addition, the company is actively engaged in research to further develop and improve its processes.

Key takeaways

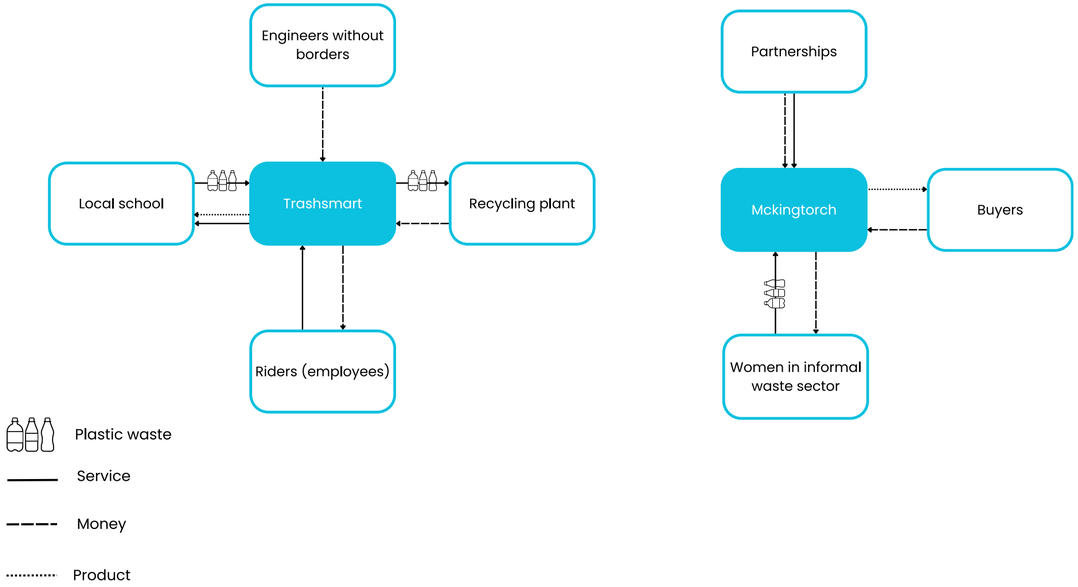
- Community involvement is essential for the success and sustainability of the system.
- Expanding the recycling process beyond drip tapes to include other types of agricultural plastics is important.
- Aggregation is a crucial step within the recycling value chain.
- Some recycling companies purchase plastic waste; however, this typically generates limited financial returns.
- Forming partnerships with recycling companies can be a strategic approach to strengthen operations and impact.



TrashSmart, www.trashsmart.org



Africa Feature Network (2026)



Business models plastic waste initiatives

Conclusion ‘the design challenge within Ghana’s waste landscape’

In conclusion, plastic waste management in Ghana is still in a developing stage and is characterized by limited recycling infrastructure, insufficient policy implementation, and a strong reliance on the informal waste sector. At the same time, plastics remain deeply integrated within everyday life and the national economy, making large-scale transitions away from plastic use complex. Despite these challenges, several promising initiatives demonstrate that community-based and economically driven recycling systems can create both environmental and social impact. The research highlighted the importance of aggregation systems, partnerships with recycling companies, and community engagement within successful recycling initiatives. In addition, creating accessible and financially attractive alternatives appears essential for encouraging more sustainable waste practices. These insights demonstrate the potential for developing localized and collaborative recycling systems for agricultural plastics within the Ghanaian context.

Interview setup

For most interviews, I prepared a few key talking points I wanted to discuss with each participant and used these as the basis for my questions, a so-called topic guide. This approach worked well, as interviews sometimes took a completely different direction than I had initially planned. For example, I was supposed to interview a PhD candidate at KNUST about waste handling. Instead, he gave me an in-depth, four-hour chemistry lesson, which proved extremely valuable for my understanding of plastic recycling and its possibilities. I documented all conversations related to the project throughout its duration, ranging from brief exchanges to more extensive discussions. These records can be found in the appendix.

To illustrate how I structured an interview in advance, I will use my first interviews with farmers in Ghana as an example. My goal was to gather insights into farming practices in Ghana, understand their relationship with HGT for the customer journey map, learn how they manage irrigation systems for the user-product journey map, and explore their perspectives on the lifespan and end-of-life of drip tapes.

General
- What crops do you have on the farm?
- Do you have other jobs outside of farming?
- How long do you already own the farm?

HG
- How do you chose a distributor for the irrigation system?
- Did you reach out to HG or did HG contact you?
- Do you make use of the farmersnetwork of HG, if yes, for what?
- What do you think of the farmer field days?
- How do you experience the contact with HG?
- What do and don’t you like about HG?
- Do you sometimes provide feedback about the materials or the information HG has provided? If yes, what kind of feedback?
- How do you receive the irrigation tube from the distributor?
- Do you know the prices of the other materials HG provides?

Journey map
- How does the installation of the irrigation system work?
- How do you use the irrigation tubes?
- How do you maintain the irrigation tubes?
- How do you repair the driptapes when they are broken?
- What is the main reason the driptapes break?
- How do you store the driptapes when you want to reuse them?
- What do you do with the driptapes after they can’t be used anymore?
- When can’t the driptapes be used anymore?
- How many reuse cycles do the tapes often undertake?
- How do you discard/ save the tapes?

Lifespan driptapes
- What do you think of the irrigation driptapes that HG provides? What are advantages and what are disadvantages of driptapes?
- How often do you buy new driptape? When do you re-order?
- What do you think about the amount of plastic on the agricultural fields?
- Do you have any ideas for reuse/ recycling?
- Are you already recycling on the farm?
- What is the most important requirement for purchasing driptape: quality/ price/ easy use/ easy delivery/ good contact with distributor/ sustainability?

Gyimah Akuako et al. (2023) emphasize the importance of avoiding one-size-fits-all sustainability solutions. Instead, it is essential to understand why plastic is used within a specific context and who depends on it.

To explore and better understand the design challenge, several methods were applied, including (customer) journey mapping and persona creation. The journey map was used to analyse the interaction between the product and the user, while identifying potential challenges and opportunities within the system.

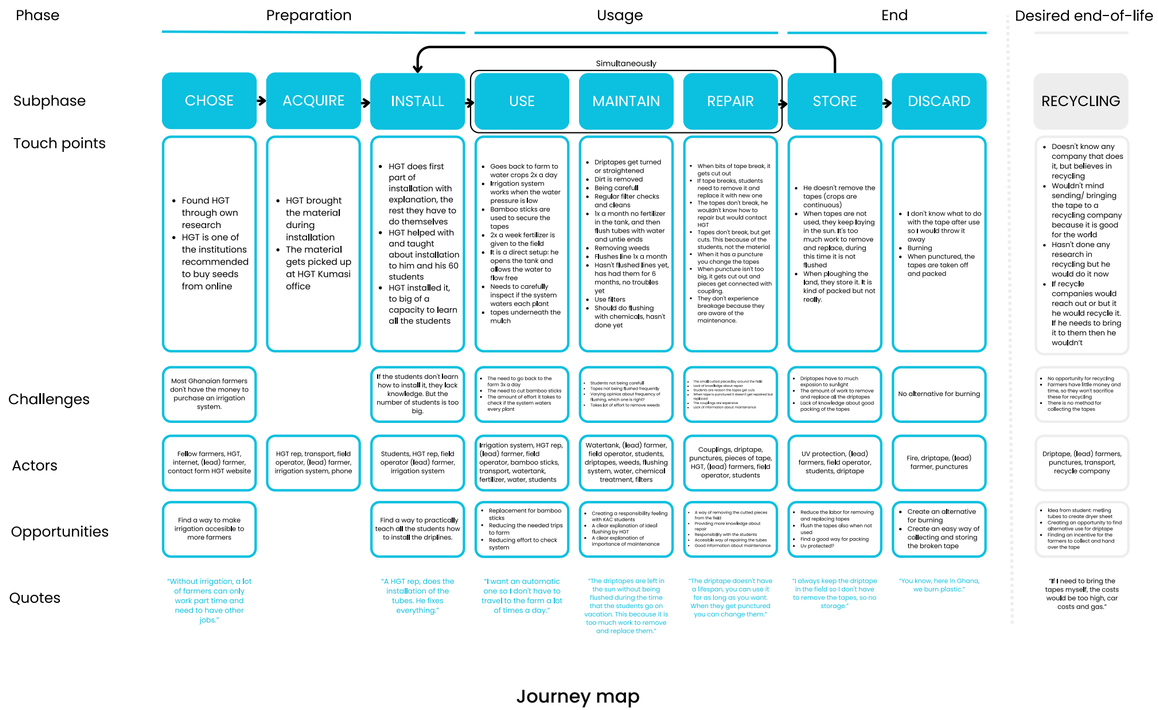
The structure of the initial interviews with farmers was based on the journey map and customer journey mapping methods. The data gathered through these interviews was subsequently used to develop personas.

6. MAPPING AWARENESS, PRACTICES AND DIFFERENCES IN DRIP IRRIGATION USE AND MAINTENANCE

Key challenges and opportunities from journey mapping

Based on the data collected through interviews (appendix A), the journey map was further refined and completed. This process revealed several initial design challenges and opportunities in the interaction between the product and the user:

- KAC lacks sufficient capacity to provide student guidance during the installation of drip tape systems, resulting in limited hands-on learning experiences related to irrigation. It is assumed, partly based on input from KAC student, that students are not acquiring adequate practical knowledge in this area.
- According to the school board, KAC students handle drip tape with insufficient care, which may affect its durability and performance.
- There is significant variation in how drip tapes are flushed, indicating a lack of standardized procedures.
- There is a general lack of accessible information regarding proper maintenance of drip irrigation systems.
- Farmers perceive couplings as relatively expensive, leading to the assumption, supported by findings from Survey 2, that they are less likely to purchase them.
- There appears to be no widely adopted alternative to burning used drip tapes, though further validation of this claim is required.
- Plastic mulch is prone to tearing easily, which may impact its effectiveness and lifespan.



Journey map


Recently laid plastic mulch


Aged plastic mulch

Similarities and differences within the target group

Analysis of the interview data and the developed personas revealed both clear similarities and notable differences within the target group, highlighting important patterns and distinctions that need to be taken into account.

Name: Samuel
Age: 24
Occupation: student at KAC

Here they want the vegetables to be organic, but due to the plastic in the ground it is not organic.

One of the reasons I wanted to study at KAC is to learn about irrigation systems.

Motivation	His father is a farmer so he wants to be one to.
Land	He manages a small piece of land at the KAC campus. He farms corn and kowpi.
Plastic waste	He is aware of plastic waste and its associated risks. As part of a business course, he developed the concept of producing agricultural sticks from plastic waste.
Irrigation knowledge	He learns about the theory of irrigation systems; however, he does not gain practical experience. At KAC, a field operator is responsible for managing the irrigation system.
Estimated lifespan of irrigation	He thinks the driptapes will last 1 year with bad maintenance. Longer with good maintenance. At campus they last less than 2 years.
Needs	Farmin is very manual work. He wants it to be more automatic.

Persona 1

Name: James
Age: 29
Occupation: Lead farmer + teacher

Burning effects the atmosphere, but there is no alternative.

From the start I have had an irrigation system, I wanted to start good.

Motivation	Farming is an investment for him. He does a lot of research himselve.
Land	He farms peppers. He has 2.5 acres of land arranged via KNUST.
Plastic waste	He believes in recycling. He wouldn't need to get anything back for collecting and brining the old driptape to a recycling plant.
Irrigation knowledge	HGT installed the irrigation system at his farm. However, he does a lot of research himselve about it and gets tips from a professor at KNUST.
Estimated lifespan of irrigation	He thinks his driptapes will last for 5 years.
Needs	He wants an automatic system for irrigation. In this way, he doesn't have to travel to the field 2x a day. He also want stronger plastic mulch that doesn't rip that easily.

Persona 2

Name: Josefine
Age: 30
Occupation: ACHI student

I wouldn't know what to do with the driptapes later, I would probably just throw them away.

Motivation	She encountered the ACHI program. She wants her own farm with chickens and vegetables.
Land	She manages a small piece of land at the KAC campus at the ACHI demofield.
Plastic waste	For a business course, She and her group created the concept of making cardboard bags out of plantain leaves. This to reduce the single use plastic bags.
Irrigation knowledge	HGT learns the ACHi students how to install the irrigation system. They give an example of the installation and after that the students have to do it themselves.
Estimated lifespan of irrigation	She thinks the driptapes will last for 3-4 crop seasons.
Needs	She needs some starting money after ACHI to be able to become a farmer.

Persona 3

Name: Benjamin
Age: 32
Occupation: Farmer + teacher

If I need to bring the old driptapes to a recycling plant myself, the costs would be too high. I need to pay for the car and the gas.

Motivation	He teaches at the campus where his farm is located. He teaches about agriculture.
Land	He farms peppers. He has 500 square meters of land at the school campus.
Plastic waste	He is not really focused on sustainability. He would just burn the tape after they wear out.
Irrigation knowledge	HGT learns him and his 60 students how to install the irrigation system, and helps them in practice.
Estimated lifespan of irrigation	He thinks that the driptapes will last for 5 years.
Needs	He says that the costs of the driptapes are a disadvantage, he needs them to be cheaper.

Persona 4

Similarities

1. The majority of the target group demonstrates some sort of awareness of the risks associated with plastic waste.

Lead farmer (appendix A4)
'Burning affects the atmosphere, but there is no alternative.'

KAC student (appendix A1)
'Plastics ruin the soil and create microplastics. Plastic doesn't decompose. It will be in the soil for over 10 years.'

This KAC student indicated that, together with classmates, he is working on an assignment focused on developing a farming business concept. Their proposal involves the production of durable, reusable agricultural stakes made from recycled plastic waste. This concept is intended as an alternative to the current use of wooden stakes, with the aim of reducing deforestation.

2. Many farmers need a second job to sustain their livelihood.

Many of the interviewed farmers have secondary occupations in addition to farming, for example working as teachers.

3. Farmers don't recycle

ACHI student (appendix B1)
'I wouldn't know what to do with the drip tapes later, I would probably just throw them away.'

Farmer (appendix A5)
'If I need to bring the old drip tapes to a recycling point myself, the costs would be too high. I need to pay for the car and the gas.'

In a survey with ACHI alumni (appendix D1), participants responded the following to the question: 'Do you have any ideas on how agricultural plastic waste could be reused or recycled? If yes, in what way?'

ACHI alumni
'Yes by burning it.'

ACHI alumni
'No, because there is no recycling plant here.'

The target group currently doesn't recycle agricultural plastic waste. Reasons for this as mentioned are that there is no alternative, and that the costs would be too high.

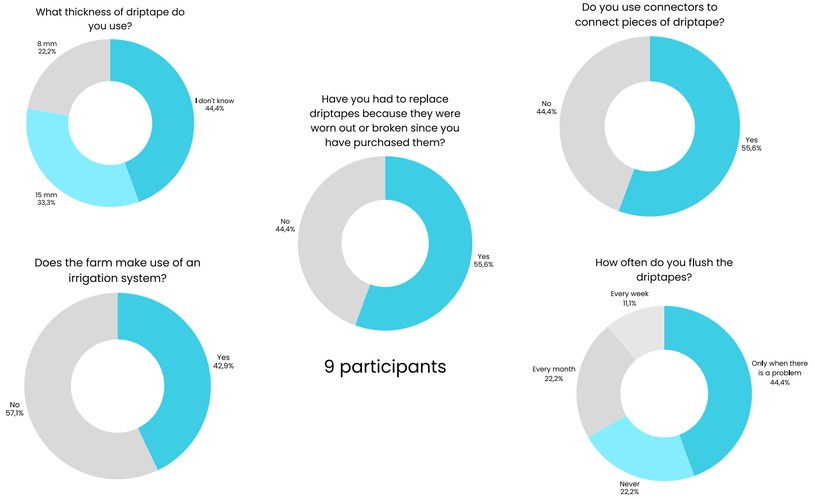
Differences

1. Maintenance guidelines

Key differences lie in irrigation system installation, tank type, flushing frequency, damage experience, storage methods, and expected driptape lifespan.

These differences suggest that levels of knowledge and education about irrigation systems vary significantly within the target group. This may indicate a lack of clear guidelines for irrigation use and maintenance. Without consistent maintenance practices, the lifespan of driptapes is negatively affected. Improved maintenance could extend their lifespan, resulting in less waste and reduced costs for farmers by decreasing the need for replacement equipment.

Evidence from a survey conducted among ACHI alumni (appendix D1) provides insights into the use of irrigation practices. As is shown in the diagrams.



Survey 1 results

	KAC team	ACHI student	Farmer	Lead farmer 1	Lead farmer 2	HGT demofield
Motivation		Small part of KAC land	500 square meter	2,5 acres		5-6 driptapes
Irrigation start date	2015	3 years ago	6 months ago	2 years ago	4 years ago	5 years ago
Installation	ACHI PM and field operator do it with help of some students	Students with the help of HGT	With HGT rep	HGT rep installed for	HGT installed with	Themselves
Tank	2 seperate tanks (one fot water, one fertilizer)	1 tank for everything	1 tank for everything	2 tanks (one water, one fertilizer)	1 tank for everything	
Driptapes	At some parts of the field	Yes	Yes	Yes	Yes	Yes
Plastic mulch	At some parts of the field	Yes	Yes	Yes	No	Yes
Type of irrigation	Drip, sprinkler and rain	Drip	Drip	Drip	Drip	Drip
Flushing	1x a semester	1x a month with only water	Never	Flushes 1x a month	Once during rain season	Flushes every 2 weeks
Taking tape of the field	When ploughing the land	When ploughing the land	Hasn't taken them of	Hasn't taken them of	Every dry season	Hasn't taken them of
Estimated lifespan driptape	1 semester	3-4 seasons	5 years	5 years		5 years
Frequency of watering	Once a day			3x a day		2x a day
Damages	Cuts	No	No	No	When she folds the tapes, she sees it will soon break	Cuts when making holes in the plastic mulch
Storage	In sun, not folded	In sun, not folded	Stay on field, no storage	Stay on field, no storage	Packed inside at home	Packed in a cool and dry place

Comparison map

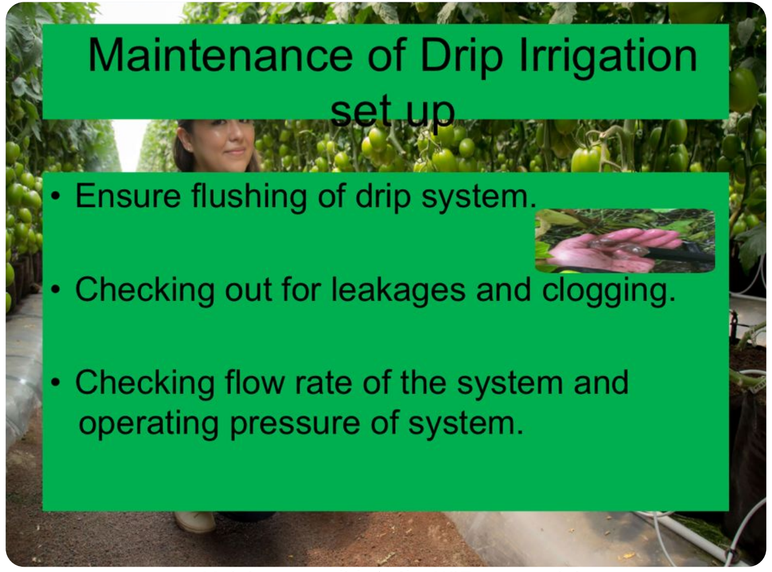
Current maintenance content

To assess whether a lack of clear maintenance guidelines exists, and to gain insight into the type of irrigation-related information currently provided to the target group, an overview was created of the educational content shared by different institutions within the system.

Although the ACHI program provides an extensive presentation about irrigation and its advantages, the material contains limited information regarding maintenance practices. Similarly, the HGT team in Ghana provides a valuable presentation explaining why farmers should adopt irrigation systems, but this also contains relatively limited maintenance guidance.

As a result, farmers often develop their own maintenance practices through experience and experimentation. This was also confirmed by the field operator (appendix A6).

Overall, these findings indicate that institutions currently provide limited and insufficiently structured maintenance guidelines for drip irrigation systems.



Maintenance slide in the HGT powerpoint

However, the necessity of such guidelines for farmers remains a relevant question. In a focus group with farmers and ACHI alumni (appendix B2), the following question was posed: “Do you think clear maintenance guidelines for the irrigation system would be valuable to you?” The overview below presents their responses. These suggests that maintenance guidelines can provide significant value to farmers.

‘Yes, because adopting maintenance culture in your farms, by repairing damage or spoilt irrigation increase the longetivity, effectivenis and efficiency outflow of water in the farm.’

‘Yes! Because, it gets you back on track in case we forget on how to maintain it. Also helps those that know nothing about drip irrigation to maintain theirs.’

‘Yes because it helps you to do proper maintenance on your damaged irrigation system and it helps prevent wastage of the system.’

‘Yes because it aims in low cost for maintenance, you use it for a longer period and farm all year round.’

‘Yes because it will help reduce cost in purchasing new irrigatio systems. If guidelines are taken properly.’

‘Yes because it helps reduce costs/ fares of paying people to come and repair/ maintain.’

‘Yes maintenance guidelines for drip irrigation system is of great value. It helps to make reference when you encounter problem with drips.’

2. Damages

Another notable difference within the target group concerns the reported causes and frequency of damage to drip tapes. Farmers primarily attribute damage to external factors such as rodents chewing the tapes, excessive sun exposure, errors during the cutting of holes in plastic mulch, or general wear and tear. In contrast, the KAC team explicitly reports a higher occurrence of damage to drip tapes on their campus.

The underlying cause of the high level of damage observed at KAC remains a key question. According to the field operator, the drip tapes do not fail due to material defects but are instead damaged through cuts, which he attributes to student handling practices (appendix A6). Similarly, both the KAC and ACHI teams report that the damage is primarily caused by students handling the materials carelessly (appendix A7).

The KAC team indicates that the drip tape must be replaced after each crop cycle due to damage. Although some surplus tape is occasionally available, this practice results in significant costs for the school.

During a field visit, the PM demonstrated a method for identifying damage by running the irrigation system and checking for leaks. According to the PM the primary cause of damage is students cutting the tapes while removing weeds. He attributes this not to a lack of knowledge, as students are taught about drip tape use, but rather to carelessness and a lack of responsibility (appendix A7). He explained that students are expected to temporarily move the tape aside during weeding and reposition it afterward; however, this procedure is often not followed. The frequency of weeding depends on the soil and crops, the timing isn’t that specific, it is necessary when the weeds are the same height as the crops.

This information suggests that the high incidence of damage to drip tapes on KAC fields is primarily attributable to students’ limited sense of responsibility in handling the materials.

To further examine this issue, the perspectives of students were also considered. A survey (appendix D2) on drip tape handling was conducted among KAC students, with a total of around 100 respondents. The results, indicate that students do demonstrate a sense of responsibility in their handling of drip tapes. This suggests that the previously assumed cause, namely a lack of responsibility, is not the primary explanation, and that other causes underlie the observed damage.





Cuts in the drip tape



The machete as a tool for cutting weeds



Leakage due to cut in drip tape

Conclusion ‘mapping awareness, practices and differences in drip irrigation use and maintenance’

The findings demonstrated that there is a lack of standardized maintenance practices, limited accessible maintenance information, and practical challenges related to product durability and repair. In addition, both educational and infrastructural limitations influence how drip irrigation systems are currently used and maintained within the Ghanaian context. The research also highlighted broader issues surrounding agricultural plastics, including the absence of accessible recycling alternatives and the financial barriers associated with repair materials such as couplings.

The research revealed both similarities and differences within the target group.

<u>Similarities within the Target Group</u>
1. The majority of the target group demonstrated some level of awareness regarding the risks and negative impacts associated with plastic waste.
2. Many farmers mentioned the need for secondary sources of income to sustain their livelihoods.
3. Recycling practices for agricultural plastics were largely absent among participants.

<u>Differences within the Target Group</u>
1. Maintenance guidelinesFarmers and other stakeholders maintained irrigation systems in different ways, indicating the absence of clear and standardized maintenance guidelines. Institutions currently do not provide specific maintenance protocols, while ACHI alumni and farmers unanimously indicated that they would benefit from clearer maintenance guidance.
2. Damages to drip tape systems
KAC reported significantly more damage-related issues, particularly cuts in the drip tapes, compared to many other farmers. KAC staff associated these damages with what they perceived as a lack of responsibility among students. However, students themselves indicated in the survey that they did feel responsible for the systems. This suggests that additional underlying causes may contribute to the damages experienced at KAC.

Based on the initial design goals, the current supply chain was analyzed. At present, this supply chain follows a linear model, in which the product moves sequentially from the producer to the distributor and ultimately to the end user.

7. DRIP TAPE SUPPLY CHAIN

Material properties and recycling potential of drip tapes

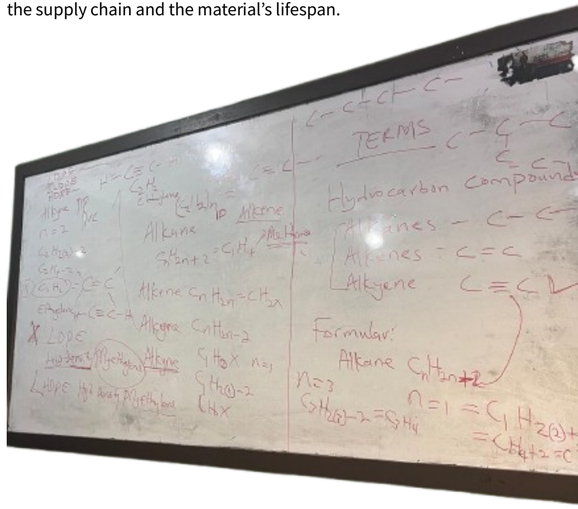
As confirmed during a quality check at a recyclings company, the drip tapes are composed of Low-Density Polyethylene (LDPE). LDPE is suitable material for drip-tape because drip tape must remain flexible. LDPE is one of the most widely used plastic materials globally, with primary applications including food packaging films, grocery bags, and agricultural mulch films. In Ghana, people drink from water sachets, these are often made from LDPE (Jnr, 2018), highlighting its widespread presence and relevance within local waste streams.

Laird Plastics (2022) states that LDPE is characterized by its flexibility, transparency, and ease of processing, offering a balanced combination of strength and pliability. Importantly, LDPE is recyclable; however, only approximately 5–10% of total LDPE production is currently recycled. Effective recycling requires the material to be properly separated from other plastics and cleaned to remove contaminants. The recycling process typically involves shredding the material into flakes, which are then melted and extruded into pellets for reuse. Depending on the level of contamination, recycled LDPE may be blended with virgin material, depending on the intended application.

Recycled LDPE can be applied in various contexts, including construction materials, plastic lumber, waste bags, film products, shipping envelopes, packaging, and composite materials. Nevertheless, several challenges limit its recycling potential, including contamination issues, low economic value relative to processing costs, and degradation of material quality over successive recycling cycles. Drip tape recycling is already being implemented by companies such as Rivulis, demonstrating that it is a feasible option.

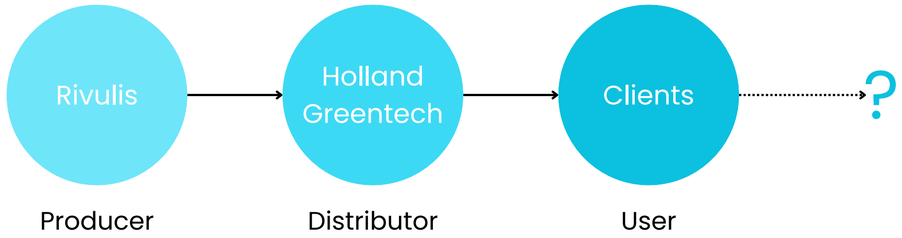
A PhD student from Kwame Nkrumah University of Science and Technology provided insights into the recycling processes of various polymers and methods for testing the quality of recycled drip tapes. He recommended visiting a recycling company to assess the material strength of drip tapes and other agricultural plastics.

The material flow forms the basis for identifying opportunities to develop a circular supply chain. Understanding the composition of drip tapes is essential in this regard, as it provides insight into the possibilities for recycling, reuse, or other strategies aimed at extending both the supply chain and the material's lifespan.



Chemistry lesson from the PhD student

Linear supply chain



Current drip tape supply chain

Role of HGT in the supply chain

As mentioned previously, HGT is not solely a distributor of agricultural equipment. In addition to supplying products, the company provides knowledge, as well as access to market and financial networks. The following data is based on conversations with the founder of Holland Greentech, employees of HGT Ghana, and lead farmers.

Trainings

Holland Greentech organises both community garden trainings and farmer field days as part of its knowledge-sharing activities. The community garden trainings take place twice a month and are primarily attended by farmers located near Accra. In addition, HGT facilitates communication through WhatsApp groups, where farmers can promote their products, and the company shares information about new products and upcoming events. Although an irrigation-focused group chat was previously established, it is no longer actively used.

According to HGT, the trainings are widely attended and utilised by farmers. In regions further from Accra, the company organises farmer field days, which can attract more than 150 participants. During these sessions, farmers are introduced to agriculture as a business. The programme includes topics such as crop protection, organic soil management, and financial insights, including comparisons of profitability with and without irrigation systems. Additionally, farmers receive guidance on identifying target markets and participate in practical, hands-on activities. Importantly, these trainings are open to all farmers and are not limited to Holland Greentech clients.

Lead farmers

Lead farmers are identified through social media outreach and training programs. HGT establishes contact with potential candidates. These lead farmers function as key promotional agents within the organization's network, contributing to the visibility and dissemination of HGT's activities and services.

In addition to their promotional role, lead farmers receive extensive knowledge from HGT. This knowledge is then further disseminated by the lead farmers to other farmers within their region, thereby creating a multiplier effect in knowledge sharing. Lead farmers are selected on a regional basis, and the selection process is strict, as candidates must meet a predefined set of requirements. Participation in the ACHI program is one of the pathways through which farmers may qualify for this role.

Lead farmers benefit from several advantages. These may include discounts on agricultural equipment or, in some cases, provision of equipment free of charge. Furthermore, they receive enhanced support compared to regular customers, such as additional advice, tailored recommendations, and access to specialized knowledge.

Each lead farmer is required to organize at least one farmer field day annually. This event is organized in collaboration with HGT. Lead farmers maintain close contact with regional representatives, who play a supervisory and supportive role. These representatives periodically visit the farms to monitor whether the provided equipment is being used correctly and to ensure adherence to agreed practices.

Finally, the relationship between HGT and the lead farmers is formalized through a contractual agreement.

Sustainability

HGT publishes an annual Green Growth Report, in which it outlines its sustainability initiatives and performance. Within this framework, the organization focuses on improving water productivity, reducing diesel consumption, and decreasing the use of chemical crop inputs. These indicators are monitored and evaluated through demonstration plots. A key priority highlighted by HGT is the reduction of post-harvest losses. Notably, there is currently no direct collaboration with the sustainability department of Rivulis.

In terms of farming practices, HGT promotes a "start small" approach, encouraging farmers to begin on a limited scale and learn from initial mistakes. This strategy reduces risk and allows for gradual skill development. This approach is reflected in the experience of an interviewed lead farmer (appendix A4), who began farming two years ago and currently cultivates only part of his available land to experiment, learn, and expand progressively.

Core component of the supply chain: T-Tape

Characteristics

Driptape is a thin-wall irrigation solution designed for short-cycle or seasonal crops, where cropping patterns frequently change and irrigation layouts are not intended for long-term use. In such contexts, more durable, thick-wall irrigation systems are less suitable, as they are typically designed for permanent installations. Driptape therefore functions as a lightweight, non-permanent solution that aligns with the needs of short-duration cropping systems.

According to a manager at Rivulis, T-Tape is particularly well suited for the Ghanaian context. It is positioned as a premium product within the market, offering strong anti-clogging performance and a relatively long lifespan compared to other driptape options.

The advantages of T-Tape, as stated by Rivulis, include effective water distribution due to close emitter spacing, high resistance to clogging, and robust material strength. Additionally, the product offers a high degree of configurability, with options in flow rate, diameter, and wall thickness to accommodate diverse agricultural requirements. T-Tape can also operate efficiently under low-pressure conditions, making it suitable for a wide range of farming environments.

Recycability

Additionally, it is important to note that T-Tape has a single-structure design, meaning that the emitter is not a separate physical component but is embossed directly into the polyethylene (PE) wall of the tape. As a result, the entire product consists of a single material, allowing it to be recycled in one step without the need for material separation. In contrast, many other drip tapes on the market are composed of multiple PE layers or include separate emitter components that are bonded or glued inside the tape. In such cases, recycling requires prior separation of these components, making the process more complex and less efficient.

According to Rivulis, T-Tape is the only drip tape on the market that enables immediate, one-step recycling of 100% of the product. For this reason, it is highly valued in countries such as France, Belgium, and Netherlands, where recycling regulations are stringent and material circularity is a key consideration.

Furthermore, Rivulis is currently exploring the development of biodegradable irrigation materials. As an intermediate step, the company introduced T-Tape White in 2024, which is manufactured using at least 50% recycled materials, reflecting a shift towards more sustainable product design.

HGT drip tape offer

As discussed in the ‘farming practices’ chapter, HGT offers different types of driptape, primarily varying in thickness and price. The availability of thinner driptape (8 mil) is mainly intended to make irrigation systems more financially accessible to farmers. This is particularly relevant in contexts such as Ghana, where many farmers lack the financial resources to invest in irrigation systems, despite their necessity during the dry season.

Although HGT promotes the use of more durable driptape, specifically the 15 mil variant, farmers often opt for the cheaper 8 mil option due to lower upfront costs. However, according to HGT Ghana, the 8 mil driptape is more prone to damage because of its softer material. This was also reflected during a field visit with the ACHI PM (appendix A7), who noted that KAC previously used thicker driptapes and was satisfied with their performance, but ultimately switched to thinner alternatives due to cost constraints.

Importantly, research by Kadziolka et al. (2011) shows that while 15 mil driptape has a higher initial cost, its longer lifespan, lasting two to three seasons compared to one season for 8 mil in this research context, results in comparable or even lower costs over time. This indicates that the 15 mil option should be understood as a long-term investment rather than a higher expense.

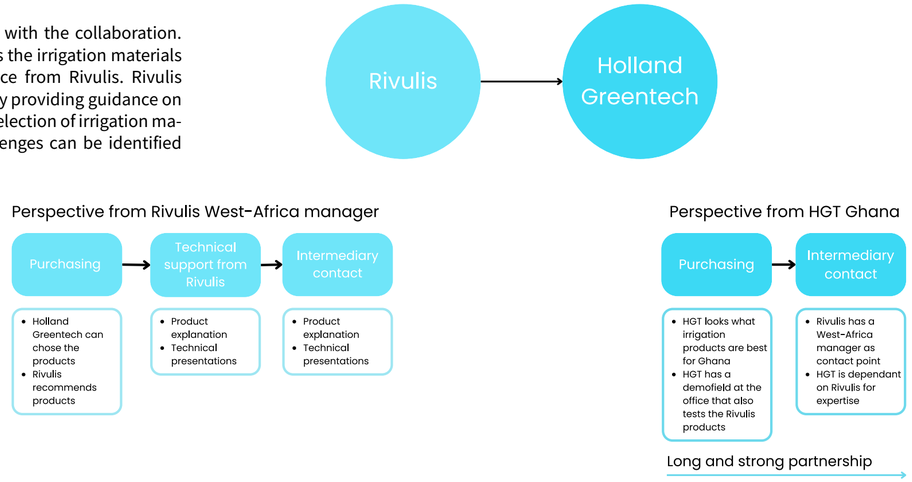
However, the preference for 8 mil driptape suggests that many Ghanaian farmers are constrained to focus on short-term affordability rather than long-term cost efficiency, likely due to limited financial capacity to make higher upfront investments.

Connections within the current supply chain

A more detailed analysis was conducted focusing on the interactions between stakeholders within the supply chain. This involved examining multiple perspectives to develop a comprehensive understanding of the collaboration, and to assess whether these viewpoints are aligned or reveal underlying challenges.

Rivulis and HGT

Both parties are satisfied with the collaboration. Holland Greentech selects the irrigation materials independently, with advice from Rivulis. Rivulis contributes its expertise by providing guidance on the appropriate use and selection of irrigation materials for HGT. Few challenges can be identified within this collaboration.

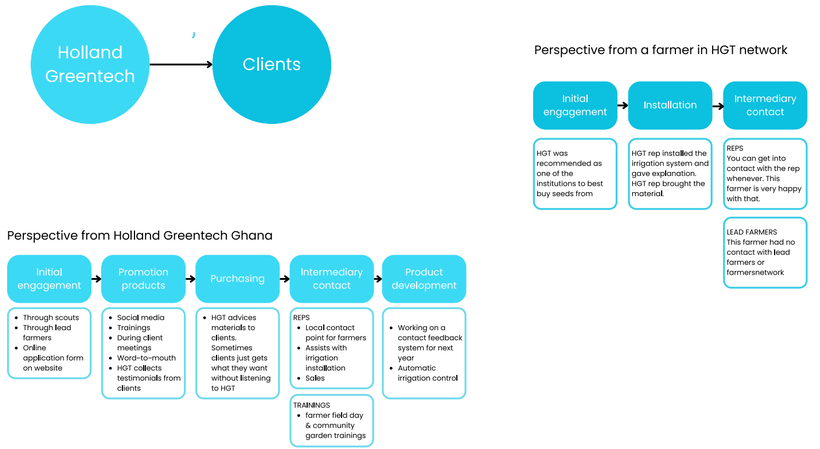


Customer journey map Rivulis and HGT

HGT and clients

Communication between HGT and its clients primarily takes place through regional representatives. Contact is maintained mainly via phone calls and text messages. Farmers report that they can reach their representative at any time and express a high level of satisfaction with HGT. One lead farmer even stated (appendix A4):

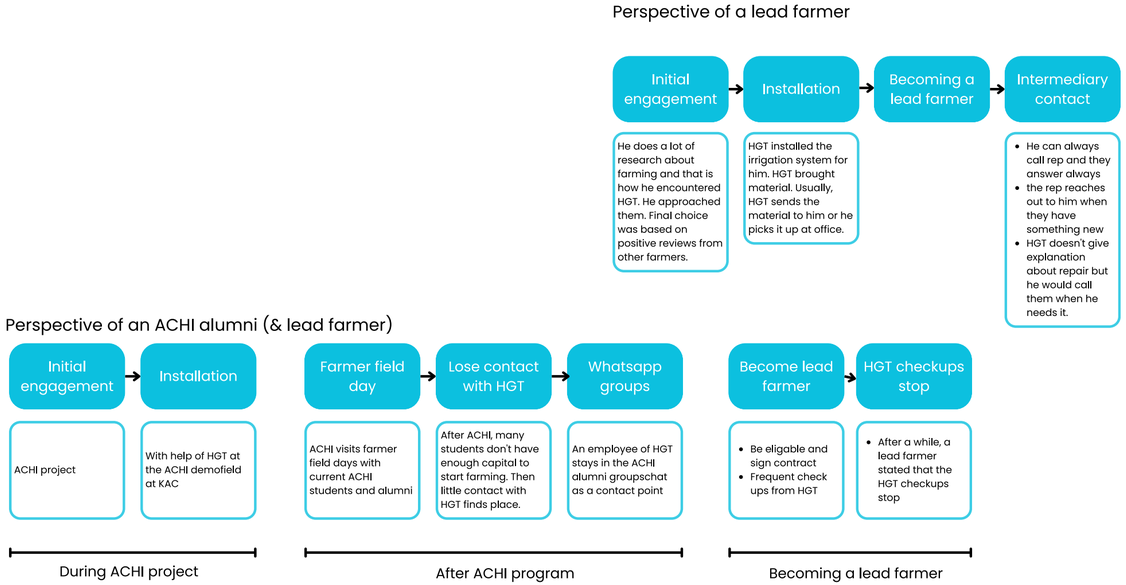
'The experience with HGT has been awesome. 'If I didn't meet them, I don't know what would have happend. I would give them a 98/100.'



Customer journey map HGT and clients pt1

Possible challenges

- HGT advises farmers on the most suitable irrigation materials; however, clients do not always follow this advice and may opt for cheaper alternatives.
- One farmer indicated that he has no contact with lead farmers and does not make use of the Holland Greentech network.
- A lead farmer reported that, over time, follow-up check-ups from Holland Greentech tend to cease.
- Representatives provide limited guidance regarding maintenance and repair.



Customer journey map
HGT and clients pt2

End-of-life of the linear supply chain

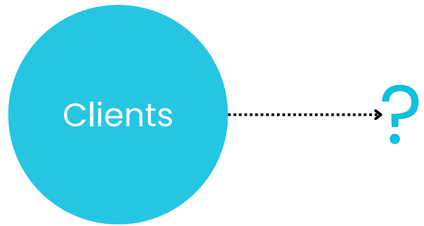
A key question remains regarding what happens to the materials once they are worn out or no longer usable. The findings from the journey mapping process highlight several current disposal practices:

1. Both interviewed farmers reported that they typically dispose of drip tapes by burning them.

2. Observations on the KAC campus revealed that significant amounts of used drip tape are left scattered across the fields.

3. During a focus group with ACHI alumni (appendix B1), participants indicated alternative disposal methods, such as burying the waste materials. One participant stated:

"I used to burn the old plastic, but I have learned that it pollutes the environment, so I dig a hole and put it in."



End of supply chain

These findings highlight that current end-of-life practices are largely informal and environmentally unsustainable. This indicates that drip tapes are either burned, buried, or left as litter on agricultural fields once they reach the end of their usable life.

The question remains why these disposal practices persist. One of the interviewed farmers (appendix A4) stated that:

"there is just no alternative."

As discussed in 'the design challenge within ghana's waste landscape' chapter, existing formal waste disposal and recycling systems often require individuals to either transport waste themselves or pay for collection services. These options involve additional costs or effort, which are not considered viable by many farmers. As a result, farmers are more likely to choose low-cost and low-effort practices, such as burning, burying, or leaving the materials in the field.



Littering plastics



Burning plastic waste



Burying/ landfill (plastic) waste

Risks of the current end-of-life practices

An alternative to the local burying, burning, or littering of agricultural plastic materials is highly necessary. Open burning of plastic waste poses severe risks to both human health and the environment. This practice releases hazardous substances such as dioxins, heavy metals, and particulate matter, which have been linked to cancer, respiratory diseases, cardiovascular conditions, and immune system damage (Wiedinmyer et al., 2014). In addition, the residual ash from burned plastics contaminates soil and groundwater, allowing toxic substances to enter the food chain.

Similarly, leaving or burying agricultural plastics contributes to long-term environmental degradation. Over time, these materials break down into microplastics that alter soil structure, reduce water retention, and negatively affect plant growth and crop yields (de Souza Machado et al., 2018).

Furthermore, microplastics can act as carriers of toxic substances, such as heavy metals, meaning they can transport these pollutants through the soil and into plants, thereby intensifying contamination and posing risks to human health through food systems (Rillig et al., 2019).

These practices represent significant environmental challenges, particularly because they frequently occur in close proximity to agricultural land.

Conclusion drip tape supply chain

The research demonstrated that drip tapes are composed of LDPE material and that drip tape recycling is technically feasible. Companies such as Rivulis already implement recycling systems for drip tapes, while the single-material PE structure of T-Tape enables relatively efficient one-step recycling compared to many alternative drip tapes. However, important challenges within the recycling process remain, particularly contamination of materials and transportation costs related to collection and processing.

The findings also showed that HGT plays a broader role than solely distributing agricultural products. The organization combines product distribution with knowledge sharing, trainings, farmer support, and community engagement through systems such as farmer field days, representatives, and lead farmers. Lead farmers in particular function as important intermediaries for spreading knowledge and promoting agricultural practices within their regions. Overall, farmers generally expressed positive opinions regarding HGT and its support systems.

At the same time, several challenges within the relationship between HGT and farmers became visible. Farmers do not always follow the irrigation advice provided by HGT and often choose cheaper alternatives due to limited financial capacity. This was especially visible in the preference for thinner 8 mil drip tape over the more durable 15 mil variant. Although the 15 mil drip tape may be more cost-efficient in the long term due to its longer lifespan, many farmers are primarily constrained by short-term affordability and lower upfront investment costs. In addition, some farmers indicated limited engagement with lead farmers or the broader HGT network, while follow-up support and maintenance guidance from representatives appeared limited over time.

The research further highlighted that the current end-of-life stage of the supply chain mainly consists of burning, littering, or burying used drip tapes. These practices are largely driven by the absence of accessible alternatives, as sustainable disposal options often require additional financial or logistical resources. At the same time, these disposal methods pose significant environmental and health risks, further emphasizing the need for more accessible recycling and circular solutions within the agricultural plastic system in Ghana.

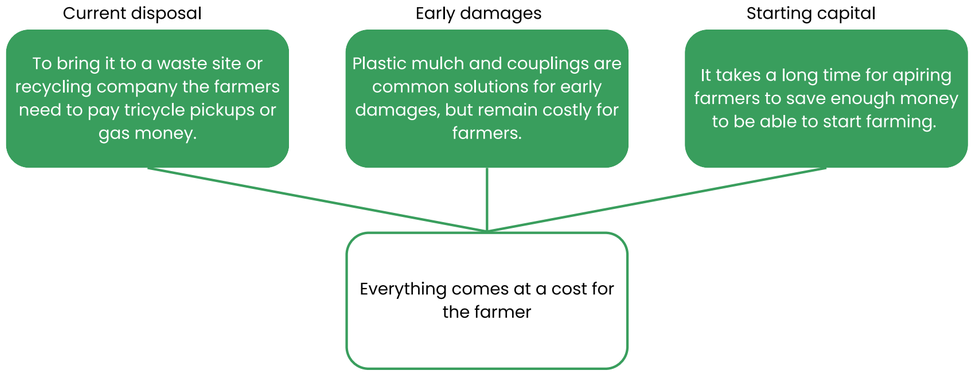


From challenge to opportunity

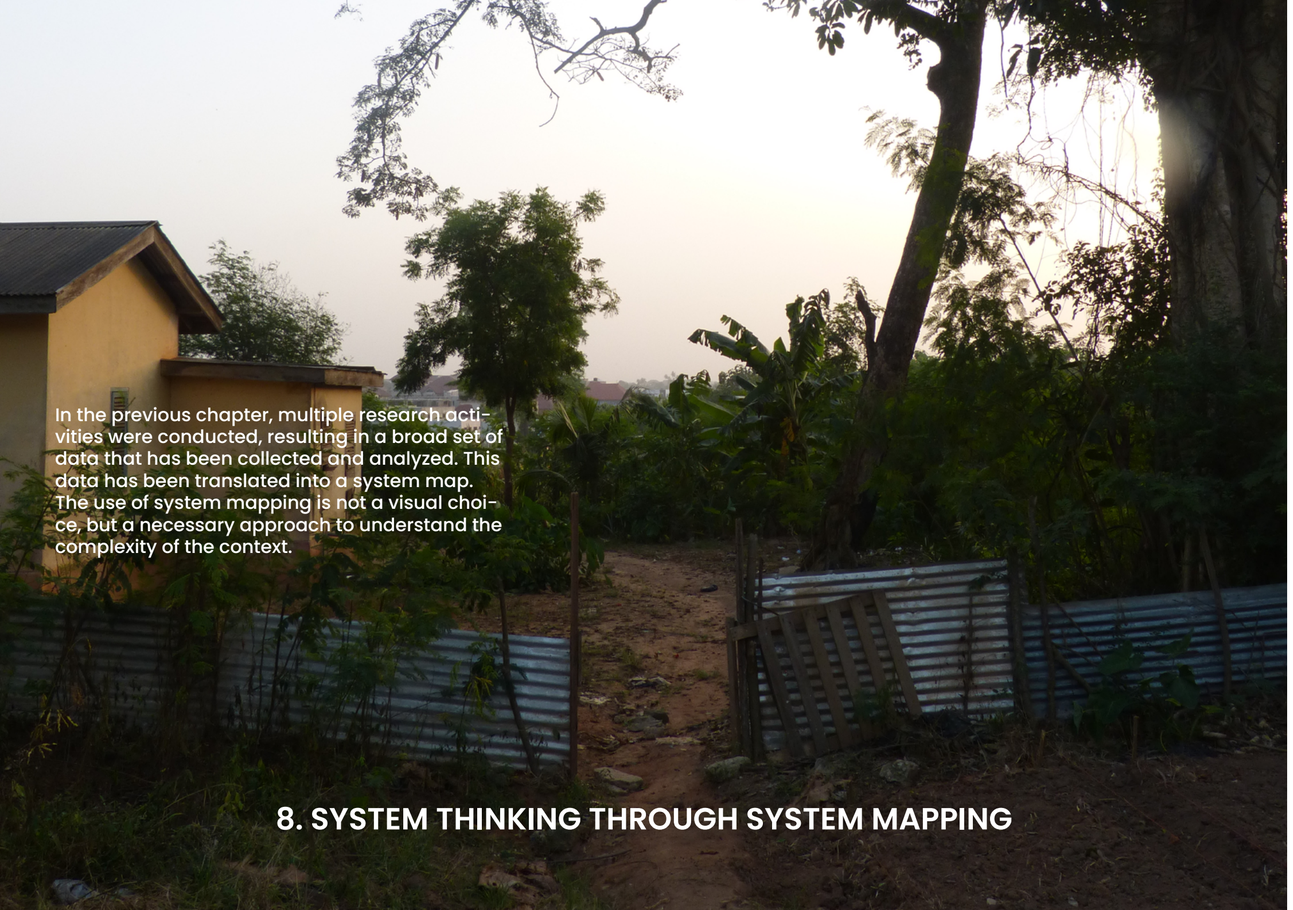
While waste incineration also occurs in the Netherlands, it takes place within a highly regulated system where energy is recovered and emissions are carefully controlled (PBL Netherlands Environmental Assessment Agency, 2022). In contrast, in Ghana, plastic waste is often burned in informal settings without proper infrastructure, resulting not only in significant health risks but also in the loss of potential economic value. As previously stated, these health risks associated with current plastic waste disposal practices must be taken into account. However, rather than approaching this solely as a challenge, it is more valuable to frame the system as an opportunity.

The research conducted through various methods indicates that financial constraints play a significant role in decision-making among Ghanaian farmers. This insight shifts the perspective from a purely problem-oriented design challenge to a more opportunity-driven approach: creating economic value from waste materials. By reframing plastic waste as a valuable resource, alternative systems can be developed in which local communities, such as farmers, are able to generate income from recycling practices. In this context, the focus lies on:

Enabling farmers in Ghana to derive financial benefits from used plastic materials, such as drip tapes.



Economic situation of farmers



In the previous chapter, multiple research activities were conducted, resulting in a broad set of data that has been collected and analyzed. This data has been translated into a system map. The use of system mapping is not a visual choice, but a necessary approach to understand the complexity of the context.

8. SYSTEM THINKING THROUGH SYSTEM MAPPING

Systems thinking for understanding complex systems

A system can be defined as “a set of elements and relations which operate together towards an overarching purpose” (Pieter Jan Stappers, 2021). This means that individual elements cannot be understood in isolation, but only in relation to one another. For this reason, system mapping is essential in this research: it allows relationships, dependencies, and interactions within the system to become visible.

This project demonstrates that the context cannot be reduced to a single problem with a linear solution. Instead, it consists of multiple interconnected challenges, each influencing one another. A traditional problem-solution approach would therefore be insufficient. System mapping enables a shift from solving isolated problems to understanding the system as a whole and identifying meaningful intervention points within it.

In addition, systems are dynamic and constantly evolving. A change in one part of the system can lead to ripple effects throughout the entire system. This highlights the importance of systems thinking: even small interventions can have significant impact. Within this perspective, the relationships between elements are more important than the elements themselves (Results for Development, 2023).

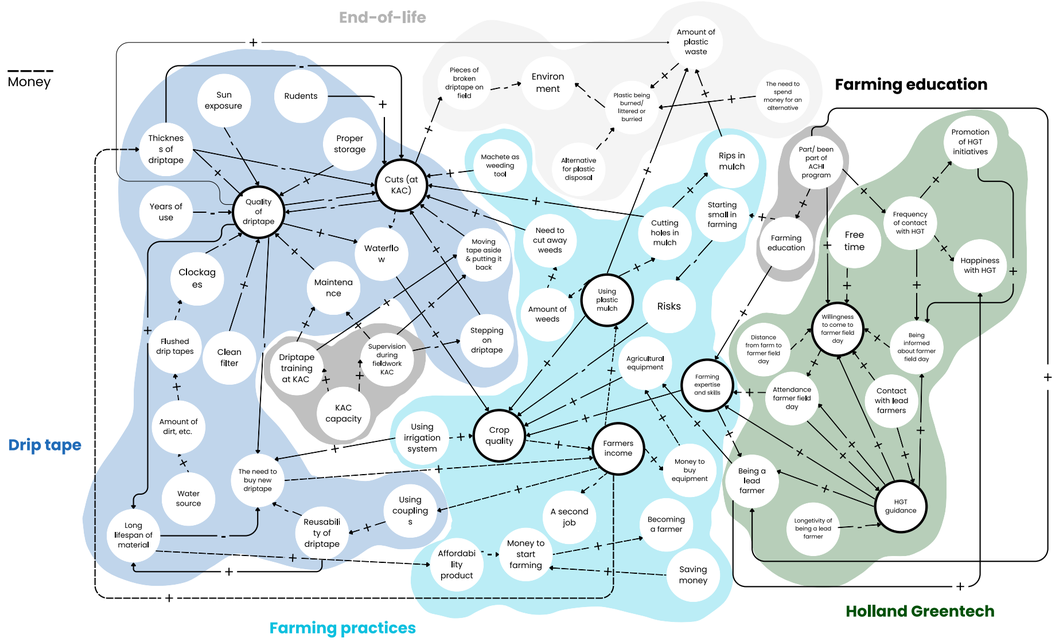
Furthermore, constructing a system map requires input from multiple stakeholders. By incorporating diverse perspectives, a more complete and nuanced understanding of the system is achieved. This is crucial for identifying interventions that are relevant, effective, and context sensitive.

Finally, systems thinking is iterative. Understanding the system develops over time through continuous reflection, refinement, and adaptation. This iterative process has been central to this research.

In a system map, the symbols between elements show how they influence each other.

- + (plus) means that both elements move in the same direction. If one element increases, the other also increases. If one decreases, the other decreases as well.

- – (minus) means that the elements move in opposite directions. If one element increases, the other decreases. If one decreases, the other increases.



Sytem map 1: the current system

Mapping the current system

This system map provides an overview of the current system, based on the research data collected throughout this study. It also visualizes the most important elements, the elements with the most connections, as presented below.

Five main themes are identified within the system: drip tape, end-of-life, farming practices, farming education, and Holland Greentech. These themes represent the core domains of the project and structure the understanding of the system.

It is important to note that the system map has been constructed based on the scope and findings of this project. The boundaries of the system are therefore not fixed, but have been defined through the research process, reflecting the elements and relationships considered relevant within this study.

The system map has been developed by synthesizing the research findings, with particular attention to the elements and interactions identified as most significant. It reflects both the structure of the system and the relationships between its components.

By visualizing these relationships, the system map highlights the complexity of the design challenge and demonstrates how small interventions can lead to significant changes within the system.

<u>Function of this system map</u>
Extending the lifespan of agricultural plastics and enabling a recycling system.

Most important elements



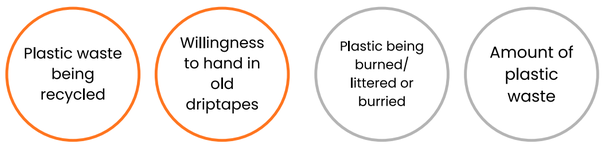
Current system map

Identifying opportunities for intervention within the current system

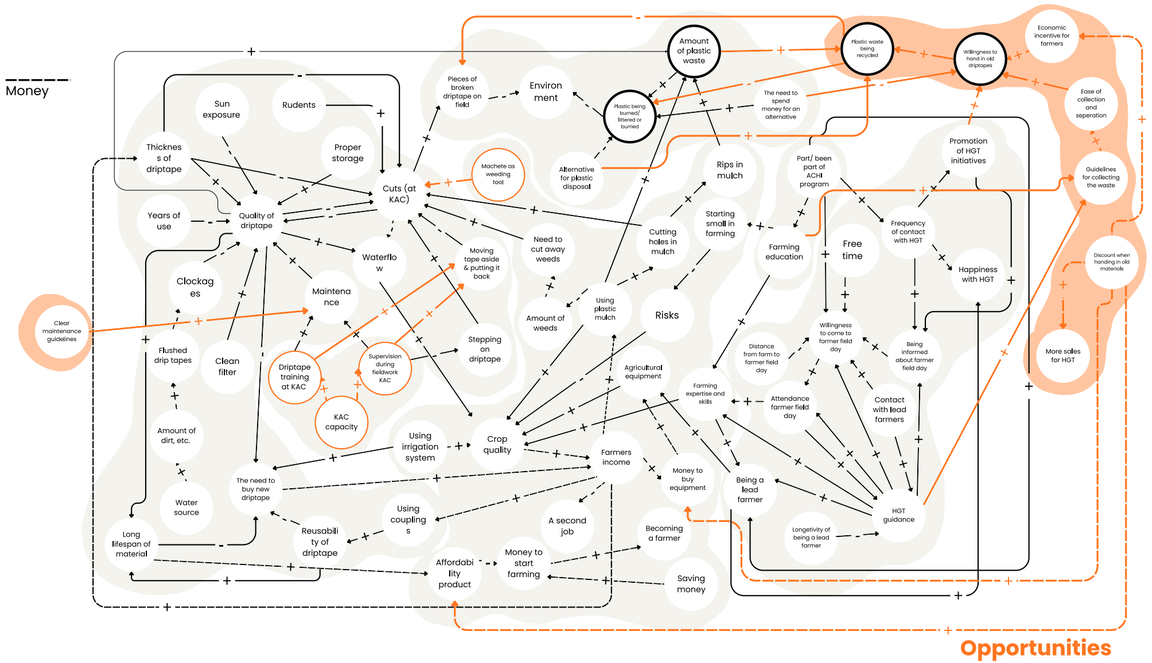
The second system map introduces new elements and connections derived from the research. These additions highlight potential opportunities for design interventions. Four additional elements have been incorporated into the key elements of the system, as shown below.

The elements highlighted in orange represent modifications to the current system map. These include both areas requiring improvement and opportunities to address previously missing elements and connections within the system.

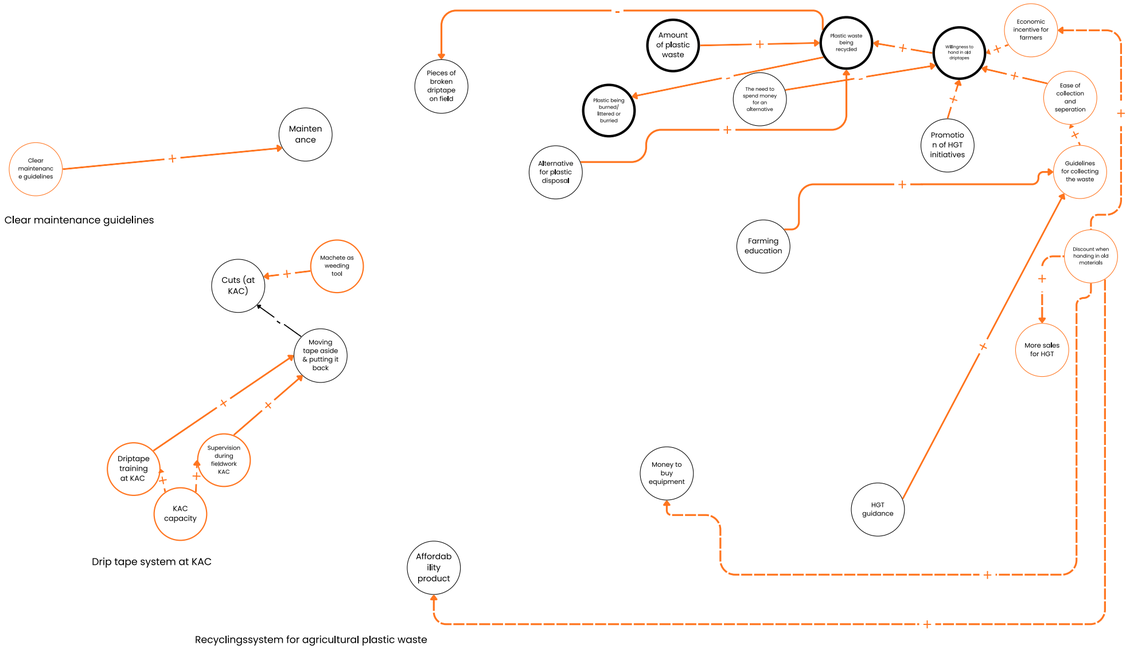
Most important elements



Opportunities current sytem map



Sytem map 2: opportunities in the current system



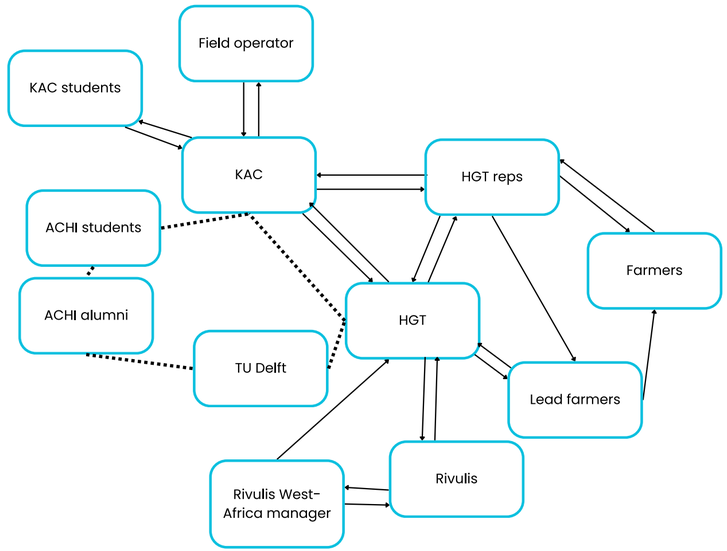
Highlighted opportunities in system map 2

Possible design interventions

Three key directions are identified: the development of clear maintenance guidelines, improvements to the drip tape system at KAC, and the implementation of a recycling system for agricultural plastic waste.

The maintenance guidelines and recycling system address gaps identified within the existing system, while the drip tape system at KAC represents an opportunity for optimization and improvement.

Systemic approach stakeholder map



Systemic stakeholder map

Reflecting on the stakeholder map presented at the beginning of this report, a more systemic approach calls for a representation in which no hierarchy is imposed among stakeholders. In such a map, all actors are considered equally relevant within the system. Below, an adapted stakeholder map is presented.

Furthermore, this project extends beyond the scope of the ACHI project alone; it addresses the broader system in which it is embedded.

Conclusion ‘system thinking through system mapping’

In conclusion, the system maps demonstrated that the challenges addressed within this project cannot be understood as isolated problems with singular solutions. Instead, the research revealed a complex and interconnected system in which elements such as drip tape usage, farming practices, agricultural education, end-of-life processes, and HGT continuously influence one another.

The system maps helped visualize these relationships and highlighted how relatively small interventions can potentially create broader systemic impact. Through the iterative development of the maps, several key opportunities for intervention became visible, particularly regarding maintenance guidelines, optimization of the drip tape system at KAC, and the development of a recycling system for agricultural plastics.

In addition, the research demonstrated the importance of incorporating multiple stakeholder perspectives when analyzing complex systems. By synthesizing insights from farmers, students, staff members, companies, and other actors, a more nuanced understanding of the system emerged. This also emphasized that the project extends beyond the ACHI program alone and should instead be understood within the broader agricultural and waste management system in Ghana.

Finally, the iterative nature of systems thinking proved valuable throughout the project. As new insights emerged, the understanding of the system continuously evolved, allowing assumptions to be challenged and intervention opportunities to become more clearly defined.



9. FRAMING THE CONCEPTUALIZATION PHASE

Conceptual misfits and excluded directions

It is important to critically assess why certain potential opportunities are not viable within this system, particularly regarding the handling of materials at the end of their lifespan. In this chapter, several of these limitations are outlined.

Switching to thicker drip tape material

As mentioned previously, HGT offers different drip tape variations, including 8 mil, 15 mil, and stronger alternatives. One could argue that removing the thinner 8 mil option would encourage farmers to switch to thicker drip tapes, potentially reducing damages and extending the lifespan of the irrigation systems.

However, irrigation systems are currently still financially inaccessible for many farmers in Ghana. The availability of a more affordable 8 mil option therefore remains important, as it lowers the threshold for farmers to adopt irrigation technologies. In addition, with proper maintenance guidelines and support, even thinner drip tape materials can still function effectively within the Ghanaian farming context.

Repurposing

Repurposing, or upcycling, is often positioned higher than recycling within the waste hierarchy, as it typically requires less energy-intensive processing and preserves more of the material's original value. In this sense, repurposing agricultural plastics presents a potentially more sustainable alternative to recycling.

Take a look at the following example: in Senegal, farmers are repurposing drip tapes to create fences around their farms.

However, findings from the research indicate that the primary design opportunity lies in creating economic value from plastic waste for farmers. While repurposing could technically be applied, for example by transforming drip tape into nets, woven baskets, or waste bins, it is likely to be too time-consuming and labour-intensive. As a result, the economic return for farmers would be minimal relative to the effort required.

Therefore, although repurposing may offer environmental advantages, it is less viable as a systemic solution within this context, particularly when considering scalability and economic feasibility.







Farmer in Senegal repurposing the drip tapes



AI generated image: trash can from old drip tapes

Handing in waste for financial return

If farmers were to individually return their agricultural plastic waste to recycling companies in exchange for a small financial compensation, the resulting profits would likely be insufficient to be economically viable as mentioned by the plastic waste initiatives.

A collective approach, where farmers collaborate to supply larger volumes of plastic waste, could increase efficiency and potentially yield higher returns from recycling companies. However, when this revenue is redistributed among participating farmers, the individual financial benefit remains limited.

Therefore, while collective collection improves system efficiency, it does not sufficiently address the need for meaningful economic value for individual farmers.

Biodegradable solutions

Transitioning from conventional plastics to biodegradable materials could effectively address issues such as burning, burying, and littering of agricultural waste. From an environmental perspective, this approach presents a promising solution.

However, biodegradable materials, similar to more durable alternatives, are often associated with higher costs (Huang et al., 2024). As discussed earlier, these increased expenses are not economically feasible for Ghanaian farmers.

Therefore, despite their environmental benefits, biodegradable solutions are currently not a viable option within this context.

Design requirements for the conceptualization phase

1. The final concept(s) shouldn't be fully dependant on external funding

Funding plays a crucial role in the agricultural sector in Ghana, particularly in enabling farmers to initiate their activities. External financial support can be necessary at the start, after which farmers are able to generate their own income and become self-sufficient.

However, within the context of this project, it is important that proposed concepts are not dependent on continuous external funding. Reliance on funding introduces vulnerability: if financial support is withdrawn, the entire system risks collapsing.

Instead, forming partnerships with commercial companies presents a more sustainable alternative. Such partnerships can provide stable financial flows and shared incentives.

2. The concept(s) should be understandable and accessible for the target group

The success of the concept(s) depends on whether farmers are able to understand and engage with them. If the concepts are not clearly understood, their implementation is likely to fail. Contextualization therefore plays a crucial role, and particular emphasis should be placed on ensuring understandability during the testing phase of the concept(s).

This challenge became evident during an interaction with a KAC student, who expressed strong interest in the project and was eager to learn more. After presenting the concept and accompanying visuals, the student indicated that he did not fully understand the project so far, particularly the journey map. This highlights the gap between design intention and user comprehension, reinforcing the need to adapt communication and representation to the local context.

3. The concept(s) should include a strong implementation and sensitization strategy

A possible implementation of the final concept(s) can only take place once a clear and structured implementation plan has been developed. This plan should explicitly outline how the concept will be executed, addressing not only the concept itself but also all surrounding factors involved in bringing it to life.

4. The concept(s) sholud be effectively promoted and communicated

Some farmers have indicated that they have limited contact with the farmer network of Holland Greentech, or are not aware of activities such as farmer field days. Therefore, for the final concept(s), communication and promotion are crucial and must be carefully planned and executed.

5. The concept(s) should align with the willingness and motivation of farmers

The intervention should connect to the practical needs, behaviours and motivations of farmers, particularly regarding financial benefits, usability and time investment. It is noticable that 'willingness of the farmer' is part of the most important elements in system map 1 and system map 2.

6. The concept(s) should provide clear short-term value for farmers

Research showed that short-term financial and practical benefits strongly influence farmer motivation and behavioural change.

7. The concept(s) should build upon existing community structures

The intervention should make use of existing farming networks, lead farmers, and knowledge-sharing systems already present within the Ghanaian agricultural context and thus already present in the system.

8. The concept(s) should remain practical and feasible within the daily lives of farmers

The concept should fit within the current daily realities, routines, and practices of farmers in Ghana.

9. The concept(s) should support circular opportunities for agricultural plastics.

The intervention should contribute to reducing harmful end-of-life practices such as burning, burying, and littering of agricultural plastics.

10. The concept(s) should be adaptable and scalable over time.

The intervention should allow for future expansion, testing and refinement based on pilot implementations and stakeholder feedback.

Establishing design goals for intervention development

In system map 2, three potential design interventions have been identified. These interventions have been translated into three final design goals, which will guide the conceptualization phase of this project.

1. Prevent and reduce damage to irrigation drip tapes at the KAC campus.

2. Enable sustainable and practical alternatives to current disposal of plastic agricultural waste

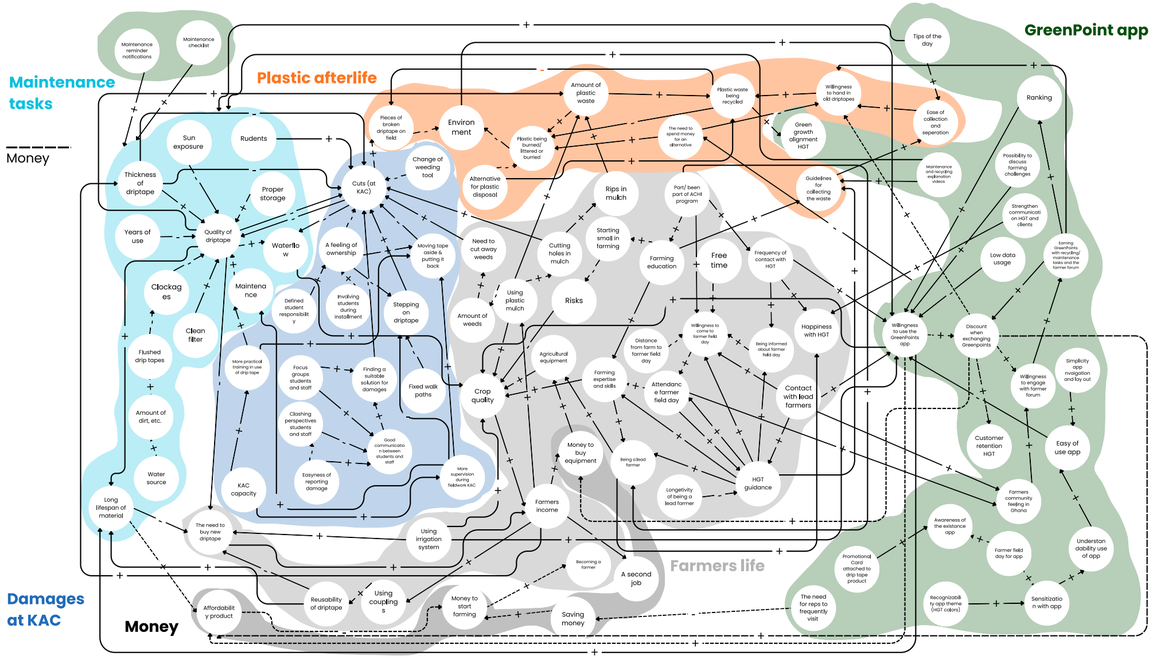
3. Develop clear and accessible guidelines for the proper maintenance of irrigation drip tape.

Conclusion ‘framing the conceptualization phase’

Potential opportunities for conceptualization that are not viable:
-Switching to thicker drip tape material
-Rupurposing
-Handing in waste for financial return
-Biodegradable solutions

General requirements for conceptualization:
1.The final concept(s) should not be fully dependent on external funding.
2.The concept(s) should be understandable and accessible for the target group.
3.The concept(s) should include a strong implementation and sensitization strategy.
4.The concept(s) should be effectively promoted and communicated.
5. The concept(s) should align with the willingness and motivation of farmers.
6. The concept(s) should provide clear short-term value for farmers.
7. The concept(s) should build upon existing community structures.
8. The concept(s) should remain practical and feasible within the daily lives of farmers.
9. The concept(s) should support circular opportunities for agricultural plastics.
10. The concept(s) should be adaptable and scalable over time.

Established design goals for intervention development:
1. Prevent and reduce damage to irrigation drip tapes at the KAC campus
2. Enable sustainable and practical alternatives to current disposal of plastic agricultural waste
3. Develop clear and accessible guidelines for the proper maintenance of irrigation drip tape



System map 3: the proposed future system

MAPPING THE PROPOSED FUTURE SYSTEM

As a guideline for the following chapters of the design goals, the proposed future system map is presented at the beginning. This system map represents a scenario in which the final design interventions of this project have been implemented.

Several new core themes have been identified: maintenance tasks, plastic afterlife, the GreenPoint app, damages at KAC, financial aspects, and farmers' livelihoods.

This chapter provides further explanation and context to support a comprehensive understanding of system map 3.



10 DESIGN GOAL 1: REDUCING DAMAGES AT KAC

Perceived causes of damage: KAC staff perspective

The following points were identified by KAC staff as causes of damage to drip tapes in the KAC agricultural fields.

1. Installation

It is noticeable that fewer damages occur at the ACHI demonstration field compared to the KAC fields. A key difference between the two contexts lies in the installation process of the drip tapes.

At the ACHI demonstration field, students actively participate in learning and carrying out the installation of the drip tapes themselves. In contrast, only a portion of the students at KAC are involved in the installation process, as the KAC team indicated that limited capacity prevents full student participation.

These findings suggest that increased involvement in the installation process may contribute to greater understanding of the system and more careful handling of the drip tapes, potentially reducing damages.

3. Maintenance and supervision

Additionally, maintenance of the irrigation system at KAC is primarily carried out by the field operator and PM. Although they are supported by “attaché” students who supervise the field during fieldwork, continuous oversight cannot be guaranteed.

In particular, when students are working individually, there is no consistent supervision to ensure that the drip tapes are properly moved during activities such as weeding. This lack of constant monitoring may further contribute to the higher occurrence of damages observed at the KAC fields.

2. Issues with the irrigation system

The KAC team also indicated that their current irrigation system is not functioning optimally. At present, they rely on a solar-powered system, which limits irrigation to specific times of the day. In addition, water availability is low, reducing the effectiveness of the system overall. As a result, students do not always perceive the value of the drip tapes.

To address this, the team is in the process of improving the irrigation infrastructure by constructing a new borehole equipped with an electrically powered pump, which will no longer depend on sunlight. The expectation is that, once the system is fully operational and water availability improves, students will better understand the importance of the drip tapes.

Currently, the perceived lack of relevance, particularly during tasks such as weeding, may lead students to handle the tapes with less care. The team anticipates that this behavior will improve once the irrigation system is functioning effectively.

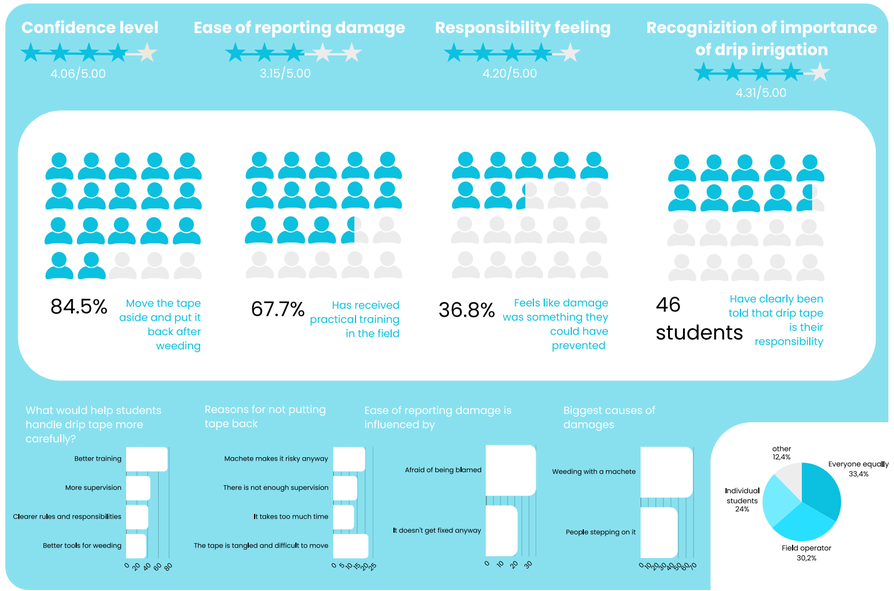
4. Grazing animals

Another cause of damage identified by the KAC staff is the presence of grazing animals. Animals entering the fields can damage both the drip tapes and the plastic mulch. Although management is aware of this issue and measures are in place to prevent it, the system is not fully effective. For example, sheep are still occasionally able to enter the fields, leading to additional damage.

Perceived causes of damage: KAC students perspective

As mentioned earlier, a survey was conducted among approximately 100 KAC students to better understand, from their perspective, the causes of the frequent drip tape damages observed at the KAC agricultural fields. The main insights from this survey are presented on this page.

Students were asked the following question: “If you could change one thing to reduce drip tape damage, what would it be?” After clustering the responses, five main themes emerged.



Survey 2 results

Additional challenges were identified through the analysis of responses to other survey questions. These insights provide further context for understanding the factors contributing to drip tape damage at the KAC fields. The hoe displayed in the survey 2 results could be a possible alternative for the current weeding equipment.

‘If you could change one thing to reduce drip tape damage, what would it be?’

1. **Better training and supervision**
2. **Penalties when assessing& reporting**
3. **changing weeding method & tools**
4. **Stepping on drip tape**
5. **Adjustments to current weeding method**

Conclusion

Initial assumptions didn't turned out to be the issue from the student's perspective: it is not a feeling responsibility issue. Students do report of moving the tape aside and putting it back.

1. Making it easier to report damage
2. Explaining to all students that it is their responsibility
3. Making clear to students who is the main responsible for the driptape
4. Better training in the use of drip tape
5. Involving students in driptape and irrigation installment
6. Education about how quickly drip tapes wear out
7. More supervision when working with drip tape
8. Making certain students responsible for checking damages and carelessness
9. Another weeding tool
10. Fixing walk path, to avoid stepping on lines
11. Making it easier to move the tape
12. Clearer rules in general



How do we translate this into practice?

Opportunities

Survey 2 results

Differences in perspectives

As observed, the current weeding method is a significant cause of drip tape damage, as reported by both the KAC team and the students. However, the perceived solutions to this challenge differ between the two groups. While both acknowledge the issue, students and the KAC team propose different approaches to reducing damage during weeding activities.

The one-pager (appendix D2) was presented to the KAC team with the aim of discussing potential next steps based on the collected data. During this discussion, differing perspectives emerged. The PM indicated that the recommended hoe for weeding, as mentioned in the one-pager, is already in use. However, the PC noted that he had not seen this tool being used before.

In addition, the team is currently developing an assessment system in which students are evaluated based on the level of damage to the drip tape within their assigned field sections.

During the conversation, several key differences in perspectives and practices were highlighted. Overall, the findings suggest that many of the challenges can be traced back to issues in communication between the KAC team and the students.

Gaps between intended practices, student understanding, and actual behavior in the field indicate that expectations and instructions may not always be clearly or consistently conveyed.

KAC staff	KAC students
'They will never report, you only know the damage when you check the drip tape yourself.' The PM believes there are no possibilities for improvement here.	They experience differences reporting damage to the KAC staff. They scored a 3.15/5.00 at 'ease of reporting damage'. Students mention they are afraid of being blamed.
PM says they explicitely tell all the students that they are responsible for the drip tape.	Only 46 out of 97 students reports having clearly been told that the drip tapes are their responsibility.
The team says that the students are already getting good theoretical and practical training.	Students report needing better practical training and supervision.
'The only option to reduce the damages now is to remove the drip tape when weeding and putting them back.'	84.5% of the students report moving the tape aside and putting it back after weeding. The students say that the macbete makes it riskt anyway.
The KAC team thinks lack of responsibility feeling by the students and carelessness towards drip tape are the reasons for the damages.	The students score 4.20/5.00 on responsibility feeling in the survey and 4.31/5.00 on recognition of the importance of drip irrigation.

Opportunities for improvement

Unviable and excluded approaches

- **Plastic mulch**: Although effective for weed control, it is expensive and generates significantly more plastic waste. In addition, it makes it difficult to visually inspect whether the drip emitters are blocked.
- **Additional couplings**: Increasing the number of couplings could reduce damage impact, but this solution is considered too costly.
- **Organic mulch** (e.g., maize remains, grass, palm leaves): According to Sam, organic mulch can attract pests that damage crops at the seedling stage. Additionally, using weeds as mulch can cause skin irritation for students.
- **Alternative weeding tools**: the PM indicated that changing the weeding tool is unlikely to reduce damage to the drip tapes.
- **Chemical weeding**: This method has been tested but was found to be insufficiently effective, as it does not eliminate all weeds. This limitation was one of the reasons for adopting plastic mulch in the first place.

Promising design approaches

Several direct opportunities for improvement can be identified. First, ensuring that all KAC students are trained in the installation of drip tape. This could be tested through a pilot study, in which one group of students receives installation training while another does not, allowing for a comparison in the number of cuts observed.

In addition, the planned improvements to the irrigation system are expected to have a positive impact. With a more reliable and effective system, students may better recognize the value of the drip tapes, which could lead to more careful handling and a reduction in damage.

Looking ahead, it appears that the KAC team is not strongly inclined to actively engage with the data presented in the one-pager. To move forward, an alternative approach could focus on improving dialogue between the KAC team and the students.

Facilitating more direct conversations would allow the KAC team to better understand the needs, challenges, and perspectives of the students. At the same time, it would help students gain greater awareness of the impact that drip tape damage has on the school's resources and operations. This mutual exchange could foster a stronger sense of shared responsibility and lead to more effective solutions.

One practical way to implement this would be through organized focus groups, bringing together students and members of the KAC team to discuss the issue and explore potential improvements collaboratively.



Final recommendations for KAC staff

1. Involving all students in drip tape installation to foster a sense of ownership.

2. Improving communication between the KAC staff and students to create a shared understanding.

3. Introducing alternative weeding tool (e.g. a scuffle hoe) that requires less force and thus reduces the risk of damaging drip tapes.

4. Improving the damage reporting system to enable timely reporting and create an open environment for early detection without negatively affecting crops.

5. Clearly assigning responsibility to the students to ensure they understand their roles and expectations.

6. Enhancing student engagement with drip tapes, for example through instructional or explanatory videos.

7. Increasing supervision during fieldwork to reduce the likelihood of damage.

8. Emphasizing proper movement practices (walking over or around drip tapes) to minimize damage.

9. Improving practical training in line with students' expressed needs.

Conclusion ‘design goal 1’

In conclusion, the research demonstrated that the higher occurrence of drip tape damages at KAC is caused by multiple interconnected factors rather than a single issue. Differences in student involvement during installation, limited supervision, communication gaps, and current weeding practices all appear to contribute to the damages observed in the fields.

In addition, the findings revealed that students and the KAC team often have different perspectives on the causes of the problem and on possible solutions. This highlights the importance of improving communication and collaboration between both groups. The research further showed that infrastructural limitations, such as the current irrigation system and water availability, also influence how students perceive and handle the drip tapes.

Overall, the results suggest that reducing damages requires a broader systemic approach focused on training, communication, supervision, and improved irrigation infrastructure, rather than solely focusing on student behaviour.

The final recommendations to the KAC staff:
1. Involving all students in drip tape installatio to foster a sense of ownership.
2. Improving communication between the KAC staff and students to create a shared understanding.
3. Introducing alternative weeding tool (e.g. a scuffle hoe) that requires less force and thus reduces the risk of damaging drip tapes.
4. Improving the damage reporting system to enable timely reporting and create an open environment for early detection without negatively affecting crops.
5. Clearly assigning responsibility to the students to ensure they understand their roles and expectations.
6. Enhancing student engagement with drip tapes, for example through instructional or explanatory videos.
7. Increasing supervision during fieldwork to reduce the likelihood of damage.
8. Emphasizing proper movement practices (walking over or around drip tapes) to minimize damage.
9. Improving practical training in line with students’ expressed needs.



Seven ACHI alumni traveled to the KAC campus to participate in a focus group on recycling and maintenance.

11. FOCUS GROUP 1 ON RECYCLING AND MAINTENANCE

Focus group 1 setup

Icebreaker
The session starts with a short introduction round in which each participant shares their name, their motivation for becoming a farmer, and their favorite vegetable. The purpose of this activity is to create a relaxed and open atmosphere, allowing participants to feel comfortable and engaged from the beginning.

Round 1: Yes/No Questions (Information Gathering)
In the first round, participants are given two post-it notes: a pink one representing “yes” and a blue one representing “no.” A series of closed-ended questions is asked, and participants respond by holding up the corresponding post-it note.

This method allows for quick and accessible collection of general insights, attitudes, and behaviors within the group.

Round 2: Individual Brainstorming (In-depth Insights)
Participants are then asked a set of open-ended questions and are given a few minutes to individually write down their thoughts and experiences. This ensures that all participants have the opportunity to reflect independently and contribute their perspectives without group influence.

After this exercise, additional context about the project and the topic of recycling is provided to ensure a shared understanding before moving to the next phase.

Round 3: Collaborative Brainstorming (Ideation)
In the final round, participants are divided into smaller groups. Each group is provided with a large sheet of paper on which they can write or sketch their ideas. The focus of this activity is on generating new concepts and exploring potential solutions related to the topic.

The aim of this round is to foster collaboration, stimulate creativity, and gather inspirational ideas from the participants.

The focus group was attended by 7 ACHI alumni and was guided by a slideshow that presented the following questions. The exact results can be found in the appendix.

Round 1
1. Do you use/ would you use irrigation at your farm?
2. Did you experience cuts in the drip tape during your time at ACHI?
3. Are you in contact with HGT?
4. Do you go to farmer field days?
5. Do you talk to other farmers about farming problems?
6. Are you a lead farmer?

Round 2
1. Name what you know and learned about irrigation.
2. Name what plastic materials you use/ would use at the farm.
3. Name what you do/ would do with agricultural plastic waste.

Round 3
1. Plastic collection
2. New products from old plastic
3. Learn about maintenance and recycling

Focus group 1 findings for design goals 2 and 3

Design goal 2: Recycling

The participants of the session were asked: “What would make plastic collection on the farm easy?” Working in groups, they were given a large sheet of paper with the words “plastic collection” written on it.

The first group suggested placing waste bins around the farm. They proposed that plastic materials should first be collected manually from the farm and then disposed of in the bins. They used the Twi phrase “fa rubber to wei mu,” which translates to: “dispose the waste here.”

The second group proposed creating awareness around the farm by placing posters on trees so that they are clearly visible to everyone. They suggested installing waste bins at designated collection points and involving waste collectors to gather and dispose of the plastic waste.

According to this group, the following steps should be followed:
1. First, information should be communicated to farmers.
2.Then, dustbins should be distributed to farmers for waste collection.
3.Waste collectors should periodically collect the waste.
4.Incentives should be provided to motivate farmers to collect more plastic waste.
5.Finally, the waste should be transported regularly to recycling companies.

This demonstrates that effective communication of the concepts to farmers is considered highly important. Participants emphasized the need to clearly inform farmers about how to use and engage with the concept, and highlighted that incentives are necessary to motivate participation. Additionally, they considered logistical aspects such as transportation, indicating an awareness of the broader system required for effective waste management. Their ideas primarily focus on the collection process and propose practical ways to make plastic collection easier and more accessible for farmers.

Design goal 3: Maintenance

Another question posed to the participants was: “How would you prefer to learn about maintenance and recycling?”

The first group suggested involving technical experts to train farmers on how to maintain irrigation systems. They proposed developing guidelines and measures to reduce damage to drip tapes, and emphasized the importance of providing instructions in both manual formats and video-based materials.

The second group proposed a wide range of learning methods. These included learning through Mofa, watching YouTube videos on irrigation maintenance, and engaging with organizations such as Holland Greentech. They also suggested visiting recycling companies, participating in the ACHI program, contacting experts at KAC, visiting irrigation sites, conducting online research, learning from fellow farmers, attending farmer field days, and learning from ACHI colleagues.

This indicates that video-based learning may be a preferred and effective method for knowledge transfer in this context. Additionally, participants frequently referred to existing structures and organizations, such as Holland Greentech, KAC, and the ACHI program. This suggests that building upon existing systems could increase the feasibility and adoption of potential solutions.

In conclusion, the session showed that clear communication, incentives, and accessible collection systems are considered important for successful plastic recycling. In addition, participants preferred practical learning methods such as videos, experts, and farmer field days, while frequently referring to existing structures such as Holland Greentech, KAC, and ACHI as valuable channels for implementation and knowledge sharing.

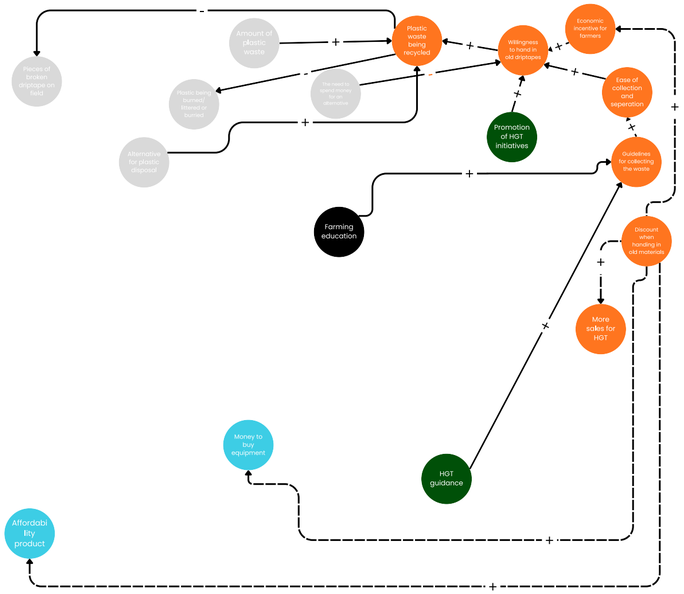


12. DESIGN GOAL 2: IMPLEMENTING A RECYCLING SYSTEM

System map

In this design intervention, nearly all element groups, represented by different colours, are included. This highlights the importance of addressing the system holistically, integrating multiple domains in the concept such as the afterlife of plastics, farming practices, the role of Holland Greentech, and farming education.

Additionally, the system map shows a significant number of dotted lines, which represent financial flows within the system. The prominence of these connections underlines the central role of economic value and monetary exchange in enabling the system to function effectively.

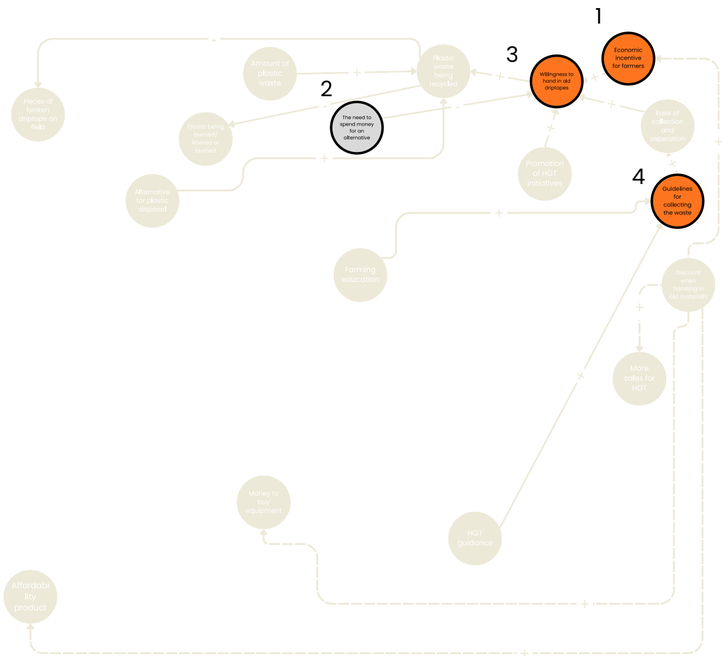


Design intervention 1 in system map 2

Program of requirements design goal 2

In the system map, certain design requirements can be identified:

1. Farmers get economic value in return for recycling, which can be achieved by discount when handing in old materials
2. Farmers shouldn't need to spend money for an alternative way of disposal, otherwise this can affect the willingness to hand in old driptapes
3. Farmers should be willing to hand in old driptapes, this can be envisioned by ease of collection of the material, promotion of HGT initiatives and again the economic incentive and guidelines for collecting the waste.
4. Guidelines for collecting the waste can be envisioned by HGT guidance and farming education.



Recyclingssystem for agricultural plastic waste

Program of requirements in system map 2

1. Farmers get economic value in return for recycling

On the first day in Ghana, a meeting took place with the HGT team. During this meeting, the team discussed their alignment with green growth principles. One idea that emerged for future recycling initiatives was to offer clients a discount when returning used materials.

Relying solely on financial compensation from recycling companies for returned plastic waste is, as mentioned, unlikely to be economically viable. However, a commercial company like Holland Greentech could make such a system work by offering discounts, especially if it aligns with their own business incentives and sustainability goals.

The founder of HGT indicated in previous meetings that there are potential opportunities to explore the implementation of a discount-based incentive system.

KCARP: Operational insights and the feasability of drip tape recycling

Introduction KCARP

Kumasi Compost and Recycling Plant Limited (KCARP) is one of the largest recycling facilities in Ghana. They process 3600 tons of waste a day. The plant processes solid waste through both recycling and composting practices. It produces compost, which is purchased by the government before being sold at subsidized prices to farmers. In addition, KCARP generates raw plastic pellets that can be reintroduced into the production cycle.

The facility has been operational since 2018 and includes an engineered landfill that generates energy to support its manufacturing processes. Waste collection is partly facilitated through informal systems: households can pay tricycle riders a small fee to collect their waste and transport it to KCARP.

Upon arrival at the plant, the waste is weighed and transported to the processing facility, where it is sorted into different material streams. Each type of waste is then handled and processed separately according to its specific requirements.

Plastic waste at KCARP is collected and transported to the facility primarily via tricycles and buses. Upon arrival, the waste enters an initial sorting phase, where various mechanical processes are used to separate the materials according to plastic type.

Following this classification, each category of plastic undergoes a cleaning and size-reduction process. Specifically, the materials are washed to remove contaminants and subsequently shredded into small flakes using specialized machinery.

In the next stage, the plastic flakes are subjected to thermal processing, during which they are melted and extruded into continuous strands of recycled plastic. These strands are then further processed and cut into uniform pellets, which serve as a standardized raw material for subsequent manufacturing applications. After this, it is sold as raw material again.

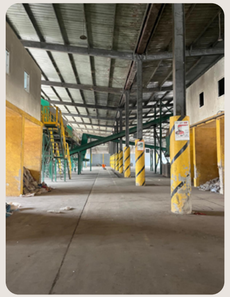
This demonstrates that washing the plastic before handing it in for recycling is not necessary, contrary to earlier assumptions.



1. Tricycles bring the waste in.



2. An overview on the different plastics they can recycle.



3. The waste seperation factory.



4. Seperated plastics.



5. Machine that washes and shreds the plastics.



6. The plastic flakes.



7. Machine that melts and extrudes the plastics



8. The final plastic pellets that are sold again.

Insights KCARP visits

During the two visits to KCARP, the safety manager and quality control manager provided insights into both the operational processes and the broader challenges related to waste management in Ghana. A key issue identified is the limited public awareness regarding the importance of waste separation. According to the safety manager, many Ghanaians do not yet fully understand the value of separating waste streams at the source. As a result, KCARP actively invests in educating its clients on proper waste separation practices. This is relevant for future recycling initiatives, especially if the scope of this project expands beyond drip tapes to include other types of agricultural plastics.

In contrast to some recycling systems, KCARP does not offer financial compensation to clients for returning used materials. Instead, their model relies on long-term partnerships and service-based value. In addition to plastic recycling, KCARP is also involved in the production of compost derived from municipal waste. This compost is purchased by the Ghanaian government and subsequently sold to farmers at subsidized rates, thereby supporting agricultural practices.

A key partner of KCARP is UPPL, a sister company that manufactures end-products from recycled plastic pellets, such as helmets. More broadly, KCARP is part of a network of approximately 76 sister companies, enabling the organization to manage diverse waste streams. Materials that cannot be processed internally, such as medical waste, are transferred to specialized partners within this network.

The facility processes waste under two main categories: “receive, treat, and recycle” or “receive, treat, and dispose.” The chosen pathway depends on the recyclability of the material, which can be affected by factors such as contamination, degradation, or the type of polymer. Non-recyclable materials are disposed of in an engineered landfill. This landfill is equipped with energy recovery systems that generate power for the recycling plant.

In terms of infrastructure, the quality control manager noted that recycling facilities are present in most regions of Ghana. To improve efficiency, transfer stations are being developed as centralized collection points where waste from surrounding areas is aggregated. This reduces transportation costs, as it would otherwise be economically inefficient to transport waste directly over long distances to KCARP.

KCARP aims to ensure that all incoming waste is utilized. The organization collaborates with several partners, including Vena and Polytank. For example, Vena supplies damaged water bottles to KCARP. Initially, these were disposed of, but KCARP proposed a closed-loop recycling system in which the bottles are processed into new products. Through collaboration with a sister company, new bottles can be manufactured from recycled material. This arrangement also offers logistical advantages for Vena, as it reduces the need to transport materials over long distances from Accra to Kumasi.

KCARP maintains laboratory facilities to conduct quality analyses of recycled pellets. Not all clients choose to repurchase recycled pellets.

Finally, the control manager emphasized the importance of perception in the adoption of recycled materials. While recycling is generally seen as positive for a company’s image in Ghana, there remains a strong cultural preference for new products. Recycled materials are often perceived as inferior, despite sometimes offering equal or even superior quality. KCARP is actively working to shift this perception through awareness campaigns and “sensitization” efforts. According to the manager, consumer behavior in Ghana is often driven by a preference for quick and inexpensive solutions, which can lead to choices that prioritize short-term cost over long-term quality and sustainability.

Feasability and challenges of drip tape recycling at KCARP

The drip tapes and plastic mulch were brought to KCARP to assess whether these materials are suitable for recycling and pelletization into new raw material. Below, photos of the resulting pellets can be found. These pellets were produced from recycled drip tapes and consist of recycled raw LDPE material. KCARP indicated that a quality control assessment would be conducted to determine whether the recycled LDPE pellets are of sufficient quality to be sold and reused. If the quality proves adequate, the drip tapes could potentially be integrated into the KCARP recycling process.

However, communication with KCARP proved difficult throughout the project. Although the contact person expressed optimism regarding the quality of the recycled drip tape pellets, repeated attempts to obtain further information through calls and messages did not result in clear answers regarding the recycling potential of plastic mulch or the future steps required to realize a functional recycling collaboration.

The intention was to further discuss possible collaboration structures with HGT or ACHI, particularly regarding practical logistics for transporting agricultural plastic waste from farms to the recycling facility. Questions remained regarding whether transportation would be most effective through frequent small-scale deliveries or through periodic large-batch collection systems. However, no further information regarding these implementation possibilities was provided.



LDPE pellets from old drip tape



The old drip tape and mulch brought to KCARP

2. Farmers shouldn't need to spend money for an alternative way of disposal

Organizing the transport of plastic waste to the recycling company

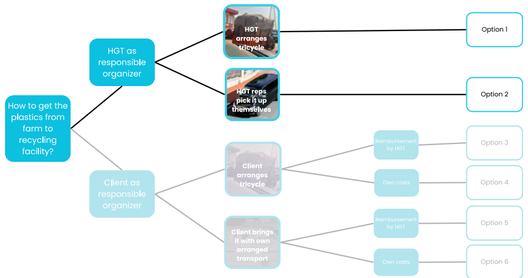
A key challenge lies in organizing the transportation of used materials from farms to the recycling facility. As mentioned in the personas, some farmers are reluctant to return used materials when this involves additional costs, such as transportation and fuel. As shown on the page next to this one, HGT clients are spread across Ghana and are often located far from a recycling company like KCARP.

An effective approach may involve HGT taking on a coordinating role in the collection process. By aggregating used drip tapes, and potentially other agricultural plastics, over time, the company could deliver larger, consolidated volumes to KCARP, which can then be pelletized in one go.

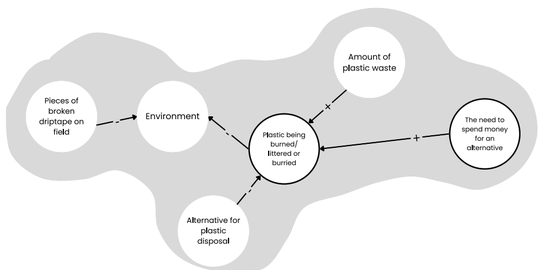
To further optimize this system, it would be beneficial to organize collection and aggregation at a regional level through HGT reps, while making use of KCARP's existing transfer stations. These centralized collection points can function as intermediaries between the regional reps and the recycling facility, thereby lowering the burden on the reps and improving the overall feasibility of the recycling system.

Within the framework shown next to this section, six basic options are presented. However, the option of 'client as responsible organizer' can be excluded. This is because, as shown in the system map, the higher the 'need to spend money for an alternative', the more likely it is that 'plastic is burned, littered, or buried' instead of recycled.

Two options then remain: HGT representatives collect the waste themselves, or HGT arranges collection through tricycles. Both options require financial investment. However, HGT already needs to allocate resources to realize the discount-based incentive system.



Plastic waste logistics framework

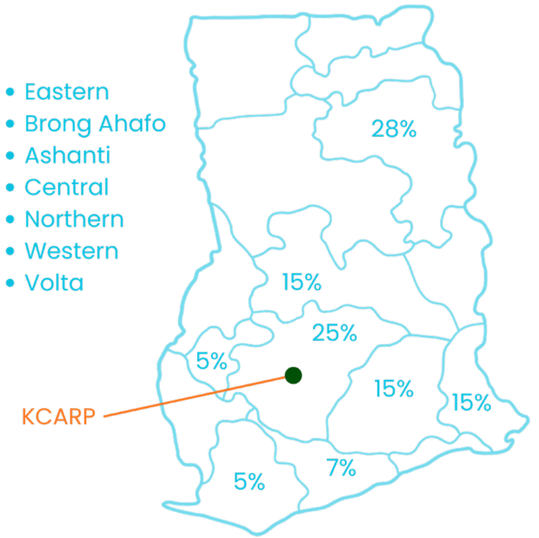


Plastic afterlife in the system map

3. Farmers should be willing to hand in old drip tapes

<u>Important implementation steps</u>
1.Promotion of recycling system
2.Education on recycling system
3.Collection and storage of plastic waste at farm
4.Pick up plastic waste from the farm to recycling point

A well-designed implementation plan will increase farmers' willingness to adopt a recycling system. Additionally, offering discounts as an economic incentive will further strengthen farmers' motivation to participate.



Regional distribution of HGT clients in comparison to KCARP

Conclusion ‘design goal 2’

In conclusion, the system map demonstrated that financial value plays a central role within the agricultural plastic system in Ghana. This resulted in four key design requirements: farmers should receive economic value in return for recycling, farmers should not need to spend additional money on disposal alternatives, the collection system should remain easy and accessible, and clear guidance regarding waste collection should be provided through structures such as Holland Greentech and farming education initiatives. The fourth requirement, together with transportation and collection possibilities, will be discussed further in a later chapter.

The research also showed that recycling drip tapes is technically feasible within the Ghanaian context. Kumasi Compost and Recycling Plant Limited already possesses the infrastructure and systems necessary for recycling processes, while the successful pelletization of drip tapes demonstrated their recycling potential. However, transportation logistics, stakeholder coordination, and financial feasibility remain important challenges.

Overall, the findings suggest that successful recycling systems for agricultural plastics in Ghana require a combination of economic incentives, accessible collection systems, stakeholder collaboration, and practical education.

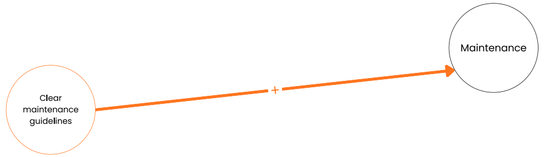


13. DESIGN GOAL 3: DEVELOPING MAINTENANCE GUIDELINES

How Tos for design goal 3

System map 2 highlighted the absence of clear maintenance guidelines.

Most important How tos
1. How to communicate the guidelines?
2. How to establish the appropriate guidelines?
3. How to structure the format of the guidelines?



Design intervention 2 in system map 2



Maintenance guideline: flushing the drip tape

1. How to communicate the maintenance guidelines to farmers?

An overview of potential communication channels for reaching farmers is presented alongside this section. Ultimately, HGT was selected as the primary communication channel. This is because HGT already maintains direct contact with farmers who purchase irrigation systems, as they are part of its existing client network.

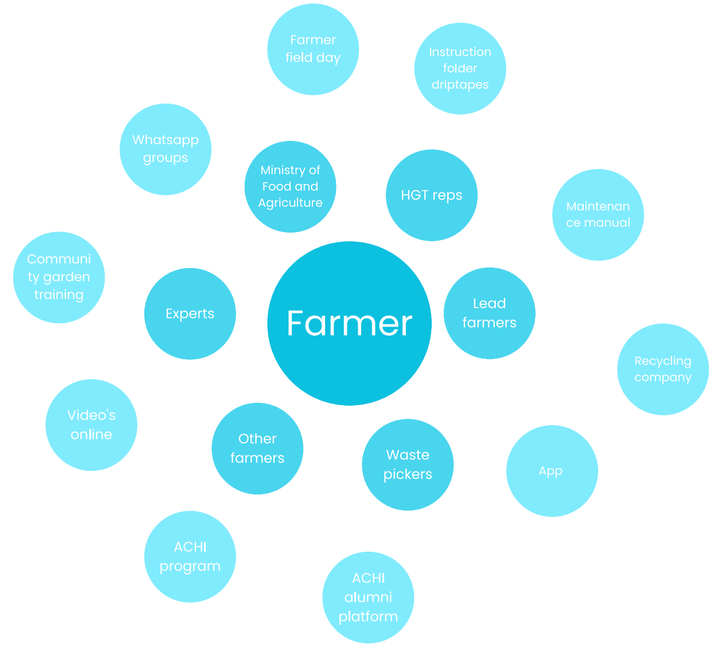
Currently, maintenance guidelines are primarily communicated through in-person training sessions and at the point of sale. However, there is no standardized or accessible format (e.g., written or visual materials) that farmers can refer to afterward. To support system performance, HGT conducts a follow-up check with farmers approximately one month after installation to assess whether the drip irrigation system is functioning properly.

During training sessions, HGT provides farmers with guidance on the proper storage of drip irrigation tapes. However, the company currently does not offer clear instructions on how to handle the tapes once they have reached the end of their usable life.

HGT communicates that the drip tapes are designed by manufacturers to be resistant to UV radiation. Nevertheless, farmers report that prolonged exposure to UV remains a significant cause of material degradation and breakage. This highlights the importance of appropriate storage practices, particularly when the systems are not in use.

'The sun is not good, one of the problems is the sun, most reason for damages.' (appendix B2)

In addition to storage, regular maintenance is emphasized, particularly flushing the system to remove sediment buildup. The required frequency of flushing depends on the quality of the water source. For example, when river water is used, the presence of algae can lead to clogging within the system. As a general guideline, HGT recommends flushing the system approximately once per week.



Farmer outreach channels

2. How to establish the appropriate maintenance guidelines?

Rivulis already provides extensive maintenance guidelines on its website, and HGT has shared a Rivulis irrigation booklet containing detailed information on maintenance practices. This information can be used to establish clear and structured maintenance guidelines. Examples of maintenance tasks include turning the drip tapes so that the emitters face the ground, straightening the tapes to ensure proper water flow, removing dirt from the tapes and emitters, temporarily moving the tapes aside during weeding and repositioning them afterward, cleaning filters, flushing lines with water, and storing the system indoors when not in use.

However, there are many variables that influence the maintenance of drip tape systems. The first variable is the type of drip tape being used. The second is the quality and source of the water. For example, in environments with hard water containing high mineral content, an acid-based flushing program may be required. In contrast, in environments with high levels of organic material, treatments such as chlorine or hydrogen peroxide may be more appropriate. Therefore, maintenance practices should not be generic, but instead tailored to the specific conditions of each farm. A customized maintenance program should be developed accordingly (Clift, n.d.).



3. How to structure the format of the maintenance guidelines?

The maintenance guidelines should function as a reminder for farmers to carry out maintenance according to the recommended frequency. However, these reminders should not become repetitive or overly familiar, as this may reduce their effectiveness over time. In addition, farmers should be provided with more detailed explanations of the maintenance guidelines, including practical and valuable tips.

This raises the question: what constitutes an effective reminder? Furthermore, are reminder systems commonly used in Western contexts also applicable in Ghana? In a Western context, reminders may take the form of birthday calendars, keychains, post-it notes, or digital notifications. For example, birthday calendars are quite popular in the Netherlands and are often placed in locations such as toilets, where people are regularly confronted with them. However, it is unclear whether similar practices exist in Ghana, or whether such placement would be relevant, for instance, whether farmers would even have access to a toilet on their farm.

During a focus group (appendix B2), farmers were asked how they currently keep track of their farming activities. Most indicated that they use notebooks to record information. Additionally, HGT already provides a structured format for tracking what is planted and when. They also recommend keeping records of financial investments made in the farm. This could potentially be integrated as an additional feature in the concept.

Following a brainstorming session, several concept formats were developed. These concepts combine basic maintenance guidelines, explanations of these guidelines, reminder systems, and tools for farmers to track their farming activities.

1. Maintenance calender

A maintenance calendar in which each month focuses on a specific maintenance task. Every month includes several practical maintenance tips. Farmers can use the calendar to note when they planted, performed maintenance, and other relevant activities. At the end of the calendar, each month and its corresponding maintenance task are explained in more detail.

2. Maintenance checklist

This checklist serves as a baseline (zero measurement) to evaluate how farmers respond to the most basic and accessible format of maintenance guidance. It provides a simple overview of essential maintenance tasks.

3. Farmer field day on irrigation maintenance

This concept is presented as an Instagram promotion for a farmer field day focused specifically on drip tape maintenance. The idea is to organize a dedicated event where farmers can learn, observe, and practice proper maintenance techniques in a hands-on setting.

4. WhatsApp reminder + HGT sustainability app

This concept combines a mobile app with WhatsApp communication. Within the app, farmers can earn points by performing maintenance and recycling activities. These points can be exchanged for discounts on agricultural products. The app displays the total points, available rewards, and a history of saved points.

Additionally, HGT sends WhatsApp reminders prompting farmers to carry out maintenance tasks. Farmers submit proof of completed tasks via a group chat, after which points are assigned by HGT. The next step is to test these concepts with the target group.

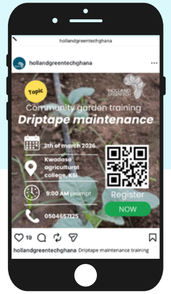


1. Maintenance calender

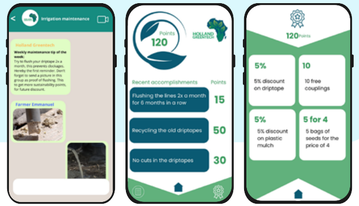


Week	Flushing	Check on damages	Flushing filters	Check on emmitter blockages	Check pressure	Chemical treatment
1	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	Not necessary
3	✓			✓	✓	
4						
5						
6						
7						
8						
9						
10						
11						Not necessary
12						
13						
14						

2. Maintenance checklist



3. Farmer field day about driptape maintenance



4. Whatsapp reminders + Holland Greentech sustainability app

First concepts for design goal 3

Conclusion ‘design goal 3’

In conclusion, the research demonstrated that clear and accessible maintenance guidelines are currently missing within the drip irrigation system. Although Holland Greentech already provides verbal guidance during trainings and installations, there is no standardized format that farmers can continuously refer back to. The findings showed that maintenance practices are highly dependent on contextual factors such as water quality, farming conditions, and the type of drip tape used, indicating that maintenance guidance should be adaptable rather than generic.

The research also highlighted the importance of selecting communication methods that fit the Ghanaian farming context. Existing structures such as Holland Greentech trainings, WhatsApp communication, notebooks, and farmer field days appear valuable for sharing maintenance information and reminders. In response to these findings, several concept directions were developed, including a maintenance calendar, checklist, farmer field days focused on irrigation maintenance, WhatsApp reminders, and the HGT sustainability app.



Eight ACHI alumni and farmers traveled to the KAC campus to participate in a focus group. The goal of the session was to test the first round of concepts and validate previously gathered data.

14. FOCUS GROUP 2 ON TESTING CONCEPTS AND VALIDATING DATA

Focus group 2 setup

The first round consisted of three open-ended questions, which participants answered individually using post-it notes. This allowed participants to reflect independently and ensured that all voices were captured. After completing this task, the responses were collectively discussed to identify common themes and differences.

The second round was conducted in groups. Participants were presented with the prototypes one by one and were asked to answer a set of guiding questions provided in a PowerPoint presentation. This phase focused on gathering structured feedback and initial reactions to the proposed concepts.

The third round shifted to a plenary discussion format. One of the ACHI students read the scenarios aloud, after which the group collectively discussed the corresponding questions from the PowerPoint. Although the initial plan was to continue working in smaller groups and document responses in writing, this approach was adapted during the session.

Open discussion proved to be more effective, as it generated richer insights and encouraged participants to build on each other's ideas. Additionally, it helped maintain engagement, as participants appeared to lose interest during prolonged periods of writing. The interactive format stimulated more dynamic exchanges and supported deeper exploration of ideas. The exact results of this focus group can be found in the appendix.

The focus group was supported by a PowerPoint presentation and printed versions of the concepts.

Round 1
1. What does a day at the farm look like?
2. How do you keep track when you plant seeds, harvest, how much you harvest, etc?
3. Do you think clear maintenance guidelines for the irrigation system would be of value to you?

Round 2 (for every concept)
1. What do you think this is?
2. What would you use this for? What would this tell you to do?
3. Is there anything unclear or confusing? What can be misunderstood?
4. Where would you place this? (Prototype 1 and 2)
5. Other comments?

Round 3 (for every concept)
Can you see yourselve as the farmer in this story?
What goes right and what goes wrong in this scenario?
Would you make use of this?
What would you change in the story or prototype?
(Do people have calenders like these?)
(What do you like about this calender?)
(Do you regularely see the instagram of Holland Greentech?)
(What do you like about this farmer field day?)
(Do you like using apps?)
(What do you like about this point system?)

Focus group 2 findings

The concepts linked to the maintenance guidelines design intervention, were tested with ACHI alumni and farmers. The following insights were gathered.

1. Maintenance calender

Participants appreciated the calendar as a reminder tool. However, they indicated that most farms lack a suitable place to display it, as many do not have a farmhouse. This limits its practicality.

Instead, participants suggested using mobile phones for reminders, such as alarms or recorded messages (e.g. 'today you need to do this'), aligning the calendar with phone-based notifications.

2. Maintenance checklist

Participants indicated they would use the the checklist, but considered mobile phones more effective. They preferred the checklist over the calendar, as it clearly outlines required activities and provides more information. They suggested using the calendar as a reminder to consult the checklist.

3. Farmer field day on irrigation maintenance

Trainings are primarily targeted at farmers already using drip tape, but are also open to those interested in irrigation so you can still go, somebody noticed. He also stated:

'most people don't go for dripapte at all because the maintenance is not clear. If you have interest in starting with irrigation, farmers would go to the maintenance farmer field day.'

Existing communication channels, such as the ACHI WhatsApp community, can support outreach. Promotion through platforms like TikTok and Facebook is recommended, as these are more widely used in Ghana than Instagram.

4. WhatsApp reminder + HGT sustainability app

Participants responded very positively to the reward system. Mobile provider MTN, which is widely used in Ghana, already applies a similar point-based approach. Participants highlighted that farmers are highly motivated by competition and rewards, and are willing to engage actively. Somebody said:

'Even if people don't know how to take the picture, they will make sure their children come and take the picture.'

This system can help farmers stay consistent and on track, making it highly beneficial.

Other interesting insights from the session

'It is very difficult to do flushing when the fertilizer is already mixed.'

'Using one tank for water application and fertigation can easily cause line breakage'

'Advertisement through radio and television for farmers who cannot read to get a clear meaning of the programme.'

'Prototype can be posted on the walls in the market places and public areas, and social media platforms.'

'I suggest that the advertisement can be done through video and audio presentation.'

'There is not enough information on how to check blockages and repairs.'

'Driptape maintenance online training program'

In conclusion, the testing sessions demonstrated that farmers were most enthusiastic about the app-based concept. It was noticeable that even when discussing non-digital concepts, participants frequently tried to integrate mobile phones into the solutions. Farmers particularly valued reminders, maintenance information, and reward systems, while the addition of competition elements such as a scoreboard increased motivation to participate.

The findings also showed that video- and audio-based communication methods are preferred for explaining maintenance practices, especially because these formats are accessible for farmers who cannot read. Existing communication channels and social media platforms already commonly used in Ghana, such as WhatsApp, TikTok, Facebook, radio, and television, were identified as valuable channels for promotion and knowledge sharing.

Overall, the results highlighted the importance of combining maintenance guidance, reminders, practical information, and motivational reward systems within an accessible and mobile-based concept.





After the testing session, it became clear that the app concept was the most preferred by participants.

15. THE FINAL CONCEPT: APP DEVELOPMENT

Concept guidelines

Integrating the recycling design goal into the concept

During testing, the app primarily focused on maintenance guidelines; however, it has the potential to integrate both maintenance and recycling tasks, thereby combining the two design interventions into a single concept. The app is designed to reward users with points for completing maintenance and recycling activities, which can then be exchanged for discounts on agricultural products.

App users

The primary target group of the app consists of farmers using irrigation materials provided by HGT. Over time, the scope of the app can be expanded to include farmers using other agricultural equipment from Holland Greentech, as well as a broader group of farmers using irrigation materials from different suppliers, increasing its overall impact and scalability.

Photo control

To ensure the reliability of photo-based proof for maintenance and recycling activities, several control mechanisms can be implemented:

- Clear photo guidelines to instruct farmers on how to capture valid proof
- Date and time stamps to verify when the activity was performed
- Photo verification within the app to standardize submissions
- Random checks by field representatives to validate authenticity
- Exclusion from the reward system in cases of misconduct

Farmers are required to upload photographic evidence of completed maintenance or recycling tasks. However, ensuring the authenticity of these submissions remains a challenge. One potential solution is the integration of automated verification methods, such as AI-based image recognition, to detect inconsistencies or repeated images. This could be combined with human oversight to create a more robust and trustworthy system.




ITERATION 1

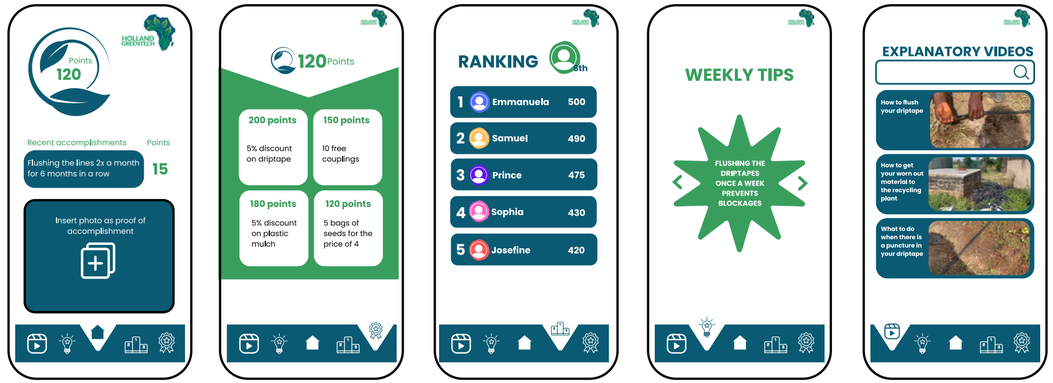
Iteration 1: hybrid or a full app?

Following the testing phase, the initial concept was developed into two potential directions, as can be seen on the next pages:

A full app

Based on insights from the testing session, several features were added to the app design, including a ranking system, weekly maintenance tips, explanatory videos, and the option to upload photo proof directly within the app.

The Holland Greentech sustainability app



Upload proof
Score overview

Rewards

Scoreboard

Tips & reminders

Explanatory videos

A hybrid version

The hybrid version integrates multiple platforms that are already widely used by Ghanaian farmers. YouTube is used for explanatory videos, while WhatsApp is used for weekly tips and reminders through a chatbot. Additionally, WhatsApp Status is used to share updates on discounts and rankings, and a physical drip tape maintenance training is organized in a community garden setting.

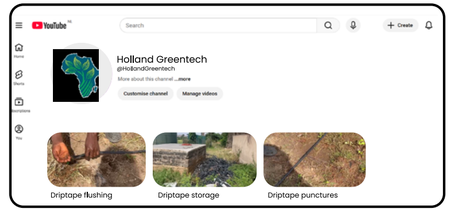
In this version, photo proof of completed tasks is submitted via WhatsApp to a Holland Greentech chatbot, which records and tracks the points earned by each user.

Hybrid version

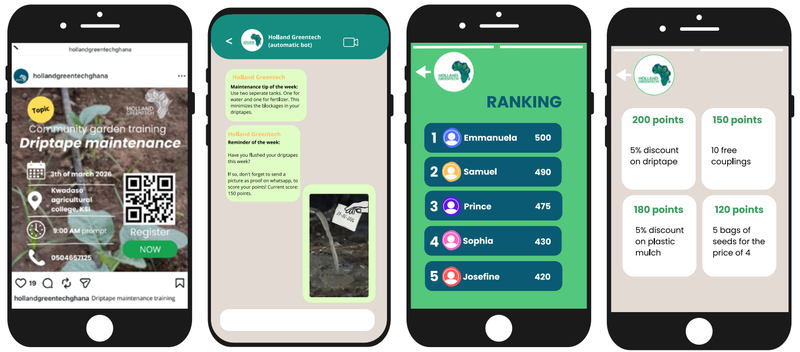
Farmer field day about maintenance or recycling

Private whatsapp HGT bot which sends reminders/ tips and keeps score of points

Everyday the **ranking** of farmers on HGT **whatsapp story**



HGT youtubechannel that posts videos of maintenance and recycling



Rewardsystem posted everyday on HGT **whatsapp story**

Discussing the app direction with HGT

A meeting was held with the founder of HGT to discuss the early concept and explore its potential within the company. During this meeting, the two versions of the concept were presented: a hybrid version and a full app. The advantages and disadvantages of both concepts were presented to support the founder in evaluating their feasibility and potential implementation. The founder was the most enthusiastic about the app and sees possibilities in that. Below some more topics that were discussed.

Important discussion points

- Clear visual communication is needed to show farmers at what point they receive discounts, in order to effectively promote the system.
- Discounts should be visualized in a relatable way, for example by showing the amount of discount per acre of drip irrigation.
- It is important to investigate the costs for farmers to bring the materials to KCARP themselves.
- HGT is currently working with Odoo (which includes CRM functionalities) to improve communication and knowledge transfer with farmers.
- Knowledge transfer is currently mainly facilitated through farmer field days, which reached approximately 5,000–6,000 farmers in the past year.
- Within HGT, communication with farmers is already a key focus area; this project contributes by providing deeper insights, specifically in relation to recycling practices.
- The project focuses on a specific market segment: farmers using drip irrigation systems. Budget constraints at HGT, particularly related to transportation costs, remain a significant challenge in furthering this project.
- It is important to clearly visualize goals and impact. For example, if currently 30% of customers return to Holland Greentech, this intervention could aim to increase that to 40%.
- Farmers should be able to easily compare the value of different options, such as drip tape lasting three years versus five years. Maintenance benefits should be communicated in relatable terms, for example by equating savings to approximately one month of income.
- The project aligns with broader green growth objectives, such as resource efficiency and material savings, which can be used to position the concept towards potential donors.

Pros and cons concepts

HGT sustainability app

+

- Automatic
- All in 1 application

−

- Developing an app can be expensive
- Farmers are not used to this system

Hybrid version

+

- Farmers already use whatsapp a lot
- Applications are cheap

−

- Labor intensive, if there is no chatbot
- Different applications can be confusing, in need of clear instructions

Following a conversation with the founder of HGT, it became evident that he favored the development of a full app-based solution. The discussion highlighted the importance of clearly communicating discounts and economic benefits through visual means in order to encourage adoption and engagement. Furthermore, the app was seen as a potential extension of HGTs broader objective of strengthening communication with its clients.



Iteration 2: a full app with contextualization taken into account

Program of requirements iteration 2

Designing an app for the Ghanaian context requires careful consideration of local conditions across multiple dimensions. Without this, there is a significant risk that the app will not be accepted or effectively used by the target group.

1. The application should be designed for Samsung devices.
2. The interface should maintain a simple and intuitive app design.
3. The application should remain clearly readable in outdoor environments.
4. Touch interactions should accommodate real-world usage conditions.
5. The application should function effectively under limited connectivity conditions.
6. The application should operate in a battery-efficient manner.
7. The application should include multilingual and language accessibility considerations.

1. The most commonly used smartphones in Ghana are Samsung devices (Intelpoint, 2025).

2. Interfaces should prioritize simplicity to ensure accessibility for the target group,
-Large buttons
-Simple user flows
-Minimal text
-Clear and recognizable icons
-Limited and intuitive navigation structures

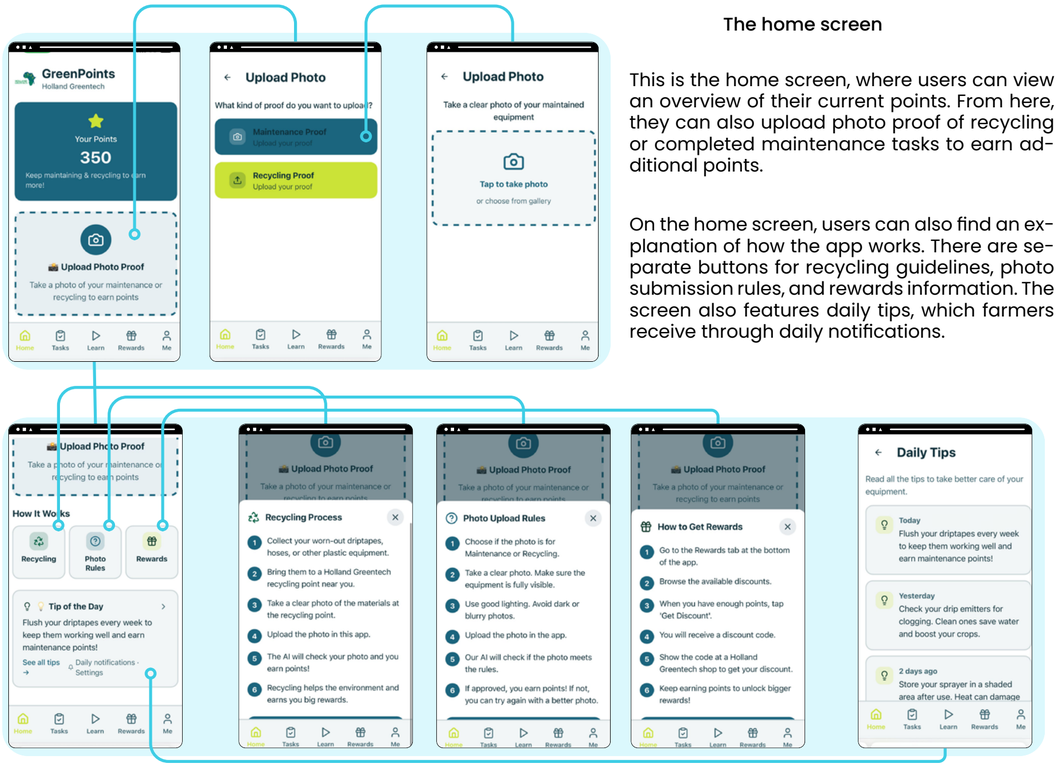
3. Outdoor readability is essential, as the app is likely to be used in field conditions
-High contrast between text and background
-Avoidance of light grey text
-Larger font sizes (approximately 16–18 px)
-Clearly visible interface elements

4. Touch interaction should account for real-world use
-Large touch targets (approximately 48–56 px in height)
-Sufficient spacing between buttons
-Design suitable for use with dirty or wet hands

5. Connectivity constraints must be considered
-Offline-first functionality where possible
-Clear feedback on loading and connection status
-Minimal data usage (e.g. limiting heavy media such as videos)

6. Battery efficiency is important
-Avoid continuous GPS usage
-Limit heavy animations and background processes

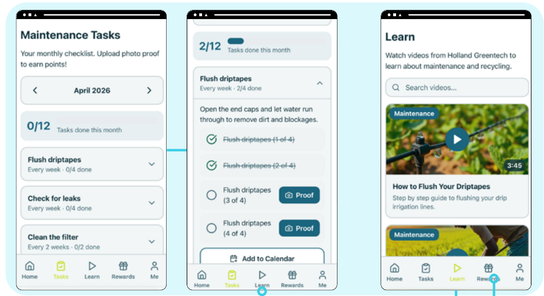
7. Language considerations
English is the most suitable default language, as local languages vary significantly.



The home screen

This is the home screen, where users can view an overview of their current points. From here, they can also upload photo proof of recycling or completed maintenance tasks to earn additional points.

On the home screen, users can also find an explanation of how the app works. There are separate buttons for recycling guidelines, photo submission rules, and rewards information. The screen also features daily tips, which farmers receive through daily notifications.



The task and learn screens

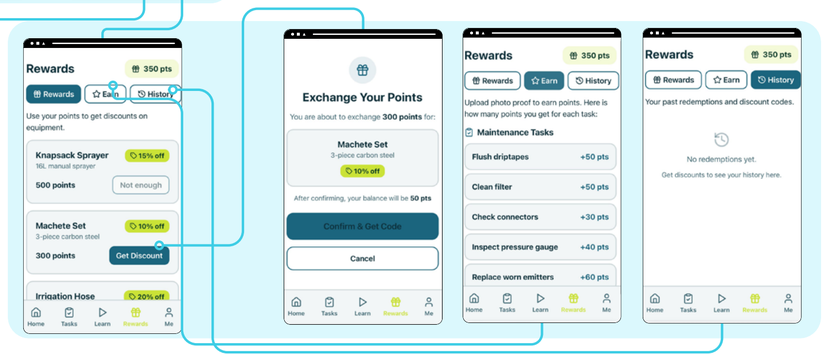
On the tasks screen, users can view a monthly overview of the maintenance tasks they need to complete. They can check off tasks as they go and upload photo proof directly to earn GreenPoints.

The learn screen offers videos that demonstrate how to carry out specific maintenance and recycling tasks.

The rewards screen

On the rewards screen, users can view an overview of the available discounts and see whether they have enough points to redeem them. When exchanging points, they receive a code that can be shared with HGT when ordering new products. The redeemed points are then deducted from their total balance.

The screen also shows how many points can be earned for each task and provides a history of previously generated discount codes.

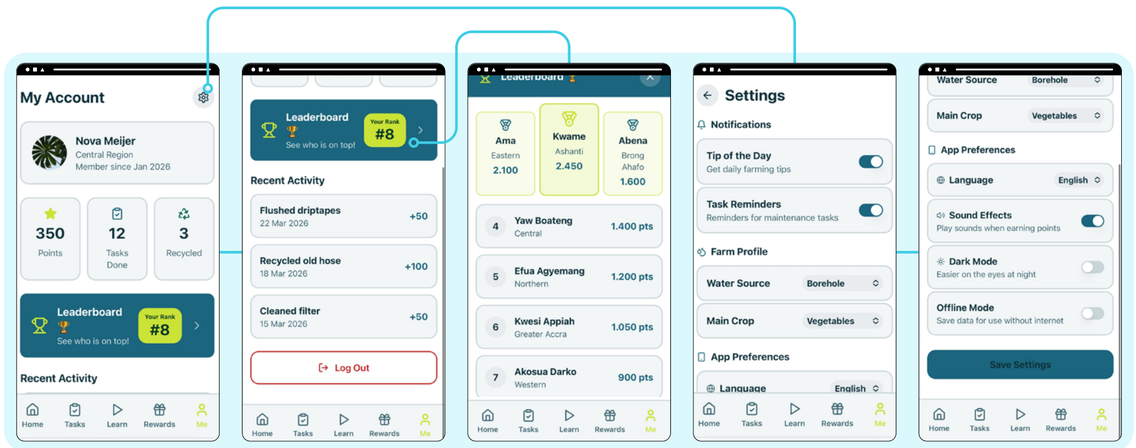


The me screen

The “Me” screen displays the user’s account information. It provides an overview of their current points, total tasks completed, and the number of times they have recycled. It also includes a button that takes users to the leaderboard.

The leaderboard shows the total number of points collected, without deductions from redeemed rewards.

Additionally, the “Me” screen highlights recent activities and serves as a gateway to the settings. In the settings, users can manage notification preferences, view their farmer profile, and adjust app settings.



Testing setup for iteration 2

The usability testing was conducted through online sessions. Participants were provided with a link to the application and asked to share their screen, allowing the researcher to observe how they navigated and interacted with the app while completing assigned tasks. During the sessions, observations were documented, including user behavior, encountered issues, successful interactions, and verbal feedback expressed by participants.

Objective of the test
To understand how users interact with the application
To gain insight into navigation, usability, and user comprehension
To evaluate the relevance and usefulness of the app
To actively gather ideas and suggestions from users
Introduction to Participants

You open the app for the first time.
What do you think you can do in this app?
What catches your eye?
If you could change something on this screen, what would it be?

Can you find how this app works or where you would get an explanation about the concept of this app?
Is this clear to you? What would you improve here?

You have completed a recycle or maintenance task.
Can you show how you would upload a photo as proof?
Was this easy or confusing?
How would you improve this?

Can you find a task and mark it as completed?
Does this feel clear to you?
What would make this easier?

Can you connect a task to your calendar?
Would you use this feature?
If not, what would make it useful?

You want to learn something specific.
Can you find a video about a topic?
Is this useful for you?
What kind of content would you like to see here?

Can you show how you would use your points to get a discount?
Is this clear to you?
What would make this more attractive?

Can you check how you earned your points?
Is this useful for you?
Would this motivate you?
What kind of rewards would you actually like?

Can you find your profile and open the leaderboard?
Do you care about this leaderboard?
Would you change or remove this feature?
What would you add instead?

Can you open the settings of this app?
Does everything here make sense?
Is something missing?

Would you use this in your daily life?
Does this feel useful for you?
Would you use this with your internet/data?
What would stop you from using this app?
If you could change one thing in this app, what would it be?
What do you think is the concept of this app? What is the idea behind it?
If you could add one feature, what would it be?
What is missing in this app for you?
Is there anything that feels unnecessary or confusing?

Test results of iteration 2

Iteration 2 was tested with two participants: the PC and a lead farmer. The testing provided several valuable insights that will support the further development of the app.

Lead farmer

At first glance, the lead farmer perceived the main benefit of the app to be increased crop yield through proper maintenance of materials. He did not mention the points system or the associated discounts, indicating that this value proposition should be made clearer upon opening the app.

Additionally, the navigation and overall understanding of the rewards section were confusing for the farmer and require improvement.

The rest of the app's navigation was well understood, with minimal difficulties. He found the current features to be very useful and suggested adding a function where farmers can discuss challenges they encounter on the farm.

'The rewards mean maximizing your potential of agricultural grounds when you recycle and maintain the ground will get more fertile, you get rewards of high yields. Secure plants from those damages is the reward.'

'It will help with the right maintenance of the farm. Usually we do manual way, we put it in notebook, app makes it easier, right on the farm you are good to go.'

'Yes, this videos are very usefull. Mostly visuals , things to do with visuals is most easy, once you view it it stays more in your mind. You can easily follow and practice same thing.'

'I hope that HGT will accept the app so it can be fully developed.'

PC

The PC was already familiar with the concept behind the app, but he made a conscious effort to evaluate it from the perspective of an average Ghanaian farmer.

He emphasized the need for greater clarity in explaining how the app works and what its purpose is. In particular, he found the "How it works" section on the home screen unclear. He also pointed out that maintenance guidelines can vary significantly depending on the type of farm, suggesting that personalization of maintenance tasks could be a valuable addition. Additionally, he noted that training for farmers on how to use the app will likely be necessary.

Overall, he understood the navigation well and highlighted that the various features of the app are highly valuable for farmers.

During the testing phase, it became clear that the app requires more clarity regarding both its purpose and how it should be used. In particular, the rewards section could benefit from further improvement and clearer communication. Test participants also suggested adding a feature that allows farmers to discuss challenges they encounter on their farms. Additionally, high data usage was identified as a potential barrier to app adoption, indicating that low-data functionality and sensitization around the app will be necessary for successful implementation.

'Yes i will use my data for it but with minimal data. it will also be great if there is an offline feature in the app.'

'Maybe if the data usage is high and if I find its use complex as well.' (about when he would stop using the app)

'I am putting myself in the shoes of my local farmers and they would need some bit of training or more graphics with the features'

'It could be nice to have a voice over on the app and secondly and alert system to prompt me to repair or take an action.'



Iteration 3: Changes based on the results of iteration 2 testing

1. User interface and visual design

- The overall layout was refined, including the introduction of visual depth through the use of shadows.
- The interface was made less text-heavy to improve readability and accessibility.
- Visual elements, such as images in the rewards section, were added to provide clearer representations of benefits.
- Key information on the home screen was restructured to offer a more immediate and intuitive overview of the application's purpose and functionality.
- The "how-to" section was made more prominent and clearer on the home screen.

2. Clarity and information

- Greater clarity was introduced in task descriptions and structure.
- The process of adding tasks to the calendar was separated and simplified to reduce confusion.
- Users can now directly access explanatory videos from tasks, improving guidance and usability.
- The number of points that can be earned per task is now clearly visible.
- An overview of how to complete tasks is immediately available on the home screen.
- The redeeming process was clarified, including adjustments in terminology to improve understanding.
- Photo submission guidelines were introduced to ensure consistency and clarity in user input.

3. Personalization and user engagement

- Personalization features were introduced, including the integration of a welcome message ("Akwaaba") and the user's name on the home screen to reinforce ownership and engagement.
- A community feature was added to stimulate interaction among users.
- Users can now earn points by supporting other farmers, preventing uniform point accumulation and encouraging collaboration.
- The leaderboard was improved by displaying total points transparently, without reductions due to redeemed rewards.
- An annual incentive was introduced, where the highest-scoring farmer receives an additional HGT prize.

4. Rewards and incentive system

- The rewards system was redesigned to improve clarity and motivation. "Saved cedis" was introduced as a more relatable metric compared to percentage-based discounts.
- The visibility and explanation of rewards were enhanced through visual support.
- The redeeming process was made clearer and more intuitive.

5. Trust and program integrity

The system was defined as primarily trust-based, with occasional checks to ensure compliance and reduce misconduct.

6. Content and feature adjustments

- Daily tips were repositioned to a more prominent location within the interface.
- Additional benefits were explicitly highlighted to strengthen the value proposition.

Community engagement

An important addition in this iteration is the introduction of an extra way for farmers to collect points. A new feature called Farmer Support was added to the app. Through this feature, farmers can share farming challenges they are experiencing, allowing other farmers to respond, provide advice, and earn points for their support. This idea originated from the lead farmer who participated in the test session.

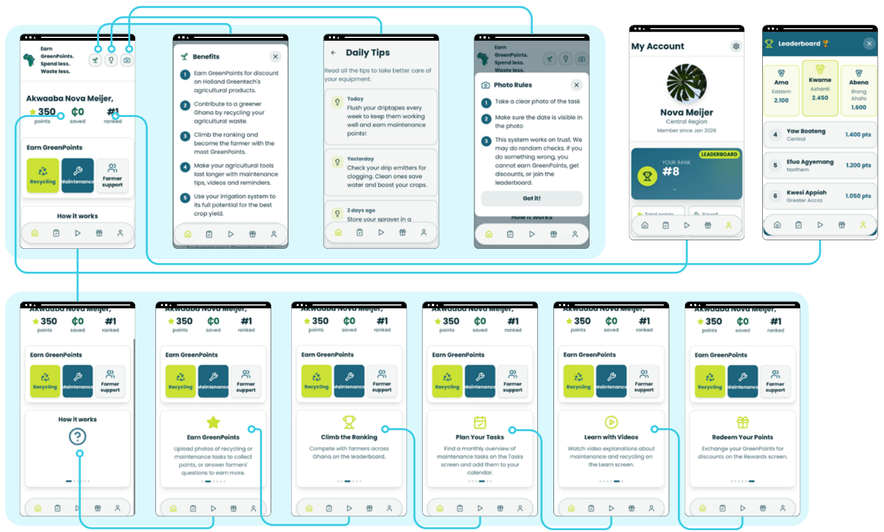
This feature strongly aligns with the goals of the project. During the research phase, it became evident that Ghana has a strong and collaborative farming community. As one farmer mentioned earlier: “Two heads are better than one.” Farmers in Ghana regularly learn from one another, exchange knowledge with lead farmers, and come together during farmer field days. Therefore, integrating a feature that digitally supports this sense of community and knowledge sharing is a natural extension of the project.

The home screen pt1

This is the home screen. Here, users can view their current points, the total amount of cedis saved through discounts, and their ranking position.

In the top right corner, there are three buttons: one outlining the benefits of using the app, one providing an overview of daily farming tips, and one explaining the photo submission rules.

Tapping on the current points or saved cedis leads to the “My Account” page, while tapping on the ranking directs users to the leaderboard.



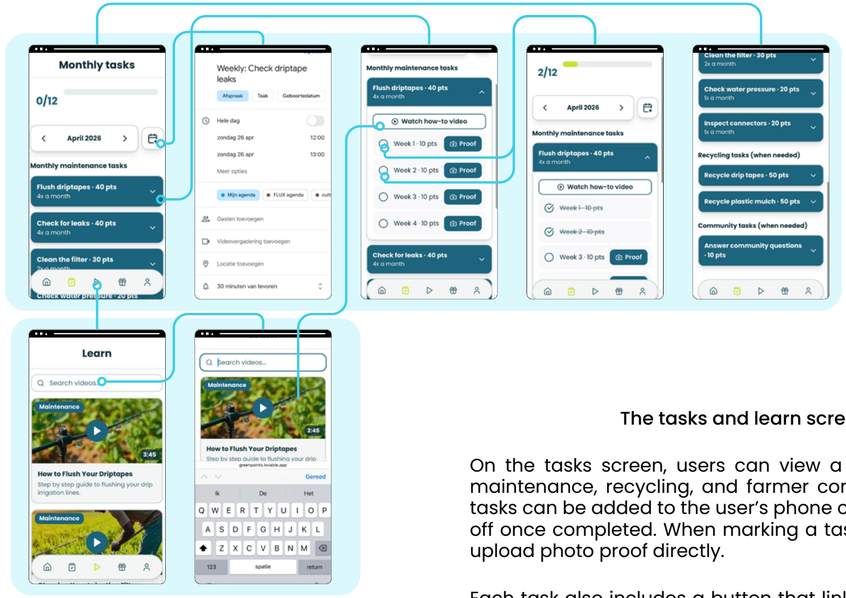
When users scroll down on the home screen, they will find the “How it works” section. This is presented as a carousel that explains, slide by slide, the different features and functionalities available to farmers within the app.



The home screen pt2

On the home screen, users can find an overview of the three ways to earn GreenPoints: recycling, maintenance, and farmer support.

For recycling and maintenance, users are required to upload photo proof of completed tasks to earn points. In the farmer support section, users can ask farming-related questions and respond to questions from other farmers. By contributing answers, users can also earn points.



The tasks and learn screen

On the tasks screen, users can view a monthly overview of maintenance, recycling, and farmer community tasks. These tasks can be added to the user's phone calendar and checked off once completed. When marking a task as done, users can upload photo proof directly.

Each task also includes a button that links to a corresponding explanation video. Additionally, the tasks screen shows how many points can be earned for each task.

The learn screen offers a variety of instructional videos related to farming.

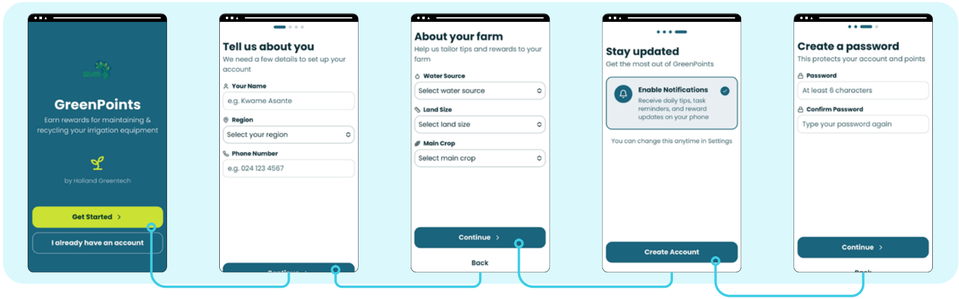


The rewards and my account screens

The rewards screen provides an overview of the available discounts that can be redeemed with points. Users can select a deal and confirm it, which deducts the required points from their total and generates a code. This code can be shared with HGT when purchasing products. The “Your discount codes” section offers an overview of both current and past discount codes.

The “My Account” screen displays the user’s ranking. When clicked, it shows their total points (without deductions from redeemed rewards) and their position on the leaderboard. The screen also provides an overview of the number of tasks completed, how many times the user has recycled, and how many contributions they have made in the farmer support section. Additionally, users can view their recent activity.

From this screen, users can access the settings, where they can manage notifications, update their farmer profile, and adjust app preferences.



The login screen

When downloading the app or logging out, users are directed to the login screen. Here, they can either log in or create a new account.

During account creation, users are asked to provide information such as the size of their farm, their water source, and their main crop. This information is used to personalize maintenance tasks within the app. Users can also choose whether to enable notifications immediately, with the option to adjust this later in the settings. Additionally, users are required to create a password.

Testing for iteration 3 pt1

The first test with iteration 3 was conducted with one farmer. The PC met with the participant in person, and together they joined the online session. Prior to the test, the PC had already explained the concept and idea behind the app, meaning that the participant's initial understanding of the concept could no longer be tested objectively. In addition, the internet connection during the session was unstable, which affected the testing process.

The test was conducted similarly to the iteration 2 test, by asking the participant to share the phone screen, perform tasks within the app, and think aloud while navigating through the interface. During the session, the farmer responded positively to the personalized welcome screen displaying "Akwaaba, [name]" and asked whether the researcher could speak Twi, indicating appreciation for local language references within the design.

The farmer interpreted the recycling section primarily as reusing the drip tape rather than recycling it as waste material. This suggests that the concept of recycling within the app may require clearer explanation and communication. During the first task, an important insight was gathererd as can be seen in the quotes.

'I think the problem you are going to encounter is that it will be tedious for farmers. The body is itching, farmers want to act practical. Maybe at the end of the day I would want to use it, but then you are tired and go to bed. There are farmers in the office that would be willing to use it.'

'For me, I am more interested in practical things on the field. The whole concept of using the phone is really not for him. Getting the pictures I can't do all the time, I can do it once in a while.'

This insight is particularly interesting because it contrasts with the findings from focus group 2, during which participants responded very enthusiastically to the app concept. This suggests that willingness to use a mobile application may strongly differ between farmers. While the lead farmer from iteration 2 and the ACHI alumni and farmers participating in focus group 2 were positive about the app, the iteration 3 participant perceived the concept as too focused on phone interaction and insufficiently practical for daily farming activities.

These contrasting responses indicate that the app may not be equally suitable for all farmers. As a result, the setup of the final test was adjusted to further validate adoption, identify barriers to use, and better understand which types of farmers are willing to engage with the application. The findings suggest that lead farmers and digitally skilled farmers could play a key role during the initial implementation phase of the concept.

Testing for iteration 3 pt2

A new format for the test was developed after the PC indicated that several farmers would already be visiting the campus for another purpose. This created an opportunity to integrate additional testing sessions during their visit. Since it was not possible to be physically present, a survey was created to support the testing process. In addition, the PC was asked to present the app to the farmers and document their initial reactions and feedback. The complete survey results can be found in appendix D3.

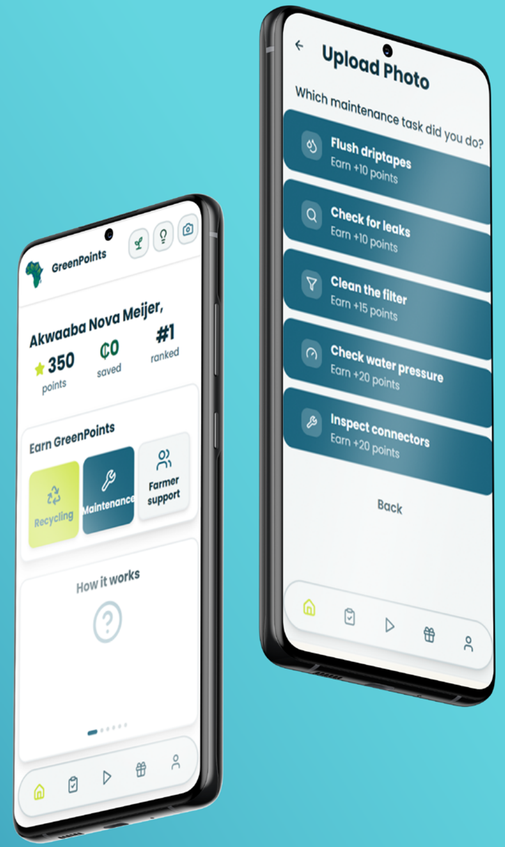
Response to GreenPoints app

'Some were very impressed about it others were skeptical about how relevant the app would be to them incase they are not sourcing their materials from Holland Greentech.'

Key insights survey

1. **Farmers are highly open to digital support systems,** digital support systems do not appear to form a major cultural barrier within this farming context. Farmers are open to technology when it is practical, useful, and directly connected to their daily farming activities.
2. **Financial and practical benefits are the main motivators**, farmers are primarily motivated by direct economic and practical benefits rather than sustainability alone.
3. **Willingness to recycle exists, but convenience is crucial**, the main challenge is not motivation, but logistics and infrastructure.
4. **Internet and data costs form the biggest barrier**, the app needs to function as a lightweight and accessible platform.
5. **Farmers value peer-to-peer learning**, 83.3% of respondents stated they would ask questions to other farmers through an app, and the same percentage indicated they would help answer questions from fellow farmers.
6. **Simplicity is essential**, complex digital systems are unlikely to succeed within this context.
7. L**ead farmers can play a central role in the system**, 50% of respondents believed the app would work particularly well for lead farmers. None of the respondents said the app would be suitable for 'all farmers'. Most chose lead farmers, younger farmers or digitally skilled farmers.

These results suggest that the initial target group for the app should primarily consist of lead farmers, younger farmers, and digitally skilled farmers. Consequently, the scope has shifted from designing for all farmers towards designing for a more specific user group. The findings also highlight the importance of creating a simple and accessible user experience, incorporating offline functionality, and developing convenient recycling systems.



Final version of the GreenPoints app

The idea for the app did not originate from a preconceived intention to design an application. Instead, the concept emerged from the research data and from continuous discussions with the users and stakeholders involved in the project. During the research, it became clear that mobile phones already play an important role within daily life in Ghana. For example, mobile services such as MTN Mobile Money are widely used, even for activities such as paying rent. This demonstrated that mobile phone usage is already deeply integrated within everyday practices, which contributed to the relevance and feasibility of an app-based concept.

After testing iteration 3, several recommendations were formulated for the further development of the app. These recommendations can be found in the recommendations chapter. The app was developed using Lovable as a supporting software tool. The corresponding AI statement can be found in the appendix.

https://greenpoints.lovable.app

Use the link to explore the app on your phone!

16. IMPLEMENTATION OF THE GREENPOINTS APP

The GreenPoints app icon

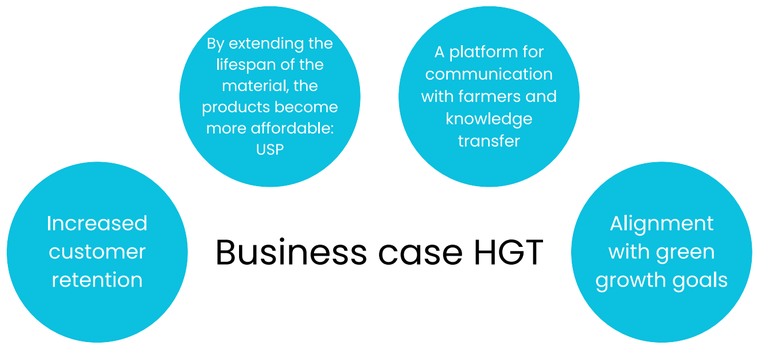


Business case and value proposition HGT

To assess whether a HGT team in Africa could pilot the app, it was important to develop a strong business case. In collaboration with the founder of HGT, this business case was created and shared with several Holland Greentech teams across Africa.

Value proposition HGT

This solution enables Holland Greentech to increase customer retention, strengthen farmer relationships, and support sustainable growth by extending product lifespan and incentivizing responsible use.



(1) Customer retention can be increased by offering discounts on HGT products, encouraging customers to return more frequently.

(2) By extending the lifespan of materials, products become more affordable over time, creating a strong unique selling point for HGT.

(3) Providing a platform for communication with farmers and knowledge transfer aligns with HGT's current focus and further strengthens this direction.

(4) While recycling is not yet part of HGT's green growth goals, integrating it would expand and reinforce their sustainability ambitions.

Business case and value proposition target group

Value proposition farmers

Earn rewards while improving your farm: increase your crop yield, save money through better maintenance and longer product lifespan, compete for extra prizes, and contribute to a greener Ghana through recycling.

(1) Earn discounts on products by collecting points through recycling and maintenance activities

(2) Compete in rankings and unlock opportunities to win additional rewards provided by HGT

(3) Contribute to a greener Ghana by recycling materials and extending product lifespan

(4) Reduce long-term costs, as proper use and maintenance make products more affordable over time

(5) Maximize crop yield by ensuring irrigation systems are properly maintained and used to their full potential



Important implementation steps

As mentioned in relation to design goal 2: recycling, there are four important implementation steps. The first two original implementation steps were adjusted to align with the app concept.

Important implementation steps
1.Promotion of the GreenPoints app
2.Education on the GreenPoints app
3.Collection and storage of plastic waste at farm
4.Pick up plastic waste from the farm to recycling point

Insights from software development in Ghana

A conversation was conducted with a Dutch entrepreneur operating a company in Ghana focused on the digitalisation of agriculture. The company developed software to support farming practices, and the discussion served as an opportunity to gain insights from practical experiences within the Ghanaian agricultural context.

The company applies a different approach compared to the concept developed within this project. Instead of farmers directly using the software, Ghanaian field agents operate the application and maintain close contact with the farmers. All farm-related information is documented within the software by these field agents. According to the entrepreneur, this approach is necessary because a significant portion of the farmers they work with are illiterate.

The software was developed in collaboration with Ghanaian engineers, emphasizing the importance of local involvement during both the design and implementation phases. It was highlighted that the software was developed incrementally, starting from the needs of the farmers and gradually translating these into functionalities. Field agents continuously tested the software with farmers to better understand their needs and identify which features were most relevant.

An important insight from the conversation was the confirmation that financial gain is one of the strongest motivations for Ghanaian farmers. Financial benefit was described as a key driver for behavioural change. It was therefore advised that the application should communicate benefits in Ghanaian cedis rather than percentages or abstract statistics, as farmers are primarily focused on clear and short-term rewards.

The conversation also highlighted challenges related to the adoption of digital technologies. Even some of the field agents initially experienced difficulties using and adopting the software, demonstrating the importance of creating an accessible and intuitive application.

In addition, the entrepreneur validated concerns regarding long-term sustainability. It was mentioned that initiatives often collapse once NGOs withdraw their support, stressing the importance of developing a concept that is not dependent on temporary funding.

Finally, the importance of a community-driven approach was emphasized. According to the entrepreneur, integrating community elements into the concept can positively support both the implementation process and the long-term adoption of the platform among farmers.

Key takeaways

1. Involving HGT representatives in the sensitization process of the GreenPoints app is essential.
2. HGT representatives should be actively involved in testing the software with farmers.
3. The software should be further developed in collaboration with Ghanaian engineers.
4. Short-term rewards should be integrated into the application to stimulate engagement and motivation.
5. Community engagement should play a central role within the concept and implementation strategy.
6. Adoption of digital technologies can be challenging, highlighting the importance of proper sensitization and guidance.

1. Promotion of the GreenPoints app

1. Card containing a QR code
2. WhatsApp groups
3. Farmer field day
4. Lead farmers adoption

The first touchpoint between the GreenPoints app and HGT clients should be the drip tape product itself. Attached to the product packaging could be a card containing a QR code, allowing farmers to directly access the app store and download the application.

In addition, Holland Greentech employees and representatives are already active in various WhatsApp groups, such as the ACHI alumni group. These existing communication channels provide an accessible opportunity to promote the GreenPoints app among farmers and create initial awareness.

Farmer field days also present valuable opportunities for introducing and promoting the application. A dedicated farmer field day could be organized around the GreenPoints concept. During such sessions, farmers could receive explanations about the value and purpose of the app, how to navigate through the platform, and how the reward system functions. In addition, practical guidance could be provided regarding taking photos to earn points, arranging recycling pickups, and responding to questions within the farmer support section of the app.

During the final testing phase and the conversation with the entrepreneur specialized in digital agriculture in Ghana, it became clear that adoption of the application may be challenging for some farmers. However, the lead farmer participating in the final test understood the application relatively easily. Based on this observation, lead farmers could play an important role in the implementation strategy. One possible approach would be to make usage of the application part of the expectations associated with becoming a lead farmer. In this way, lead farmers could function as role models for other farmers, similar to how they currently demonstrate agricultural practices while receiving products or support from HGT.



Promotional card attached to drip tapes

2. Education on the GreenPoints app

During the farmer field days where farmers are introduced to the app, an additional digital literacy training could also be provided. This training could help farmers better understand smartphone usage, app navigation, and the process of uploading photos and interacting with the platform. Such support may improve confidence in using the application and contribute to smoother adoption.

In addition, HGT representatives can play an important role in the education and implementation of the GreenPoints app. Whenever representatives visit farmers, they could assist them with using the application, solving technical issues, and explaining the reward system. To effectively support farmers, HGT representatives should become highly familiar with the application themselves. Therefore, a dedicated training for HGT representatives would be necessary prior to implementation.

3 & 4 Collection and storage of plastic waste on farm and pick up plastic waste from the farm to the recycling point

When farmers decide that agricultural plastic materials can no longer be reused and should be recycled, the materials should first be carefully packed and stored indoors, or otherwise protected from direct sunlight, until collection takes place. Proper storage is important to reduce material degradation and maintain the quality of the plastic for recycling.

After preparing the materials, farmers should contact an HGT representative to indicate that they have plastic waste ready for collection. Farmers should communicate the estimated quantity of material, allowing representatives to keep track of how much recyclable material is available within their region. Representatives could periodically organize collection days during which they gather materials from multiple farmers. In addition, materials could already be collected during regular farm visits, whenever representatives are visiting farmers for other purposes. This approach would allow the materials to be transported to KCARP in larger batches, making the collection process more efficient.

This collection structure could be implemented across different regions in Ghana through the existing network of HGT representatives. Representatives operating further away from Kumasi, and therefore further from KCARP, could transport the collected materials to regional transfer stations before final transportation to the recycling facility.

Example cost overview for the GreenPoints reward system for HGT

The following calculation is provided as an illustrative example rather than an exact financial prediction. The actual costs and farmer behaviour should be further evaluated through a pilot implementation of the application. The example primarily demonstrates how the potential financial impact of the reward system could be calculated by HGT.

1. Maximum points per month

Task	Points	Frequency	Monthly total
Flushing drip tapes	40	4x per month	160
Checking leaks	40	4x per month	160
Cleaning the filter	30	2x per month	60
Checking water pressure	20	1x per month	20
Inspecting connectors	20	1x per month	20

Montly maintenance subtotal = **420 points**

2. Total yearly points

- 1x recycling task (50 points), 10 community responses (10 x 5 points)
- 420+ 50 +50= **520 points**/month
- And thus, 520x12= **6240 points**/year

3. What does this cost HGT?

- Reward 1: 1000 points-> 15% discount on seed sachets
- If seed sachet costs 80 GHS, then 0.15 x 80 = 12 GHS discount
- Reward 2: 3000 points-> 10% discount on drip tape 0.1x2200 = 220 GHS discount

4. Realistic yearly farmer reward value

- 3x seed sachet discount= 36 cedis
- 2x drip tape discount = 440 cedis
- 36+440= **476 GHS/year**

5. Now scale to HGT users

High activity farmers will create an estimated total of 500 drip tape users x 150 GHS = 75.000 GHS per year.

Based on the point and reward structure used in this example, the estimated yearly cost for Holland Greentech could amount to approximately 75,000 GHS under a high adoption scenario. However, these costs should be interpreted as an investment in customer retention, sustainable farming behaviour, recycling engagement, and long-term farmer relationships rather than solely as financial losses through discounts.

Conclusion ‘implementation GreenPoints app’

In conclusion, the research demonstrated that successful implementation of the GreenPoints app depends not only on the functionality of the concept itself, but also on strong sensitization, education, and community engagement strategies. Four key implementation steps were identified: promotion of the app, education surrounding app usage, collection and storage of plastic waste, and transportation of the waste towards recycling facilities.

The findings highlighted the important role of Holland Greentech representatives, lead farmers, and existing communication channels such as WhatsApp groups and farmer field days within the implementation process. In addition, the research showed that adoption of digital technologies may be challenging for some farmers, emphasizing the importance of accessible design, local guidance, and gradual implementation.

Financial motivation also emerged as a key factor influencing farmer participation. Short-term and clearly understandable rewards were identified as important drivers for behavioural change and engagement within the system. At the same time, the proposed recycling system demonstrated potential feasibility through the existing HGT representative network and regional collection structures. However, the actual financial and logistical impact of the system should be further evaluated through pilot testing and long-term implementation research.





CONCLUSION

Final deliverables

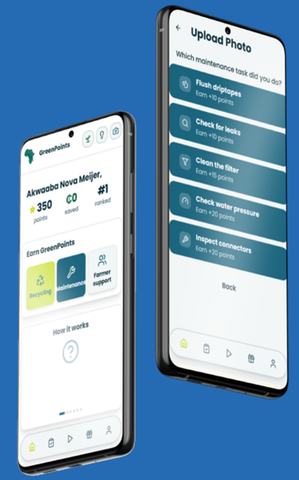
Based on the opportunities identified within the current system map, two final deliverables were developed through this research. The first deliverable consists of recommendations for the KAC staff, corresponding to design goal 1, aimed at reducing damage to the drip tapes at KAC.

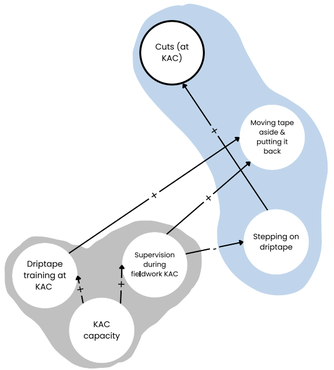
The second deliverable is the GreenPoints app, which addresses design goals 2 and 3. The app was developed to provide the target group with clear maintenance guidelines in order to extend the lifespan of the drip tapes, while simultaneously supporting the development of a recycling system for agricultural plastics.

1. Recommendations KAC staff

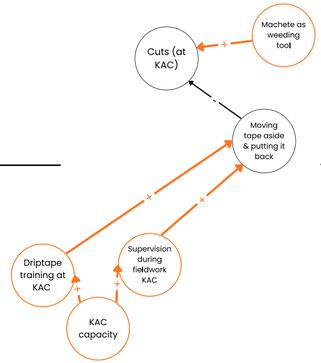
1. Involving all students in drip tape installation to foster a sense of ownership.
2. Improving communication between the KAC staff and students to create a shared understanding.
3. Introducing alternative weeding tool (e.g. a scuffle hoe) that requires less force and thus reduces the risk of damaging drip tapes.
4. Improving the damage reporting system to enable timely reporting and create an open environment for early detection without negatively affecting crops.
5. Clearly assigning responsibility to the students to ensure they understand their roles and expectations.
6. Enhancing student engagement with drip tapes, for example through instructional or explanatory videos.
7. Increasing supervision during fieldwork to reduce the likelihood of damage.
8. Emphasizing proper movement practices (walking over or around drip tapes) to minimize damage.
9. Improving practical training in line with students' expressed needs.

2. The GreenPoints app





Drip tape system at KAC (current system map)

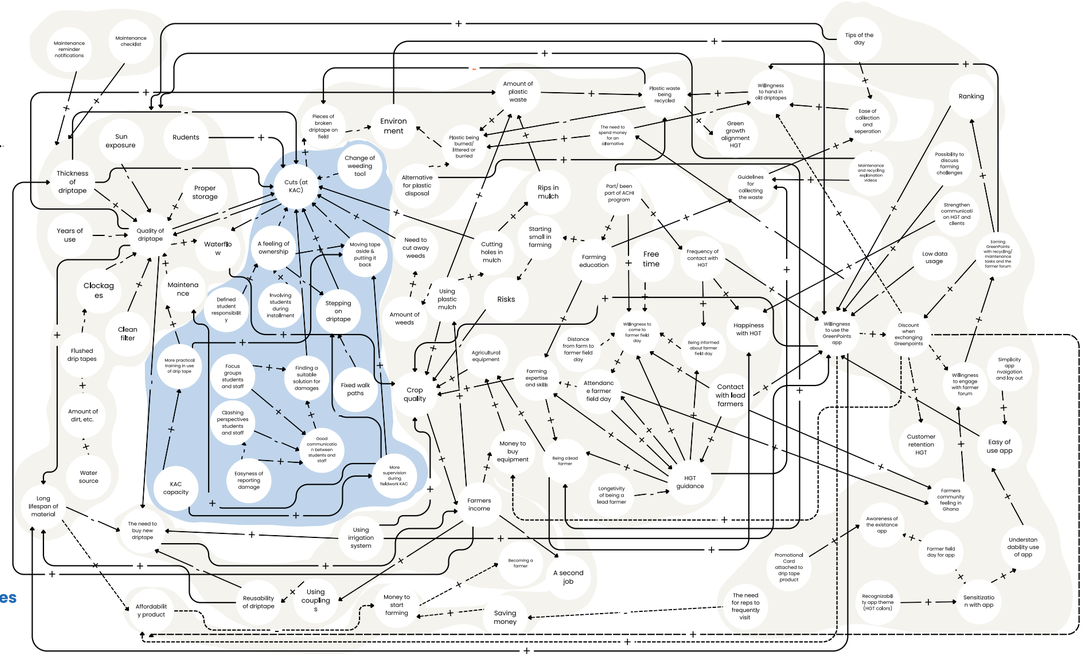


Drip tape system at KAC (opportunities system map)

Design goal 1: From the drip tape system at KAC in the current system map to opportunities for improvement in system map 2 and recommendations for improvement in the future system map.

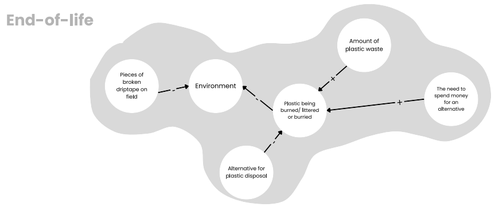
Money

Damages at KAC



KAC Recommendations in the future system map

1.



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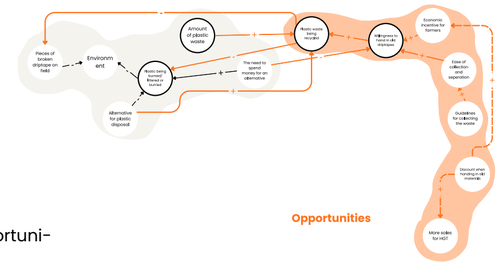
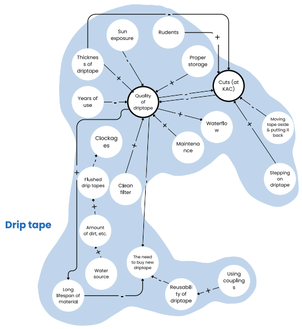


Design goal 2: From end-of-life in the current system map to recycling opportunities in system map 2 and the GreenPoints app in the future system map.

1.



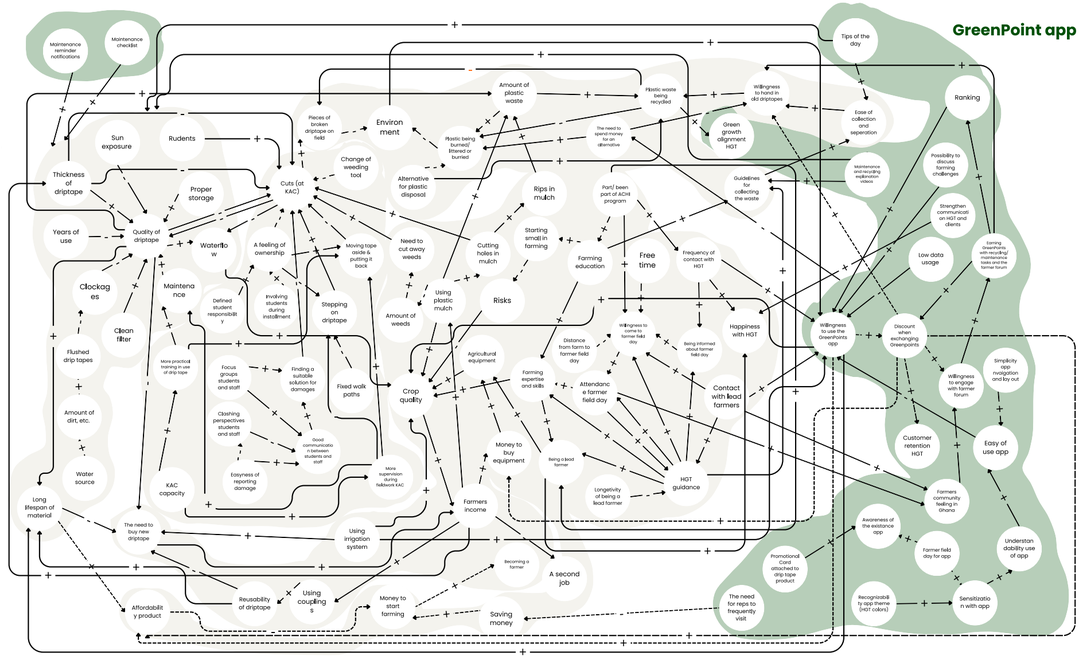
2.



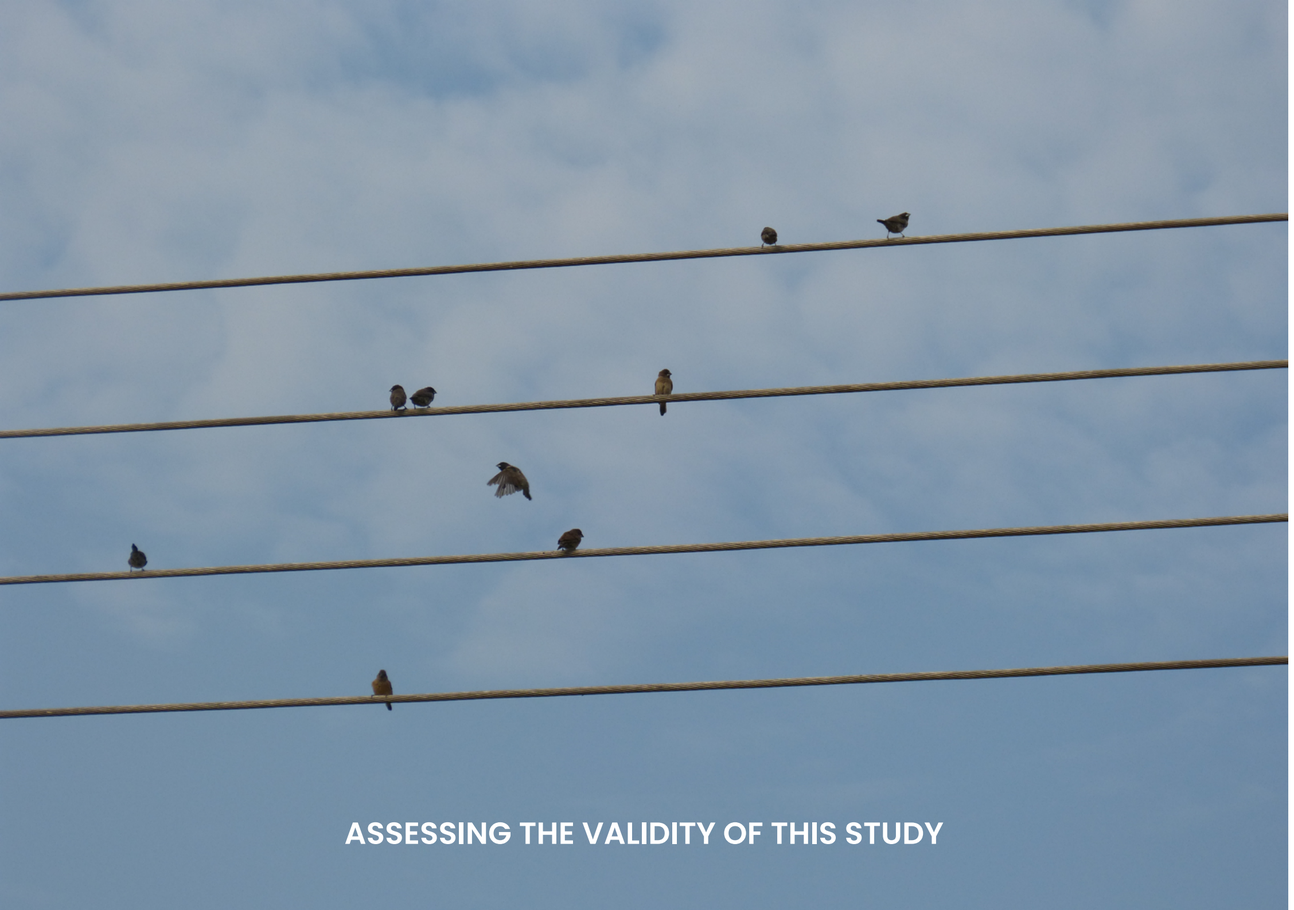
Design goal 3: From the absence of maintenance guidelines in the current system map to opportunities for maintenance guidelines in system map 2 and the GreenPoints app in the future system map.

3.

Money



The GreenPoints app in the future system map



ASSESSING THE VALIDITY OF THIS STUDY

Validating with ‘the 9 principles for design for the developing world’

The 9 principles

1. Co-design with people from the specific developing world context encourages designer empathy, promotes user ownership, and empowers resource-poor individuals.
2.Testing the product in the actual setting is an essential part of design for the developing world, not merely a final step.
3. Importing technology without adapting it to the specific developing world context is ineffective and unsustainable.
4. Both individuals in urban and rural contexts can benefit from poverty alleviation efforts.
5. Women and children are more affected by poverty alleviation efforts than men.
6. Project management techniques that are adapted to the specific developing world context enable a more effective and efficient design process.
7. Products for the developing world have greater impact when contextualized, developed, and implemented by interdisciplinary teams.
8. Cooperation with governments and local influencers contextualizes and enables poverty alleviation plans.
9. There are existing distribution strategies that can be used to successfully introduce products into developing world markets.

The 9 principles in this study

1. Focus groups were organized with members of the target group, allowing participants to actively contribute ideas and insights related to the identified design challenges. This supported a co-design approach and increased contextual relevance of the concept.
2. The GreenPoints app was tested with farmers within the Ghanaian context. However, due to time limitations, long-term testing and implementation were not possible within the scope of this study. Longitudinal testing is therefore recommended for future research.
3. The GreenPoints app was specifically adapted to the Ghanaian context through the development and application of a contextual program of requirements. Factors such as outdoor readability, connectivity limitations, battery efficiency, and digital accessibility were taken into account.
4. The design intervention considered farmers both within and around urban areas, acknowledging that agricultural communities in different geographical contexts can benefit from the concept.
5. The ACHI program actively encourages the participation of women within its farmer batches. As a result, women were also included within the target group and the broader design intervention.
6. The project combined conventional Western project management methods with more context-sensitive approaches, such as informal conversations, loose interviews, and relationship-based interactions. This flexibility supported communication and trust-building within the local context.
7. The project was developed primarily from a design perspective, which forms a limitation of the study. Although different stakeholders contributed insights, a more interdisciplinary collaboration involving additional local experts and disciplines could further strengthen the concept and implementation strategy.
8. Cooperation with governments and local influencers was not extensively explored within this study and is therefore considered a recommendation for future implementation and research phases. Such collaborations could support larger-scale adoption and long-term sustainability.
9. The study made use of existing structures and networks within the current agricultural system, such as HGT representatives, farmer field days, WhatsApp groups, and ACHI networks. Building upon these existing distribution and communication structures may support the successful implementation of the GreenPoints app.

General validation of the final concepts

This validation was conducted based on the general requirements and additional insights gathered throughout the project.

Impact

Reduction of agricultural plastic waste
The project addresses the growing issue of agricultural plastic waste caused by damaged drip tapes and plastic mulch systems. Interviews and field observations revealed that damaged driptapes are frequently burned, buried or discarded due to the absence of clear recycling systems. The proposed concepts therefore focus on reducing material damage, extending material lifespan, and creating opportunities for plastic collection and recycling.

Within the app concept, recycling systems and reward structures were introduced to encourage farmers to collect and store agricultural plastics rather than burn or dispose of them. Additionally, the recommendations for KAC focus on reducing drip tape damage through better maintenance practices, improved sensitization and reducing accidental cuts during weeding activities.

Improved irrigation maintenance
The research demonstrated that many issues with irrigation systems are not caused by a lack of knowledge, but by unclear maintenance routines. The concepts therefore focus strongly on improving maintenance awareness and creating structures that support consistent maintenance behavior.

The app concept introduces:
-maintenance reminders
-maintenance checklists
-visual maintenance guidance
-reward systems
-peer-to-peer learning opportunities

These interventions aim to improve the lifespan and effectiveness of irrigation systems over time.

Strengthening knowledge sharing
The project builds upon existing farming communities and communication structures. Farmers already learn from each other through farmer field days, ACHI alumni groups, lead farmers and informal support systems. The app concept strengthens these existing systems by creating additional opportunities for communication, support and knowledge exchange between farmers.

Long-term sustainability awareness
The research showed that farmers are aware of the environmental problems caused by plastic waste, but practical alternatives are currently limited. The project therefore contributes to creating awareness while simultaneously connecting sustainability to practical and economic benefits.

Desirability

Alignment with farmer motivation
Research findings showed that farmers are primarily motivated by:
-economic value
-ease of use
-practical farming support
-increased crop productivity

The concepts therefore strongly focus on visualizing economic benefits and providing direct value to farmers.

Interest in reward systems
During focus groups and app testing, participants responded very positively to the reward and points system. Farmers were particularly motivated by:
-discounts
-rewards
-competition

The idea of earning points after maintenance activities or recycling actions was perceived as motivating and engaging.

Community and peer support
Farmers indicated strong interest in communicating with other farmers through the app. Participants appreciated the idea of asking questions, sharing challenges and helping each other solve farming problems.

This demonstrates that the app concept aligns well with existing community behaviors and social structures.

Desire for simplicity
Both surveys and the focus groups revealed that simplicity is essential for adoption. Participants repeatedly emphasized that the system should:
-be easy to use
-require minimal technical knowledge
-contain clear visual communication
-preferably function offline

The app concept was designed to clearly communicate and visualize the value farmers can gain from using the system. Short-term value is created through the points-based reward system. This immediate feedback and reward structure aims to motivate continued engagement and make the benefits of the system directly visible to the users.

Suitability

Suitability for the Ghanaian farming context
The concepts were developed based on extensive field research, interviews, observations, surveys and focus groups conducted with:
-farmers
-lead farmers
-ACHI alumni
-KAC students
-KAC staff
-HGT representatives

As a result, the concepts directly respond to real challenges experienced within the Ghanaian farming context.

Building on existing structures
The concepts do not introduce completely new systems, but instead build upon already existing structures such as:
-ACHI farmer networks
-Farmer Field Days
-lead farmer systems
-HGT communication channels
-WhatsApp communities

This increases the suitability of the concepts within the current agricultural ecosystem.

Focus on relevant user groups
Research results indicated that the app is currently most suitable for:
-lead farmers
-younger farmers
-digitally skilled farmers

Therefore, the scope shifted from designing for all farmers towards focusing on a more specific target group during the early stages of implementation.

Adaptation to existing farming realities
The concepts were adapted to practical realities identified during research, including:
-low internet accessibility
-high mobile data costs
-transportation barriers
-limited recycling infrastructure
-manual farming practices

This resulted in strong emphasis on:
-offline accessibility
-low-data usage
-simple interfaces
-practical implementation strategies

Feasibility

Technical feasibility
The app prototype was successfully developed using AI app development platform Loveable and tested with users during multiple iterations. The testing process demonstrated that the core functionality of the concept is technically achievable.

Existing communication infrastructure
As mentioned before, the concepts build upon already existing communication systems. Because these systems are already active, implementation becomes more feasible compared to introducing entirely new infrastructures.

Feasibility of maintenance support
The maintenance support aspects of the concept, such as:
-reminders
-checklists
-visual guidance
-peer support

can realistically be implemented within existing farming routines.

Feasibility challenges
Research also identified several important feasibility challenges:
-internet and mobile data costs
-low digital literacy for some farmers
-limited recycling infrastructure
-transportation barriers
-the need for sensitization and training

These findings highlight that future implementation should prioritize:
-low-data systems
-offline accessibility
-simple onboarding
-gradual implementation

The recommendations developed during the project will be formally communicated to KAC staff. Additionally, a promotion strategy for the app concept has been developed to support future adoption and engagement.

Viability

Economic value for farmers
The concept focuses strongly on creating direct economic value for farmers. Farmers repeatedly indicated that economic benefits are one of the strongest motivations for behavioral change.

The reward system therefore visualizes short-term value through:
-discounts
-points
-rewards
-reduced maintenance costs

Long-Term viability of the app
The app currently focuses on clients of HGT which creates a realistic and manageable starting point for implementation. The system also supports HGT's broader goal of improving communication with farmers and strengthening customer relationships.

Scalability
The concept was designed to remain adaptable and scalable over time. While initially focused on HGT clients and selected farmer groups, the system could potentially expand in the future through:
-governmental support
-agricultural organizations
-recycling partners
-larger farming networks

Reducing dependence on external funding
The project aimed to avoid complete dependence on external funding. The app concept itself does not currently rely fully on external financial support. However, scaling the system, improving recycling infrastructure, or increasing capacity at KAC may require additional financial support in the future.

Practical viability
The concepts were intentionally designed to fit within the daily lives of farmers by focusing on:
-simplicity
-practicality
-short-term value
-low-threshold participation

This increases the likelihood that the concepts can realistically be maintained and adopted over time.



Validating with ‘Contextualization research in Low-income settings’

Contextualization of:

1. The research process and methods

Formal interviews were not conducted; instead, most interactions took the form of informal conversations in the field or in casual settings. To create a more comfortable environment for participants, familiar individuals were sometimes present during these conversations. Notes were taken in a notepad whenever possible to capture key insights.

Observational data was systematically documented throughout the project. This included recording project-related conversations as well as contextual insights gathered in Kumasi and on campus. Observations were also noted during everyday situations, such as traveling by Uber, to capture spontaneous and contextual insights. In addition, visual data was collected through photographs and videos.

Participatory design methods were further applied by organizing focus groups and testing sessions within the local context, enabling active involvement of participants in the design process.

To gain insight into students’ perspectives on drip tape damage at KAC, an anonymous survey was conducted. Participants were explicitly informed that their responses were anonymous and would not have any consequences within the school environment, ensuring openness and reducing response bias.

2. The research findings

Interview data was documented as closely as possible to how participants expressed themselves, minimizing additional interpretation. Throughout the research process, it became evident that several initial findings were not fully validated or lacked accuracy (see the Assumptions chapter). Therefore, the data was continuously revisited and cross-checked.

To strengthen the validity of the research, multiple perspectives were incorporated by engaging with a diverse range of stakeholders involved in the project. Furthermore, the limitations of the study are explicitly acknowledged and discussed, and are translated into recommendations for future research.

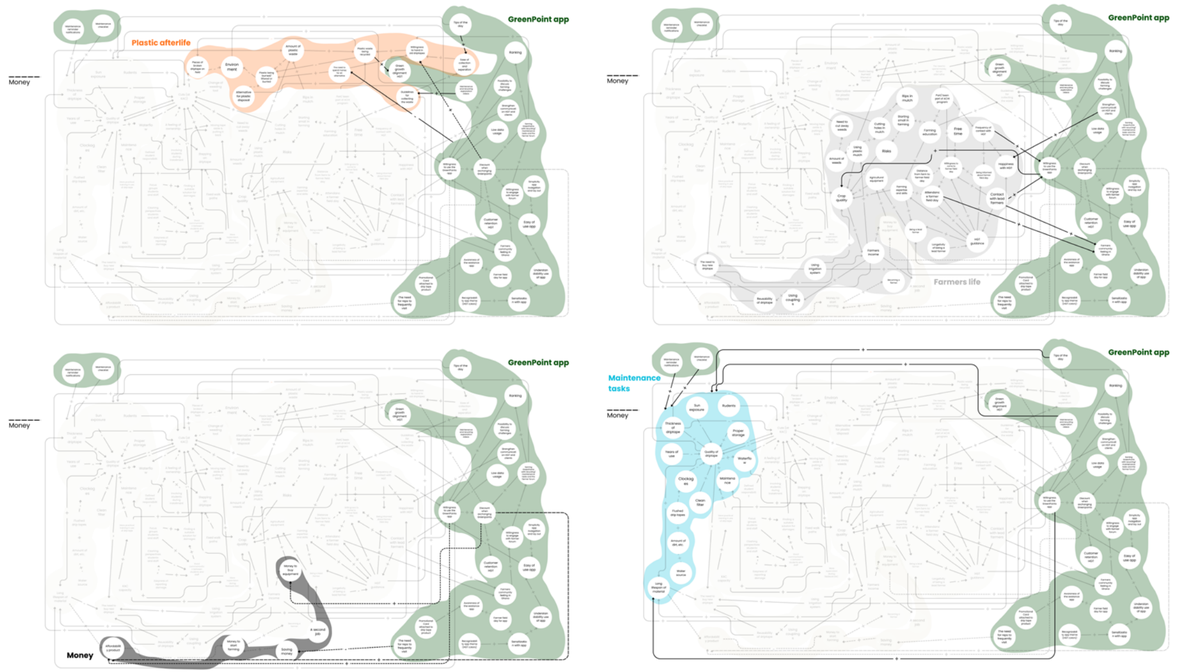
3. The researcher

Throughout the research, I continuously reflected on my own positionality (see Positionality section). During focus groups, the Ghanaian project coordinator of the ACHI project was present and supported communication in cases where language barriers arose. His presence also contributed to creating a more comfortable and open environment for participants.

At the beginning of the project, I explicitly documented my assumptions (see Assumptions section) to distinguish them clearly from established facts. Throughout the research process, I remained aware of these assumptions and critically reflected on their potential influence on the study.

The GreenPoints app as systemic intervention

The GreenPoints app influences many of the key themes identified in the final system map. The concept addresses topics such as maintenance behaviour, the afterlife of agricultural plastics, financial motivation, and the daily lives of farmers. Through the integration of these themes within a single concept, the app demonstrates how the most important insights and challenges identified throughout the project were taken into account during the design process.





18. ASSUMPTIONS

One notable aspect of this research was that the conclusions often did not align with the assumptions I had during this reserach. From the beginning of the project, I tried to critically reflect on my own assumptions and remain aware of the fact that, as a Western designer, I might interpret situations, behaviours, and values differently than the community in Ghana. Despite this awareness, some assumptions were inevitably still present throughout the process.

Interestingly, whenever these assumptions were contradicted by the research findings, the actual insights and conclusions became even more evident. In many ways, this has a certain beauty to it, as it demonstrates the importance and value of community engagement within projects such as this one. By actively involving stakeholders, farmers, and local actors throughout the process, assumptions could be challenged and replaced by context-specific insights grounded in lived experiences. The moments in which my assumptions proved incorrect therefore became some of the most valuable learning moments within the project.

Below, an overview is provided of several assumptions made throughout the research process and how these related to the eventual findings.

1. At the start of the research, I assumed that most farmers did not store drip tapes properly when they were not in use. This assumption was based on one example in which the drip tapes were stored poorly. However, after speaking to more farmers, it became clear that many farmers actually pack the drip tapes carefully and store them indoors after use.
2. Related to Design Goal 1 concerning damages at KAC, I initially interpreted the explanations provided by KAC staff as the main cause of the damages, namely a lack of responsibility among students. However, at that stage I had only explored one perspective within the challenge. Since students were not present on campus during my time in Kumasi, I had not yet spoken to them directly. After later conducting a survey among students, it became clear that the challenge was more complex and involved additional underlying factors.
3. At first, I assumed that farmers in Ghana had more immediate concerns than the environmental impact of plastic waste. However, this assumption was quickly challenged during the very first farmer interview, in which the farmer immediately stressed the negative impact of plastic burning on air quality. This demonstrated that the issue was not simply a lack of awareness or education, but rather a lack of accessible alternatives for waste disposal.
4. After spending time at the KAC campus, I assumed that many farmers experienced severe damages to their drip tape systems. Although damages do occur among farmers, further interviews revealed that KAC itself experiences relatively more damage-related issues compared to many other farmers.
5. At the beginning of the project, I believed that the material used for drip tapes was not suitable for the Ghanaian context and that the main problem originated from the material itself. However, after speaking with both the drip tape producer and farmers, it became clear that the material is generally suitable for the context, provided that the systems are properly maintained. This insight further strengthened the relevance of the proposed design intervention.
6. Related to this, I also assumed that most farmers considered the lifespan of drip tapes to be short. However, this perception mainly came from KAC. Other farmers generally did not describe the lifespan of the drip tapes as particularly short.
7. During the testing of the first concepts with the ACHI alumni, I expected participants to be most enthusiastic about the more practical concepts, such as the maintenance calendar. This assumption was based on the observation that many farmers currently work with notebooks and handwritten records. Surprisingly, the participants showed the most enthusiasm towards the app concept instead.
8. Following this positive feedback, I assumed that most farmers would respond positively to the app concept. However, during the final testing phase, it became clear that the app might not be suitable for every farmer, or that successful adoption would require a strong sensitization and support phase. While some farmers enjoyed interacting with the phone and app, another farmer described the concept as tedious phone work and emphasized a preference for practical fieldwork instead.



17. LIMITATIONS

Limitations in contextualization in this research

The project was conducted in Ghana over a period of three months, which allowed me to immerse myself in the local context. However, I quickly realized that developing a deep understanding of a place and its cultural dynamics requires significantly more time. Toward the end of my stay, I started to gain deeper insights into the core of the design challenge, and even in the final weeks, new and valuable understandings continued to emerge. This suggests that longer-term engagement would be highly beneficial for this type of research. Due to practical constraints, this was not feasible within the scope of this project.

In this research, I applied several Western design methods, such as journey maps and customer journey maps. However, I found it difficult to fully assess their suitability within this specific context. To address this limitation, I developed a system map, which helped me to better capture the broader-context and remain sensitive to local dynamics.

Although observational research was conducted, I recognize that there were opportunities to engage in more extensive observation. Remaining unobtrusive proved challenging, as my presence as a foreign researcher was highly visible. Especially at the beginning of the project, I was still adjusting to the environment and felt hesitant to fully engage in observational practices. In hindsight, I would aim to overcome this hesitation, as such observations can provide valuable insights.

In addition to focus groups, testing sessions, interviews, and observations, other methods could have been employed, such as participant self-documentation (e.g., diaries). These methods may offer richer insights and are therefore recommended for future research.

General limitations

Limited access to KAC students during the research period

A limitation within this study was that a significant part of the target group, namely the KAC students, was not present on campus during most of the research period due to their annual three-month break. As a result, it was difficult to actively engage with this group throughout the project, which limited the amount of direct input gathered from the students.

Challenges of conducting research from the Netherlands

In addition, part of the conceptualization phase was carried out from the Netherlands. Conducting research and maintaining communication with stakeholders in Ghana from abroad proved challenging. Difficult network connections and the importance of personal, face-to-face interaction within the Ghanaian context complicated communication processes. This became particularly evident during contact with KCARP, where personal inquiries appeared to be significantly more effective than communication through calls or text messages.

Limited scalability beyond HGT clients

At this stage, the concept has been specifically developed for clients of Holland Greentech. Since Holland Greentech operates as a commercial company, the concept could potentially provide a competitive advantage. As a result, scaling the intervention to include other agricultural suppliers in Ghana may prove difficult, limiting the broader reach of the concept among farmers outside the HGT network.

Lack of interdisciplinary project team

One of the principles within the “9 Principles of Design for the Developing World” emphasizes the importance of interdisciplinary collaboration in projects such as this. Interdisciplinary teams provide a wider range of perspectives, expertise, and approaches. Although this project involved conversations with various stakeholders and experts in the field, the project itself was mainly executed individually as part of a graduation thesis. Conducting the project within a larger interdisciplinary team could therefore have strengthened the research and the resulting design intervention.

Absence of long-term testing and validation

Furthermore, the long-term impact of the GreenPoints app has not yet been tested. Features such as maintenance reminders, behavioural change, and long-term improvements in maintenance practices could not be evaluated within the timeframe of a graduation project. Longitudinal testing and pilot implementation are therefore recommended for future research.

Financial feasibility of the recycling infrastructure

Finally, the project requirements stated that the intervention should ideally not become dependent on external funding. However, during conversations with Holland Greentech, concerns were raised regarding the transportation costs related to collecting and transporting agricultural plastics to the recycling company. If these costs would need to be covered entirely by the farmers themselves, the value and attractiveness of the recycling system could decrease significantly. Therefore, some level of financial support or partial funding may still be necessary to ensure the feasibility and long-term success of the recycling infrastructure.



18. OTHER IDENTIFIED CHALLENGES & FUTURE RECOMMENDATIONS

Governmental involvement and policy opportunities

At this stage, there is no direct governmental involvement within the project. However, one of the “9 Principles of Design for the Developing World” emphasizes the importance of involving governmental institutions, as they can create impact on a larger systemic scale. The Ghanaian minister of Food and Agricultural visited the Green Village. Although it was mentioned that recycling initiatives are not yet actively implemented within their work, the topic is currently on their radar. The ministry showed interest in the project documentation (appendix C), and contact information of a ministry representative was shared for potential future collaboration.

In addition, governmental support could play a role in improving access to repair materials such as drip tape couplings. Couplings can significantly reduce waste by allowing farmers to repair damaged drip tapes instead of discarding large sections. However, farmers mentioned that these couplings are currently relatively expensive. Government subsidies could therefore support wider adoption of repair practices.

Recommendations for the recycling system

To further realize the recycling system proposed within this research, Holland Greentech or the ACHI program should establish further collaboration with KCARP to discuss implementation steps, logistics, and responsibilities.

At this moment, the proposed supply chain is not yet fully circular. To close the loop, HGT could potentially purchase recycled raw material pellets from KCARP. During discussions, HGT showed interest in exploring possibilities for creating new products, such as seed trays, from the recycled material. This could be further investigated in future research and implementation phases.

In the future, the recycling system could also expand beyond drip tapes alone. Additional agricultural plastics could potentially be included within the GreenPoints system. However, these materials would first need to be tested by KCARP to determine whether they are suitable for pelletizing and recycling processes.

Agricultural sustainability opportunities

KCARP currently produces organic compost derived from waste materials. Staff members at KAC expressed interest in exploring whether this compost could be integrated within their agricultural system. In addition, HGT could investigate whether organic compost products could become part of their product distribution portfolio in the future.

Another recommendation concerns the promotion of thicker and more durable drip tapes. Although these products are more expensive initially, they generally have a longer lifespan and may reduce long-term costs for farmers. HGT could place more emphasis on communicating and visualizing these long-term financial benefits to farmers.

Farmers also mentioned that the current plastic mulch tears relatively easily. Stronger mulch materials could therefore improve durability. In addition, some damages occur when farmers manually create planting holes within the mulch. Pre-manufactured planting holes could potentially reduce damage to both the mulch and nearby drip tape systems.

Recommendations for the GreenPoints app

For further development of the GreenPoints app, HGT representatives should continue testing together with farmers to better understand what type of educational video content farmers would find most valuable within the app.

More research is also recommended regarding app operation and digital accessibility within the Ghanaian context. Currently, relatively little literature exists regarding app usability in Ghana. However, insights into locally dominant digital systems and behaviours, such as the widespread use of MTN services, could support the development of a more accessible application.

As discussed within the limitations chapter, the long-term impact of the GreenPoints app has not yet been tested. A pilot implementation is therefore recommended. During discussions with HGT founders, Rwanda was suggested as a potentially suitable pilot location due to the relatively short travel distances within the country, which could simplify logistics and implementation.

In addition, more detailed decisions regarding the app still need to be made by HGT. These include determining: the exact maintenance tasks included within the app, personalized maintenance recommendations, the point and discount structure, the content of educational videos and additional platform functionalities.

Additionally, after testing iteration 3, it became clear that future development should focus strongly on simplicity of use, offline accessibility, and the convenience of recycling systems. These aspects were identified as essential factors for making the app suitable and accessible for the target group.

Communication and farmer engagement

The communication surrounding farmer field days could be improved. Results from Survey 1 (see Appendix) showed that several farmers indicated they did not attend farmer field days simply because they were unaware that these events were taking place. This is particularly important, as farmer field days were repeatedly identified as highly valuable spaces for learning, knowledge exchange, and community engagement.

Broader challenges within the farming context

During the research, farmers expressed interest in more automated agricultural systems, particularly regarding irrigation. Some farmers live relatively far from their farms and mentioned that remotely operating irrigation systems could reduce travel time and improve efficiency.

Another issue observed during the project relates to the accessibility of farming itself. Several participants mentioned that aspiring farmers often lack the initial financial capital required to purchase seeds, materials, and equipment. This creates barriers for entering the agricultural sector. Providing access to starting capital or financial support systems could therefore support young or beginning farmers.

Waste management also emerged as a broader issue at the KAC campus. Plastics such as water sachets and bottles are frequently discarded along the roadside and on campus grounds by passersby and local residents. In addition, a large waste accumulation site was observed behind the student housing area, where it was mentioned that residents from nearby towns also secretly dump waste. These issues create environmental and sanitary challenges within the campus environment.

Finally, one farmer mentioned that she only uses the irrigation system during the rainy season rather than the dry season. This initially appeared contradictory, but the farmer explained that there is insufficient rainfall during the dry season to refill the local water source used for irrigation. This highlights broader water availability challenges within the farming system and demonstrates the importance of providing farmers with information and strategies related to water management and irrigation planning.





PERSONAL REFLECTION

Looking back at the project proposal that was written at the start of the graduation project, I reflect on my motivation and personal ambitions. I wrote down that during my bachelor end project, “I learned that a problem often isn’t just one problem and certainly doesn’t have one perfect final solution.” I think now, after this project, I actually understand what I was saying. It is funny, because this exactly matches systems thinking. I was introduced to systems thinking during my bachelor; however, I had never really applied it in a large design project before. I have learned so much from this way of designing and from the systemic approach. I learned that there does not need to be one big design intervention that can “change the world.” Change starts small and gradually; otherwise, it is simply not feasible. Sensitization and implementation play such a big role in realizing an opportunity, and this does not happen overnight. It happens by involving the community, by really figuring out what the needs of your target group are, and by identifying which possibilities suit them best.

I also mentioned in the proposal that “I want to become better at working in a structured way, also by using appropriate methods. Additionally, I want to improve my documentation and concept visualization skills.” The thing that gave me structure were the design methods I used, especially the systems map. It brought together all the data collected over all those months in Ghana, where so much is happening, into a complex, yet visual overview. This helped me a lot in not losing touch with the project throughout the process. I can also honestly say that I am proud of my documentation and concept visualization skills. This is something that I really enjoy doing, especially creating the showcase.

An important thing that I learned is that, whenever I doubted the directions I had taken during the project, the only thing that really helped me was having a meeting with my supervisors. I needed confirmation that I was moving in the right direction. While this is normal during a graduation project, I feel that I have now built the confidence to choose the direction of a project without needing too much guidance.

Another thing I wrote down was: “I want to figure out if I, as a designer, am a good fit for this sector and whether I might want to continue working in it.” I have never felt this much motivation while working on a project during my entire studies. In advance, I thought: what do I know about irrigation and plastic recycling? However, by doing research and talking to experts, you gain so much knowledge, knowledge that is already there. I loved engaging with different stakeholders and perspectives. It is a combination of partnerships and design, and these are two roles that I am really fond of. Especially in a context like Ghana, where the culture is so rich and where people engage with each other in public transportation instead of staring at their phones. So yes, this is definitely a direction that I want to continue pursuing.

Ghana has been the experience of a lifetime, even though it was not always easy. I am incredibly happy that this became the topic of my graduation project, and I look back on it with nothing but joy.



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APPENDIX

Appendix A: Interviews

Appendix A includes the interviews that are briefly referenced in the report. Additional interviews were conducted during the research process; however, these were either already extensively discussed within the report or considered less relevant for inclusion in the appendix. Nevertheless, all interviews conducted throughout the research contributed to shaping the direction and outcomes of the study.

A1: Student at KAC conversation 1

This student is a 24-year-old first-year student at the KAC. His father is also a farmer, which strongly influenced his decision to pursue farming as a future career. Through his father, he became familiar with the KAC and eventually enrolled in the program.

At the KAC, the student works on his own small piece of land, where he grows corn and cowpea. He explained that students participate in practical agricultural activities both in the morning and afternoon. In the future, he hopes to focus more specifically on vegetable farming.

During the interview, the student discussed the issue of plastic use in agriculture. When asked whether he minded the plastic present on the fields, he immediately responded that he did. According to him, plastic negatively affects the soil and contributes to the creation of microplastics. He explained that the plastic materials used in farming do not decompose and can remain in the soil for more than ten years. He mentioned that this topic is also discussed in their education at the KAC.

The student emphasized that the vegetables produced at the school are intended to be organic; however, he believes that the presence of plastic compromises this goal. Some students are responsible for maintaining the irrigation tubes, and when parts of the tubes break, the damaged sections are cut out and discarded.

At the moment, the student is involved in an project together with six other students. The group is exploring ways to reuse agricultural plastic waste by transforming it into plastic sticks for supporting lettuce and cucumber plants. His current role involves generating ideas and developing a business plan for the project. He also mentioned the possibility of brainstorming together with the group in the future.

When asked what he dislikes about farming, the student explained that much of the work is still very manual. He expressed a desire for more automated equipment to make farming more efficient. However, when discussing what he appreciates about farming, he highlighted that farming always provides something valuable in return, even when financial resources are limited: namely, food. Additionally, he pointed out that crops such as cocoa and cashew contribute significantly to economic growth.

Finally, the student mentioned that another individual at the KAC is currently looking into purchasing a machine for drying cocoa. In relation to this, the student proposed the idea of melting discarded irrigation tubes to create sheets that could potentially be used during the cocoa drying process.

Conversation 2

During a follow-up conversation, the student explained that many farmers in the region do not have access to irrigation systems. According to his own estimation, only around 10–15% of farmers currently use irrigation. As a result, many farmers are unable to farm full-time and are required to take on additional jobs to support themselves financially.

The student further discussed the potential reuse of LDPE plastic material from agricultural irrigation systems. He suggested that the material could be repurposed into drying sheets for cocoa production. Currently, wooden structures are often used during the drying process, which contributes to deforestation. Reusing LDPE materials could therefore provide a more sustainable alternative.

Additionally, the student explained that one of the primary reasons he chose to study at the KAC was to gain more knowledge about irrigation systems and agricultural technologies. He sees irrigation as an important factor in improving agricultural productivity and enabling farmers to work more sustainably and consistently throughout the year.

A2: Conversation PC ACHI

During the interview, the project coordinator discussed the use, maintenance, and disposal of driplines at the KAC. According to the interviewee, the majority of KAC students do not receive detailed education about dripline maintenance. This is mainly due to the large number of students and the limited number of plots equipped with irrigation systems. Not all agricultural plots at the KAC currently use driplines.

The interviewee explained that responsibility for the maintenance of the driplines mainly lies with field managers. For example, the field manager responsible for the field, oversees the irrigation system and its upkeep. Students themselves are generally not formally trained in maintaining the driplines.

At the end of each farming cycle, the driplines are removed from the fields. During this process, the tubes often become damaged or break. According to the interviewee, this is partly caused by careless handling of the materials by students. When a dripline breaks, students are expected to remove the damaged line and replace it with a new one, as spare driplines are available.

Regarding maintenance practices, the interviewee described that driplines can become twisted, bent, or covered with soil during use. Maintenance therefore involves manually straightening the lines and removing dirt from them. However, there does not appear to be a formal maintenance protocol. Instead, students are expected to rely on practical judgement and experience when handling the systems.

The interviewee reflected on the causes of damage to the driplines and explained that many driplines are replaced after each agricultural cycle because they are already damaged or broken by the time the cycle ends. Since replacement lines are relatively accessible, students may not always feel a strong sense of responsibility toward preserving the materials carefully.

When discussing plastic waste management, the interviewee stated that there are currently no structured initiatives aimed at collecting or reducing plastic waste from the fields. Plastic waste management practices vary and may include burning the plastic, selling it, or burying it in the ground. The interviewee was uncertain about the exact procedures and suggested that field staff or another interview participant could provide more detailed information.

The interview also addressed agricultural equipment at the KAC. According to the interviewee, there is a shortage of modern and automated farming equipment. Many tasks are still completed manually using handheld tools. The interviewee specifically mentioned the need for more mechanized equipment, such as power tillers, to assist with preparing planting beds and other labor-intensive activities.

Finally, the interviewee reflected on discussions with ACHI project students, who indicated that driplines generally do not break easily when maintained properly. However, based on observations at the KAC, much of the damage appears to occur because students are not always careful when handling or removing the driplines at the end of each farming cycle.

A3: Field visit and conversation with ACHI students and PC

During a tour led by the project coordinator of the ACHI program together with several ACHI students, insights were gathered about the students' ambitions, agricultural practices, irrigation systems, and sustainable innovations being developed within the program.

One of the students explained that he is currently following the ACHI program and hopes to eventually start his own farm focused on vegetables, poultry, and other agricultural activities. According to the project coordinator, the student has strong entrepreneurial ambitions. The ACHI program encourages students to develop not only farming skills but also entrepreneurial thinking and long-term growth strategies.

During the tour, the students demonstrated a solar dryer that is used to dry vegetables through heat generated by sunlight. The system was originally developed by a student from the Delft University of Technology and operates without electricity, making the drying process significantly more affordable and accessible. The solar dryer can dry vegetables within a single day. An example given was the drying of sweet potatoes, which can subsequently be processed into baby food powder.

The ACHI students are also encouraged to develop their own prototypes, services, and product ideas as additional sources of income. One student, for example, is experimenting with producing shampoo from lettuce. These projects are intended to stimulate entrepreneurship and explore value-added agricultural products.

During the field visit, the students explained how they learned to install plastic mulch and drip irrigation systems through training provided by HGT. Typically, instructors demonstrate the installation process on one or two plots, after which the students are expected to independently apply the same methods on the remaining fields. The students are also responsible for preparing the fields themselves, including shaping and raising the soil beds.

The plastic mulch is primarily used to suppress weed growth. Beneath the mulch, drip irrigation lines are installed. These driplines are connected to a large water tank, which in turn is connected to underground piping systems. The irrigation system distributes not only water but also fertilizer mixtures, which are added directly into the water tank.

Regarding maintenance, the students explained that they were taught to flush the irrigation system once per month using only water, without fertilizer, in order to remove fertilizer residues from the pipes and driplines. During this flushing process, the ends of the driplines, which are normally tied closed around a pole in the ground, are opened to allow the entire system to be cleaned thoroughly.

Unlike some earlier observations made at the KAC, the ACHI students stated that they do not experience frequent breakage of the driplines. According to them, this is because they are highly conscious of proper maintenance and careful handling of the irrigation systems. They estimated that driplines can typically last between three and four farming seasons when maintained correctly.

When asked what happens to the drip tapes after these seasons, the students explained that they were unsure what should happen to the material once it is no longer usable. Their expectation was that the materials would most likely be discarded as waste.

The students also discussed the importance of proper spacing between irrigation lines. In some cases, there is approximately 40 centimeters between sections. Although this may initially appear inefficient, the spacing is intentionally designed for crops such as peppers, whose roots naturally spread into the surrounding soil areas.

Finally, the students explained that an important principle within the ACHI program is learning to start on a small scale and gradually expand over time. This approach is intended to help future farmers build sustainable and manageable agricultural businesses step by step.

A4: Farmer 1 interview

During the interview, the lead farmer discussed the development and management of his farm, his experiences with irrigation systems, and his collaboration with Holland Greentech and Kwame Nkrumah University of Science and Technology (KNUST).

The farmer explained that he personally cuts bamboo sticks from the forest to support and position the driptapes on the farm. He currently cultivates only habanero peppers and manages approximately 2.5 acres of land, with opportunities for future expansion. The farm was established two years ago through a partnership with KNUST, which provides the land, while the farmer finances all farming activities and materials himself.

The farmer feeds the crops with fertilizer twice a week, especially during the early stages of crop growth. To manage irrigation more effectively, he uses separate tanks for water and fertilizer. According to him, this system is important because crop water needs vary depending on temperature and weather conditions, while fertilizer application remains more controlled.

Before fully developing the farm, he initially planted maize to test the soil conditions, particularly because maize performs relatively well under low-water conditions. He explained that there are different types of soil across the land, which also influences farming strategies and crop performance.

The farmer emphasized the importance of professional support networks and knowledge sharing. He receives advice from a professor at KNUST, whom he considers one of his key "resource people." He explained that successful farming depends strongly on having knowledgeable individuals around who can provide guidance and expertise.

In addition to farming, the farmer also works as a teacher. He described himself as someone who continuously researches farming practices and actively seeks new knowledge. Through his relationship with HGT, he learned the importance of starting small and gradually scaling up while learning from mistakes in manageable ways.

The farmer also reflected on the economic realities of maize farming. According to him, maize cultivation requires large areas of land to become profitable. He explained that market prices have changed significantly in recent years: whereas 100 kilograms of maize previously sold for between 1000 and 2000 Ghanaian cedis, prices have now decreased considerably. He currently sells produce for approximately 35 cedis per kilogram.

From the beginning of the project, the farmer chose to install an irrigation system because he wanted to establish the farm professionally from the start. All irrigation materials and farming supplies are purchased through HGT. He explained that he initially approached the company himself after hearing positive experiences from many other farmers using their systems and products.

The farmer described his experiences with HGT as highly positive. According to him, the company provides reliable support, answers phone calls when assistance is needed, and actively informs farmers about new products or innovations. He stated that without meeting the company, he does not know how his farming journey would have developed. Overall, he rated the company 98 out of 100. Although he occasionally provides feedback regarding delivery-related issues, he emphasized that the products themselves consistently function well.

As a lead farmer, he explained that precision and accuracy are extremely important. This includes calculating seed quantities, assessing risks, and carefully planning farming operations. He noted that Holland Greentech shared much of this knowledge with him, and he now transfers this expertise to other farmers as well.

The farmer either collects materials directly from the HGT office in Kumasi or has them delivered. A representative from the company is responsible for installing the irrigation tubes and handling technical repairs when necessary.

According to the farmer, the irrigation system itself is relatively simple to operate. He opens the water tank and allows the water to flow naturally through the system. However, he expressed interest in upgrading to an automated irrigation system to reduce the need to travel to the farm multiple times per day. He estimated that an electric automated system would cost approximately 2500 Ghanaian cedis.

The first activity the farmer performs when arriving at the farm is inspecting the crops for insects and pests. In terms of maintenance, he explained that he consistently keeps the farm clean, removes weeds after each farming season, and flushes the irrigation lines approximately once per month.

Unlike some other interview participants, the farmer stated that the drip tapes on his farm rarely break. He explained that the tapes are always left lying in place on the fields and are not removed or stored, which minimizes handling and reduces the risk of damage. He expects the driptapes to last approximately five years before replacement becomes necessary.

The farmer identified several disadvantages of using drip tapes. According to him, the system is time-consuming because it requires continuous attention and monitoring to ensure that every section of the crop receives sufficient water. He regularly checks whether all plants are being irrigated properly.

When discussing the end-of-life disposal of the drip tapes, the farmer explained that he would most likely burn the materials once they no longer function. Although he recognizes that burning plastic negatively affects the atmosphere, he currently does not know of any recycling companies capable of processing the materials. Nevertheless, he strongly believes in the importance of recycling and stated that he would willingly transport or send the used driptapes to a recycling company if such an option became available. According to him, he would not expect any financial compensation for doing so, as he considers it beneficial for the environment and society. He also mentioned that he had not previously researched recycling possibilities himself, but that the conversation encouraged him to begin looking into the topic.

The farmer further suggested that collaboration with universities could be valuable for experimentation and testing. He indicated that access to land for testing purposes might potentially be arranged through university connections.

Finally, the farmer emphasized that he values quality, sustainability, and durability over low prices when selecting agricultural materials. In relation to plastic mulch, he explained that he prefers thicker and stronger materials. While the mulch currently used is approximately 20–40 microns thick, he would prefer a thickness of around 60 microns because it is more durable and resistant to damage.

A5: Farmer 2 interview

During the interview, the farmer discussed his experiences with drip irrigation systems, his collaboration with HGT, and the practical realities of managing a relatively new pepper farm.

The farmer currently cultivates peppers on a plot of approximately 500 square meters located on land that is part of a school property. He has been managing the farm for approximately five to six months, making this his first active production cycle and harvest. In addition to farming, he also works as a teacher in agriculture at the school.

The farmer explained that he initially came into contact with Holland Greentech when searching for seeds and agricultural materials. According to him, the company was recommended as one of the reliable suppliers in the area, after which he independently reached out to them. He stated that he is very satisfied with the support provided by the company and regularly contacts representatives at the Kumasi office whenever assistance or information is needed.

Unlike some other farmers, the interviewee does not actively participate in lead farmer networks and has limited contact with lead farmers. Instead, he primarily relies on direct communication with HGT representatives.

Regarding the installation of the irrigation system, the farmer explained that HGT provided training for both himself and approximately sixty students during the installation process. The company also supplied the irrigation materials required for the setup.

In terms of maintenance, the farmer stated that he has not yet flushed the irrigation lines because he has not encountered any operational problems so far. However, HGT did provide instructions regarding maintenance and repair practices, including recommendations to use additional filters within the irrigation system to reduce potential clogging problems.

The farmer expects the drip tapes to last approximately five years, although he expressed some uncertainty about whether this lifespan will actually be achieved in practice. Once the tapes are no longer usable, he expects that they will most likely be disposed of by burning them.

According to the farmer, the greatest advantage of the drip irrigation system is its ease of use. He described the technology as a “gamechanger” because it significantly reduces labor intensity and simplifies farming activities. He compared the system to the manual watering methods he still uses for some other crops and explained that manual irrigation often fails to deliver water deep enough into the soil, unlike drip irrigation systems.

The farmer also discussed the possibility of recycling used driptapes. He stated that he would be willing to recycle the materials if recycling companies actively reached out to him or purchased the waste materials directly. However, transporting the materials to a recycling facility himself would likely be too expensive due to transportation costs. Additionally, he mentioned that if the used driptapes could serve another practical purpose, he would gladly reuse them in a different application.

Maintaining a clean field was described as an activity that requires continuous effort and discipline. Despite the labor reduction achieved through irrigation technology, keeping the field organized and free from weeds still demands regular maintenance work.

The farmer identified the cost of the driptapes and irrigation materials as the main disadvantage of the system. Nevertheless, he believes the benefits outweigh the disadvantages because the system reduces labor demands and contributes to healthier crop production.

Finally, the farmer explained how the irrigation system operates on his farm. A well supplies water to a storage tank, after which gravity is used to distribute the water across the field because the farmland is positioned lower than the tank itself.

A6: Field operator conversation

During the interview, the field operator discussed his responsibilities regarding irrigation management, maintenance practices, and the use of different irrigation technologies on the agricultural campus.The field operator explained that he is responsible for managing the irrigation systems on campus and for sharing technical knowledge with students. Due to the large number of students, he often trains a smaller group of students directly, after which these students are expected to transfer the knowledge to their peers.

At the time of the interview, three different irrigation systems were being used on campus: drip irrigation, sprinkler irrigation, and raintube systems. The field operator stated that he installs all three systems himself.

The irrigation systems receive water from multiple connected water sources, including pond water, boreholes, and wells. According to the field operator, all water sources are interconnected so that if one source becomes unavailable, another source can continue supplying water to the irrigation systems.

The field operator reported having regular contact with HGT, mainly because the company supplies seeds and irrigation-related materials to the campus. He also mentioned that the company has discussed the possibility of introducing automated irrigation systems in the future. At present, however, the irrigation systems still operate manually.

During the interview, the field operator also discussed the costs of certain agricultural materials. According to him, a dripline system costs approximately 2250 Ghanaian cedis. The raintube systems are purchased from another supplier because Holland Greentech does not supply raintubes. He further explained that cucumber seeds cost approximately 550 cedis per sachet and are purchased seasonally depending on cultivation needs.

For smaller punctures or cuts, the driptapes can be repaired rather than fully replaced. The damaged section can be cut and reconnected using specialized connectors supplied by Holland Greentech. According to the field operator, these connectors are sold in sachets containing fifty pieces, with each connector costing approximately 15 Ghanaian cedis. He indicated that a large number of connectors are used regularly for repairs and maintenance.

When students leave the campus during vacation periods, the driptapes are generally not used. The field operator explained that maintenance during these periods mainly consists of flushing the irrigation lines. Ideally, he believes the systems should also receive chemical treatment by flushing chlorine through the pipes to prevent contamination or blockages. However, in practice, the driptapes are often left exposed to the sun without flushing because removing and reinstalling the systems would require too much labor.

The field operator flushes the irrigation lines approximately once per semester. Most systems are equipped with filters, which he regularly inspects and cleans to maintain proper water flow. He explained that much of his maintenance knowledge was developed independently through experience rather than formal training.

According to the field operator, the driptapes themselves rarely break due to material failure. Instead, most damage occurs in the form of cuts or punctures caused by students handling the materials carelessly. He stated that, in principle, the driptapes do not have a fixed lifespan and can continue being used as long as they remain functional. Only when punctures become too severe are the tapes replaced.

The field operator also mentioned that HGT informed them that punctured driptapes could potentially be returned to the company in exchange for compensation or replacement benefits. When damaged driptapes are removed from the fields, he collects and stores them separately.

In terms of performance, the field operator expressed satisfaction with the drip irrigation systems. He particularly appreciated that the systems continue to function effectively even under low water pressure conditions. When discussing recycling possibilities, the field operator stated that he believes the plastic materials could technically be recycled, but that the campus currently lacks the infrastructure and capacity to organize such recycling processes.

A7: Field visit and conversation with PM

During a field visit together with the project manager of the ACHI program, observations were made regarding the operation, maintenance, and challenges of the irrigation systems used on the agricultural fields. The project manager guided the visit and demonstrated how the irrigation system functions in practice while ongoing maintenance activities were taking place.

At the time of the visit, workers and students were replacing several drip tapes across the fields. During this process, it became clear that many practical aspects of the irrigation system had to be explored independently rather than being formally introduced. The project manager demonstrated the functioning of the irrigation infrastructure while questions were asked throughout the observation process.

The fields are prepared in raised soil beds, although crops are not planted directly in the middle sections of the ploughed soil. According to the project manager, these middle sections are mainly associated with weed growth. Plastic mulch has only recently been introduced to the fields, starting from the current semester. The mulch is intended to reduce weed growth and therefore minimize the need for manual weed cutting.

The irrigation systems across the fields are interconnected. As a result, increasing water pressure in one section requires reducing or shutting off water flow in other sections of the system. To check whether driptapes are damaged, water is pushed through the lines while visually inspecting for cuts or leakages.

According to the project manager, many driptapes have recently been replaced due to frequent damage. The primary cause of this damage is students accidentally cutting the driptapes while manually removing weeds from the fields. The recent introduction of plastic mulch has reduced the need for weed cutting and therefore also reduces the number of accidental cuts in the irrigation lines.

The PM also discussed technical challenges related to the pumping system. The main pump tends to stop functioning after approximately thirty minutes because it becomes blocked. As a result, a new pump has recently been purchased. Additionally, the irrigation system is partially dependent on solar energy. This means that when there is insufficient sunlight, the system cannot function effectively.

Not all fields currently use plastic mulch because the material is considered too expensive to implement everywhere. When drip tapes become damaged, smaller damaged sections are sometimes cut out and the shortened driptapes are reused on smaller field sections. In other situations, connectors are used to reconnect damaged sections. However, connectors are also relatively expensive, which limits how frequently they are used.

According to the PM, financial resources generated from successful crop seasons are often reinvested into improving the farming systems, such as purchasing additional plastic mulch.

The PM also expressed concerns regarding student behavior and responsibility on the fields. According to him, students often leave materials such as planting trays and other waste on the fields after working. He described this behavior as careless and linked it to a lack of responsibility rather than a lack of technical knowledge.

Regarding crop management, vegetable crops are fertilized approximately once every two weeks. The irrigation infrastructure includes separate tanks for water and fertilizer, and a third tank is currently under construction. The crops receive approximately 0.5 liters of water per day, and the irrigation system typically operates for about one hour daily.

The PM explained that the irrigation system has been in use since 2015. However, the drip tapes themselves are replaced every semester, requiring the purchase of a completely new set of tapes each cycle. In the past, thicker and more durable driplines were used, and the project manager stated that these performed significantly better. However, due to increasing costs, the institution shifted toward cheaper alternatives.

Finally, the PM emphasized that many students are taught how the irrigation systems work and how they should be maintained. According to him, the frequent damage to the driptapes is therefore not caused by a lack of knowledge, but rather by a lack of care and responsibility in practice.

A8: Farmer 3 interview

During the interview, the lead farmer discussed her experiences with drip irrigation systems, maintenance practices, and her long-term involvement with the ACHI program and Holland Greentech. The farmer explained that she has been managing her farm for approximately thirteen years and belonged to the first batch of the ACHI program. Through the ACHI training, she was introduced to drip irrigation systems and later became a lead farmer within the program.

The drip tape system was provided to her free of charge after completing the ACHI training and becoming a lead farmer. She explained that if the system had not been provided through the program, she would have purchased it herself because she considers irrigation highly valuable for farming.

As a lead farmer, other farmers regularly visit her farm to ask questions and seek advice about farming practices. She explained that many farmers are especially interested in raintube systems, although she personally believes that driptape systems are particularly effective for certain vegetable crops.

The farmer has been using the same driptape system for approximately four years without major problems. However, she recently started noticing changes in the material quality. According to her, the color of the driptapes has begun to change, and the material appears weaker when folded. She expects that the tapes may soon begin to break and will eventually need replacement.

She explained that she does not know the exact thickness of the driptapes because the materials were simply supplied by HGT. During the initial installation, representatives from Holland Greentech installed the system together with her. Since then, she has learned to install and reinstall the system independently after each dry season.

The irrigation system operates using groundwater as its main water source. Water is pumped into a polytank through a filtration system before being distributed through the driptapes.

Unlike some other farmers, the interviewee does not use the driptapes during the dry season. Instead, she removes the tapes, folds them, and stores them inside her house. According to her, this is necessary because otherwise the materials may be stolen or damaged by rats. Additionally, the irrigation system becomes less effective during the dry season because the borehole water supply is insufficient.

In terms of maintenance, the farmer only flushes the irrigation lines when a problem occurs or when reinstalling the system after storage. During regular use, she manually straightens the driptapes to prevent sand accumulation and weed growth around the lines. She explained that during the ACHI training, maintenance was mostly taught theoretically rather than through practical demonstrations.

To avoid damaging the driptapes while removing weeds, she temporarily moves the tapes to the side before cutting vegetation. Unlike some other farmers, she does not use connectors to repair damaged sections because HGT did not provide connectors during her training.

Two pieces of her driptape system have already become old and unusable, and she has separated these damaged sections from the functioning materials.

The farmer explained that she appreciates the drip tape system because it makes agricultural work easier and allows better control over water use. However, she identified cost as the main disadvantage of the system. Financial limitations also prevent her from using plastic mulch, even though she is aware of its advantages for reducing weeds and protecting irrigation systems.

Regarding disposal practices, the farmer stated that she would normally burn old driptapes after use. However, she also explained that if a recycling program became available, she would be willing to send the materials for recycling instead.

The farmer noted that contact with Holland Greentech has decreased significantly over time. According to her, representatives from the company visited regularly during the early stages of the project, but these visits have become infrequent. The last direct visit took place approximately two and a half years ago when she experienced problems with cucumber crops and requested assistance.

Despite the reduced contact, the farmer stated that she would still participate in programs or events organized by HGT whenever possible. She regularly attends Farmer Field Days together with the ACHI program and also participates in an HGT-organized event in Accra that serves as a closing program for students.

Appendix B: Focus group evaluations

Evaluations of the results of focus group 1 and focus group 2 have been made.

B1: Focus group 1 evaluation

A co-creation session was organized with seven alumni from the ACHI program. The participants represented different ACHI batches, specifically batches 1, 5, 9, and 10. At the beginning of the session, the participants appeared somewhat shy and reserved. However, after emphasizing that all ideas and questions were welcome, that there were no wrong answers, and by expressing appreciation for their attendance, the atmosphere became more relaxed and interactive. Following most questions, additional discussions took place in which participants explained the reasoning behind their responses.

Initially, it was expected that most attendees would already be actively working as farmers. However, during the session it became clear that only a few participants were currently farming professionally. As a result, several questions had to be reframed from present-tense questions such as “Do you have?” to future-oriented questions such as “Would you want?”

Motivation to become a farmer
When discussing motivations for becoming farmers, the participants mainly referred to two themes: income generation and food security. Participants explained that farming offers opportunities to generate income while also responding to increasing food demand caused by population growth.

Round 1 — Irrigation, Farming Networks, and Farming Practices
Interest in irrigation systems
All participants indicated that they would like to use irrigation systems in their future farming practices. Irrigation was viewed as an important tool for increasing farming efficiency and enabling year-round production. However, affordability was identified as a major challenge. Participants explained that irrigation systems are expensive and often require farmers to gradually save money before they can invest in such technologies. Several participants emphasized the importance of starting small and expanding over time as financial resources become available.

Experiences with damage to driptapes
Participants acknowledged that cuts and damage to driptapes occur regularly. Several causes were identified:
-Exposure to sunlight causes the plastic materials to become weaker and more brittle over time.
-Driptapes are frequently damaged during manual weed removal activities.
-Plastic mulch itself can also weaken and tear more easily after prolonged exposure to environmental conditions.

Participants additionally suggested that cutting holes manually into the plastic mulch contributes to weakening the material. According to them, pre-made planting holes in the mulch would likely reduce accidental tearing and damage.

Contact with Holland Greentech
Most participants were familiar with HGT, and several maintained contact with the company. One participant explained that a representative from HGT had joined the ACHI alumni communication group. Participants generally described the company positively and highlighted that HGT seeds are known for extending the shelf life of crops. However, the products were also described as relatively expensive.

Farmer field days and knowledge sharing
Participants explained that during the ACHI program they regularly attended farmer field days, where they visited farms and exchanged knowledge with other farmers and alumni from locations such as Wenchi. According to the participants, all ACHI batches are invited to attend these events, which function as opportunities for networking and learning.

Collaboration between farmers
All participants emphasized the importance of collaboration and knowledge exchange between farmers. One participant summarized this by stating that “two heads are better than one.” Despite this appreciation for collaboration, none of the participants identified themselves as lead farmers.

Round 2 — Irrigation Knowledge and Plastic Use
Knowledge and perceptions of irrigation
Participants described irrigation as essential for successful farming. They highlighted several advantages, including:
-Efficient water use
-Easier fertilization through fertigation systems
-Increased farming efficiency
-The possibility of year-round farming
-Improved crop productivity

At the same time, several disadvantages were also identified:
-High initial investment costs
-Difficult maintenance processes
-Challenges in obtaining spare parts
-Complexity during installation and setup

Participants specifically mentioned PVC pipes and connectors as important components of irrigation systems.

Several participants stated that irrigation makes farming more attractive and professional. Others emphasized that irrigation systems are “the key to successful farming.”

Plastic materials used on farms
Participants identified several plastic-based agricultural materials commonly used on farms, including:
-Seed trays and nursery crates
-Driptapes
-PVC pipes
-Plastic mulch
-Watering cans
-Seed drills

One participant explained that he personally uses a small garden with soil-filled sacks and containers. He waters the plants manually and mainly grows crops for personal consumption. According to him, taking care of the plants in the morning is an enjoyable way to start the day.

Plastic waste management practices
Participants discussed several current disposal practices for agricultural plastics. Burning plastic was commonly mentioned, although awareness existed regarding the negative environmental consequences. One participant explained that he previously burned plastic behind his house until neighbors complained, after which he started placing the waste in trash bins collected by waste tricycle services. These tricycles travel through neighborhoods collecting waste for a small fee, usually around five cedis depending on the amount of waste.

Other disposal methods mentioned included:
-Digging pits and burying plastic waste
-Throwing waste into general garbage sites
-Reusing undamaged plastic materials
-Sending plastics for recycling, although this was described as uncommon

Some participants explained that organizations such as KBI, an ACHI partner organization, provide environmental awareness training regarding waste management. Several participants explicitly acknowledged that plastic takes a long time to decompose and negatively impacts the environment. Although recycling was considered preferable, many participants indicated that recycling infrastructure and opportunities are currently limited.

Round 3 — Plastic Collection and Recycling Ideas
Improving plastic collection on farms
articipants developed several ideas for improving plastic waste collection systems on farms.

Suggested interventions included:
-Installing dedicated waste bins on farms
-Creating awareness campaigns using signs and posters placed on trees and public locations
-Establishing collection points specifically for agricultural plastics
-Encouraging farmers to manually collect and separate plastic waste
-Providing waste bins directly to farmers
-Organizing regular transportation of plastic waste to recycling facilities
-Offering incentives to motivate farmers to collect more plastic waste

One participant proposed a slogan encouraging farmers to place plastic waste directly into collection bins.

Potential new products from recycled plastic
Participants also brainstormed possible products that could be made from recycled agricultural plastics. Ideas included:
-Plastic stakes for farming
-Plastic watering cans
-Plastic nursery crates
-Plastic mulch
-Tapes for budding and grafting
-Water tanks
-Packaging bags

Learning about irrigation maintenance and recycling
Participants identified several ways through which farmers could learn more about irrigation maintenance and recycling practices. Suggested learning methods included:
-Receiving training from technical experts
-Learning from Holland Greentech after purchasing irrigation kits
-Watching YouTube videos and online tutorials
-Conducting independent online research
-Visiting irrigation sites and recycling companies
-Learning through Farmer Field Days
-Learning from fellow farmers and ACHI colleagues
-Contacting experts from institutions such as Kwadaso Agricultural College

Participating in the ACHI program itself
Participants additionally suggested creating practical maintenance measures to reduce damage to driptapes and organizing collection systems where damaged driptapes could be stored centrally before being transported to recycling companies in exchange for new materials.

Overall, the co-creation session demonstrated that participants were highly aware of both the opportunities and challenges associated with irrigation systems and agricultural plastics. The discussions also revealed strong interest in collaborative learning, recycling initiatives, and practical solutions for improving sustainable farming practices.

B2: Focus group 2 evaluation

A second co-creation session was organized with ACHI alumni and farmers to evaluate several prototype concepts related to irrigation maintenance, plastic waste management, and communication systems. The session was divided into three rounds.

During the first round, participants individually answered questions using post-it notes, after which the responses were discussed collectively. In the second round, participants worked in groups and evaluated several prototype concepts one by one using guiding questions presented in a PowerPoint presentation. The third round originally aimed to continue group-based written exercises, but this approach was changed into open discussions after it became clear that participants were becoming less engaged with continuous writing activities. The group discussions generated significantly richer insights and stimulated collaborative idea generation.

Round 1 — Farming Practices, Record Keeping, and Irrigation Maintenance
Daily life on the farm

Participants described daily farm activities as primarily focused on checking and monitoring crops. Several participants emphasized that farming is physically demanding and requires continuous attention.

Common themes included:
-Monitoring crop health and growth
-Watering and irrigation
-Observing plant wellbeing
-Harvesting crops
-Managing labor
-Emotional responses linked to crop performance

Participants explained that successful crop growth creates feelings of happiness and motivation, while crop failure or the inability to pay workers creates stress and anxiety. Farming days were generally described as busy and highly task-oriented.

Record keeping practices

Participants explained that keeping detailed records is considered important for successful farming. Record keeping methods included:

-Tracking planting dates
-Monitoring rainfall
-Recording fertigation activities
-Tracking harvesting periods
-Monitoring sales and financial investments
-Recording seed emergence and crop yields
-Taking pictures and videos for documentation

One participant explained that Holland Greentech
also provides templates for keeping track of farming activities, including planting schedules and harvesting records.

Participants emphasized that financial tracking is equally important, particularly documenting investments and expected returns after harvest. Several participants used farm record books and structured templates to organize this information.

Importance of irrigation maintenance guidelines

All participants agreed that clear irrigation maintenance guidelines would be highly valuable.

The main reasons included:
-Reducing costs for purchasing replacement irrigation systems
-Preventing damage and improving maintenance practices
-Serving as reminders for maintenance activities
-Improving irrigation efficiency and water flow
-Reducing dependency on technical representatives
-Lowering repair and transportation costs
-Helping inexperienced farmers maintain irrigation systems independently

Participants explained that when technical representatives from HGT visit farms for repairs or support, farmers often need to pay transportation and service costs. As a result, accessible maintenance guidelines could reduce these expenses significantly.

Round 2 — Prototype Evaluations
Prototype 1: Irrigation Maintenance Calendar
Participants evaluated a prototype irrigation maintenance calendar designed to help farmers schedule and remember maintenance activities.

Positive feedback

Participants appreciated that the calendar could:
-Serve as a reminder system
-Track irrigation activities
-Improve driptape lifespan
-Provide maintenance tips
-Encourage proper maintenance culture

Suggestions included:
-Including guidance on protecting pipes from rodents
-Using UV-resistant pipes
-Displaying the calendar in farmhouses

Challenges identified
Several participants identified limitations:
-Many farmers do not have farmhouses or suitable places to hang calendars
-Exposure to weather conditions could damage paper calendars
-Flushing instructions were considered too limited and insufficiently detailed

Participants suggested:
-Laminating the calendar to make it waterproof
-Hanging calendars near farming tools
-Combining physical calendars with mobile phone reminders and alarms

One participant explained that he stores farming tools in a small corner at home, suggesting that such locations would be more practical than placing the calendar directly on the farm.

Prototype 2: Maintenance checklist

Participants generally preferred the checklist concept over the calendar because it provided more detailed and practical information.

Advantages identified
The checklist was considered useful for:
-Tracking weekly maintenance activities
-Recording repairs and inspections
-Monitoring emitter blockages
-Improving irrigation system lifespan
-Providing structured maintenance instructions

Participants appreciated the possibility of storing the checklist both physically in the farmhouse and digitally on mobile phones.

Suggested improvements
Participants requested:

-More detailed flushing instructions
-Information about identifying blockages
-Guidance regarding repair intervals
-Scheduled reminders linked to mobile phone calendars

Participants suggested combining the checklist and calendar systems into one integrated tool.

Prototype 3: Social media training promotion
Participants evaluated a prototype social media advertisement promoting irrigation maintenance training sessions and Farmer Field Days.

Responses
Participants indicated strong interest in attending irrigation maintenance training sessions, especially if focused specifically on driptape systems.

Participants highlighted that many farmers avoid using driptape systems because maintenance procedures are unclear. Therefore, specialized training was considered highly valuable.

Suggested communication channels
Participants recommended promoting training sessions through:
-TikTok
-Facebook
-WhatsApp communities
-ACHI alumni groups
-Radio and television
-Posters in public spaces and marketplaces

Participants explained that Instagram alone would not effectively reach many farmers, particularly those with lower literacy levels. Audio and video-based communication methods were therefore recommended.

Prototype 4: Reward and points system

The final prototype involved a digital reward system connected to irrigation maintenance activities.

In this concept, farmers would receive weekly maintenance tips through WhatsApp groups. Farmers could upload pictures showing maintenance activities, such as flushing irrigation lines, in exchange for sustainability points. These points could later be exchanged for discounts on products such as driptapes, mulch, or connectors.

Participant reactions
This prototype generated the strongest positive response during the session.
Participants described the concept as:
-Motivating
-Competitive
-Engaging
-Easy to understand
-Beneficial for long-term maintenance behavior

Several participants compared the system to existing mobile network provider reward systems, such as MTN point systems, which are already familiar within the region.

Participants believed that the reward system would strongly motivate farmers to maintain irrigation systems properly. The competitive aspect was considered particularly attractive, and participants explained that even farmers unfamiliar with taking pictures would likely ask younger family members to help them participate.

Participants also suggested expanding the system to include rewards for recycling agricultural plastics, even though most farmers currently lack the ability to recycle materials independently.

Questions raised during the discussion included:
-How points would be earned
-How discounts would be calculated
-Whether Holland Greentech would support such a system

Participants repeatedly emphasized that the system could help “keep farmers on track” regarding irrigation maintenance practices.

Additional insights and discussions
During the discussions, participants also reflected on broader challenges related to irrigation systems and farming practices at the KAC and within the ACHI network.

One participant explained that KAC should ideally function as a “field of excellence” where visitors can observe high-quality agricultural practices. However, participants felt that the current irrigation infrastructure and field conditions still require significant improvement.

Additional challenges identified included:
-Rodent damage to driptapes
-Sun exposure weakening plastic materials
-Cuts underneath plastic mulch causing hidden leakages
-Lack of detailed maintenance knowledge among farmers

Participants suggested exploring more rodent-resistant and UV-resistant irrigation materials in the future.

Overall, the co-creation session demonstrated strong interest in practical maintenance support systems, digital learning tools, reward-based engagement strategies, and collaborative knowledge-sharing approaches for improving irrigation management and sustainability practices among ACHI alumni and farmers.

Appendix C: Poster for visit Ghanaian minister of food and agriculture at The Green Village

Reducing agricultural plastic waste in Ghana through

recycling & lifespan extension



Drip tape

Current diposal

Burning
Burying
Littering

Challenges
It is not that farmers aren't aware of the risks of this way of disposing, but there is no suitable alternative.

Namely, to bring it to a waste site or recycling company **the farmers need to pay** tricycle pickups or gas money.

Early damages

Rodents
Weeding method
Lack of clear maintenance guidelines

Challenges
Plastic mulch and couplings are common solutions for early damages, but remain **costly** for farmers.

The lack of clear maintenance guidelines leads to improper maintenance, **reducing the lifespan** of drip tape.



From challenge to opportunity: turning agricultural plastic waste into **economic value** for the Ghanaian farmer





Together **with** Ghanaian farmers, insights were gathered through interviews, focus groups, surveys, and field visits with ACHI alumni and experts.

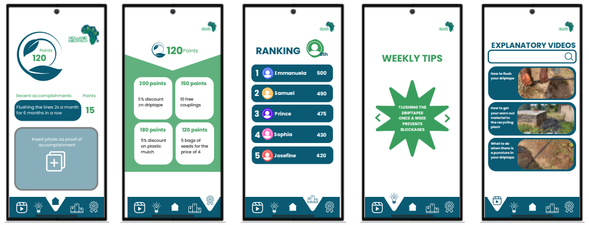
The Kumasi Compost & Recycling Plant (KCARP) is testing the **recyclability** of the drip tapes and plastic mulch. Recycled pellets have been produced and are currently being evaluated. Early results are **promising**, with potential integration into KCARP's production process.







The greenpoint app



A strong **implementation plan** is key. Adoption will be supported through training and promotion. The design prioritizes clarity and ease of use.

The **economic incentive**: a discount on farming products when recycling and maintaining.

Earn points by showing proof of recycling and maintenance tasks

+Exchange points for discount on agricultural plastics
+Reduced costs through longer-lasting irrigation materials
+Personalized maintenance guidance
+Always accessible via mobile phone
+Timely maintenance reminders
+Easy-to-follow maintenance videos

ACHI
Transforming the Horticulture Sector in Ghana

Appendix D: Survey questions and result one-pagers

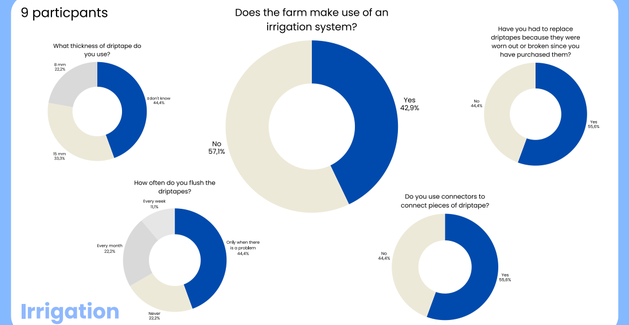
D1: Survey 1, Reducing plastic waste in agricultural fields

1. How long have you been working on a farm?
Less than 1 year / 1–3 years / 4–7 years / More than 7 years
2. What kind of farmer are you?
Farm owner / Tenant farmer / Family farm worker / Seasonal worker / Member of farming cooperative / Community-based farmer / Other
3. What kind of farm do you work on?
Open-ended response
4. In which region is the farm located?
Ahafo / Ashanti / Bono / Bono East / Central / Eastern / Greater Accra / North East / Northern / Oti / Savannah / Upper East / Upper West / Volta / Western / Western North
5. Are you a lead farmer?
Yes / No
6. Does the farm make use of an irrigation system?
Yes / No
7. What is your main water source for irrigation?
Borehole / River-stream / Rainwater harvesting / Reservoir / Dam / Other
8. How long have you been using an irrigation system on your farm?
Less than 1 year / 1–3 years / 4–7 years / More than 7 years / I don't use an irrigation system / Other
9. If you have driptapes, do you flush your driptapes?
Yes / No
10. If yes, how often do you flush the driptapes?
Every day / Every week / Every month / A few times per season / Only when there is a problem / Never / Other
11. What thickness of driptape do you use?
8 mm / 15 mm / I don't know
12. Have you had to replace driptapes because they were worn out or broken since purchase?
Yes / No
13. If yes, how often do you replace the driptapes?
Once / Twice / 3 times / 4 times / 5 times / Other
14. Do you use connectors to connect pieces of driptape?
Yes / No
15. How do you store driptapes when not in use but intended for reuse?
Rolled up and stored indoors / Stored outside / Buried-covered on the field / Not stored (discarded after use) / Other
16. Do you bury the driptapes under the plastic mulch?
Yes / No
17. If there was a program to collect old driptapes, what would motivate you most to participate?
Give for free if collected / Participate for reward / Participate if collection is easy / Would not participate / Other
18. Do you use plastic mulch on your farm?
Yes / No
19. If yes, how often do you replace the plastic mulch?
Every season / Every year / Every 2–3 years / Only when damaged / I don't use plastic mulch / Other
20. Do you attend community garden trainings or farmer field days?
Yes / No
21. If no, what is the main reason?
No time / Too far to travel / Not useful for my farm / I was not informed / Other
22. Where do you usually get your farming information?
Holland Greentech / Own research-experience / Other farmers
23. Do you have regular contact with Holland Greentech representatives in your region?
Every day / Every week / Every month / Every couple of months / Every half year / Every year / Never
24. Do you know local lead farmers?
Yes / No
25. Do you have contact with local lead farmers?
Yes / No
26. What are the two most important factors when purchasing driptape?
Quality / Price / Ease of use / Easy delivery / Sustainability / Good contact with distributor
27. Do you currently reuse plastic agricultural waste for an alternative purpose?
Open-ended response
28. Do you have ideas on how agricultural plastic waste could be reused or recycled?
Open-ended response
29. Do you have any other comments or suggestions?
Open-ended response

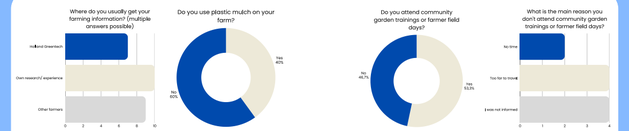
15 participants

Reducing plastic waste in agricultural fields - ACHI alumni

9 particpants



Irrigation



Other

Do you have any ideas on how agricultural plastic waste could be reused or recycled? If yes, in what way? If no respond no.

Yes, it can be collected and be sold out to the plastic industries to be used for the manufacturing of other plastic product.

The waste in general could be organic (biodegradable) and inorganic (non biodegradable plastic) materials. Plastic manufacturing companies can reuse them to make plastic chairs and other domestic use and possibly plastic for agricultural use.

NO, because there is no recycling plant here.

Yes by burning it

Yes by recycling them to rain hose plastic mulch

Reuse and recycle ideas

D2: Survey 2, student survey, drip irrigation & field work (KAC)

1. Which year are you in at KAC?
First / Second / Third / Alumni / ACHI alumni / Other

2. If you are an Alumni of KAC, in what year did you graduate?
Open-ended response

3. How often do you work on fields with drip irrigation?
Every day / A few times per week / A few times per month / Rarely / Never / Other

4. How confident do you feel working with drip irrigation during field activities?
Scale 1–5 (Not confident at all – Very confident)

5. What do you think drip irrigation is mainly used for?
Saving water / Bringing water directly to plant roots / Improving crop growth / Reducing weeds / I am not sure

6. Have you received training on how to work with drip tape?
Yes, practical training in the field / Yes, only theory / No / I don't remember

7. How reliable is the irrigation system when it is needed?
Scale 1–5 (Never reliable – Always reliable)

8. What problems do you experience most with the irrigation system?
Low water pressure / No water when expected / Leaks or broken tape / Blockages / System already damaged before use / I don't experience many problems

9. Think about the last time you weeded using a machete near drip tape. What did you usually do with the tape?
Left it where it was / Moved it aside and put it back / Moved it aside but not back / I am not sure / Other

10. If the drip tape is NOT moved or put back, what are the main reasons?
Takes too much time / Tape is tangled or difficult to move / Did not know I should move it / Not enough supervision / Machete makes it risky anyway / Irrigation often does not work / Not my responsibility / Other

11. How often do you see damaged drip tape during field work?
Never / Sometimes / Often / Almost every time

12. What do you think causes damage to drip tape most often?
Weeding with machete / People stepping on it / Poor installation / Old or worn-out material / Animals / Water pressure problems

13. When drip tape is damaged, what usually happens?
Repaired immediately / Reported to staff / Left until later / Tape replaced / I am not sure / Other

14. How easy is it to report damage?
Scale 1–5 (Very difficult – Very easy)

15. What makes reporting damages difficult?
Don't know who to tell / Takes too much time / Afraid of being blamed / It does not get fixed anyway / Not my responsibility / Nothing, reporting is easy

16. How important do you think drip irrigation is for crop growth at KAC?
Scale 1–5 (Not important – Very important)

17. How responsible do you personally feel for keeping drip tape in good condition?
Scale 1–5 (Not responsible – Very responsible)

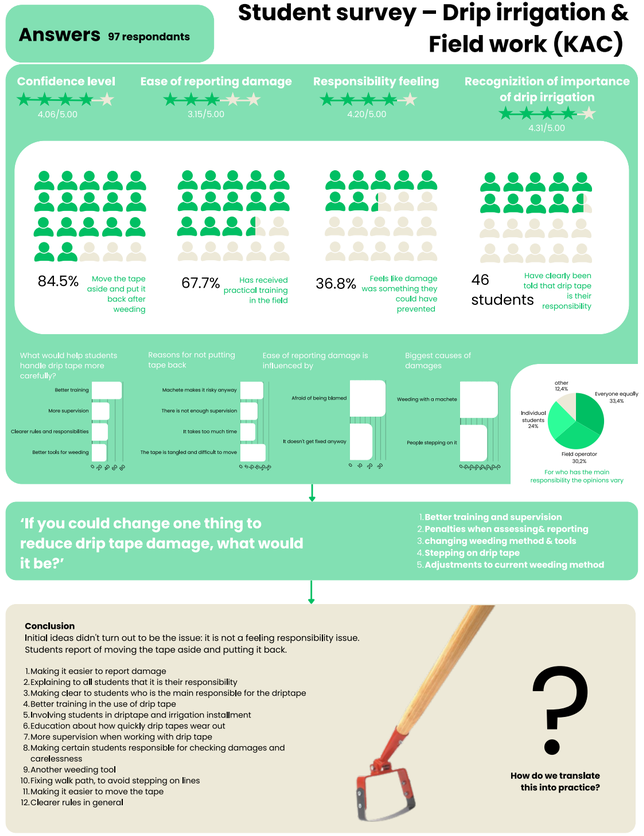
18. Why do you feel this level of responsibility?
Clearly told it is my responsibility / Never clearly told who is responsible / Decisions made by instructors or staff / No power or tools to fix problems / Damage happens anyway / No consequences for damage / No clear benefits when used well / Only responsible when instructor is present / Not part of evaluation / Other

19. What would help students handle drip tape more carefully?
Better training / Clearer rules and responsibilities / Better weeding tools / Clearer crop growth results / More supervision / Rewards or recognition / Penalties / Other

20. Who do you think is mainly responsible for the condition of the drip tape?
Individual students / Student groups or teams / Instructors / Field operator / Everyone equally / I don't know / Other

21. When drip tape gets damaged, how does it usually feel?
Something I could have prevented / Accident / Something that happens anyway / System problem / Someone else's responsibility / I don't think much about it / Other

22. If you could change one thing to reduce drip tape damage, what would it be?
Open-ended response



D3: Survey 3, Farmer questionnaire, GreenPoints app

1. **What is your age?**
   Open-ended response
2. **Are you a lead farmer?**
   Yes / No
3. **For how long have you already been using irrigation?**
   Open-ended response

Part 1: Phone Use
4. **How often do you use your smartphone?**
   Every day / A few times a week / Rarely / Other
5. **What do you mainly use your phone for?**
   WhatsApp / Calls / Videos / Farming information / Mobile money / Other
6. **How comfortable are you using apps?**
   Scale 1–5 (Difficult – Comfortable)

Part 2: Interest in the GreenPoints App
7. **Would you be interested in an app that gives rewards or discounts for maintaining drip irrigation, recycling agricultural plastic, and helping other farmers?**
   Yes / Maybe / No / Other
8. **What part sounds most interesting to you?**
   Earning discounts / Learning about farming / Recycling plastics / Helping other farmers / Competing with other farmers / Other

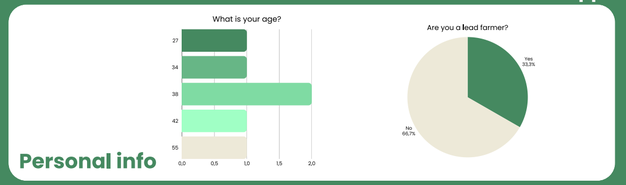
Part 3: Barriers
9. **What would make it difficult for you to use the app?**
   Internet-data cost / Phone skills / Time / Taking photos / Not interested in phones / Other

Part 4: Recycling
10. **Would you be willing to store agricultural plastics if they could later be collected for recycling?**
    Yes / Maybe / No
11. **What would motivate you most to recycle plastics?**
    Money-discounts / Cleaner farm / Helping environment / Helping community / Other

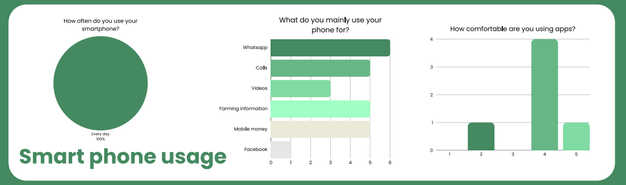
Part 5: Community
12. **Would you ask questions to other farmers through a phone app?**
    Yes / Maybe / No
13. **Would you help answer questions from other farmers?**
    Yes / Maybe / No
14. **Do you think this app would work better for:**
    All farmers / Mainly younger farmers / Mainly lead farmers / Mainly farmers already comfortable with smartphones / Other
15. **What would make this app truly useful for you?**
    Open-ended response
16. **Other comments?**
    Open-ended response

6 participants

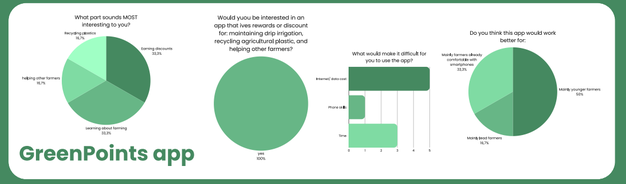
Farming questionnair GreenPoints app



Personal info



Smart phone usage



GreenPoints app

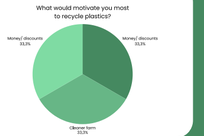
Almost all farmers would be willing to store agricultural plastics if they could later be collected for reyccling.

Almost all farmers would ask questions to other farmers through a phone app and would help answer questions from other farmers.

Recycling

Other comments?

Can't wait to have the app.



What would make this app truly useful for you?

Add pest and disease management, user friendly, when it is able to help keep reduce cost of production, if the app can work without internet and to be very simple to use, improve my farming skills and the app will help to dispose the old drip irrigation

Appendix E: consent form

The showcase video deliverable includes the face and voice of a participant. To ensure ethical consent and permission for use, a consent form was prepared and signed by the participant.

CONSENT FORM 16/03/2025

Reducing Plastic Waste In Agricultural Fields, Ghana

Responsible researcher: Nova Meijer

You are being invited to participate in a research study titled “System design for the extended use and recycling of agricultural plastics in Ghana.” This study is being conducted by master’s student Nova Meijer from TU Delft, Faculty of Industrial Design Engineering (IDE), in collaboration with the ACHI project, a partnership between TU Delft, Kwadaso Agricultural College, and Holland Greentech. These parties provide guidance and support during the research project.

The purpose of this research study is to gain a clearer understanding of the project scope, specifically the design challenge of reducing damage to plastic materials and plastic waste in agricultural fields. Participation will take approximately 5 minutes.

The data collected will be used for the MSc thesis of the researcher at TU Delft. Data will be collected in the form of a video recording (PIRD), which includes identifiable personal data (face and voice) These recordings will be used as part of a final video deliverable for the MSc thesis project and may be included in presentations or documentation related to the thesis.

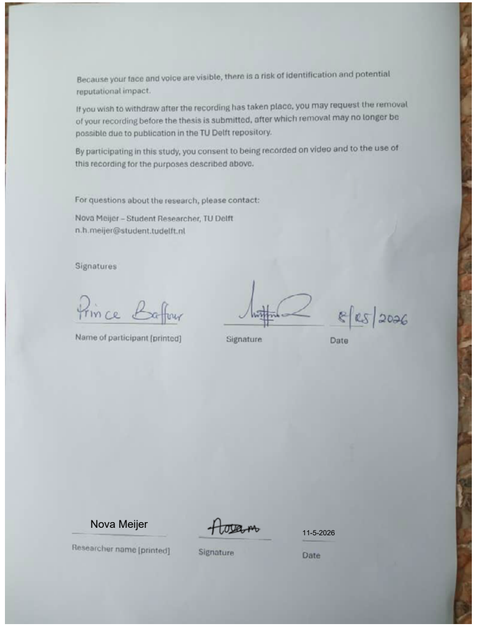
During the recording, you will be asked to answer questions related to the current plastic waste operations at Kwadaso Agricultural College. Your full appearance (face and body) will be visible in these recordings.

Participation involves minimal risk. However, because the recordings include your identifiable appearance, there is a small potential privacy or reputational risk if the video becomes publicly accessible.

As with any digital activity, the risk of a breach is always possible. To the best of our ability your responses in this study will remain confidential. We will minimize any risks by storing the data in the TU Delft OneDrive secure storage environment with restricted access. Access to the recordings will be limited to the researcher and the supervising researcher at TU Delft.

The video will be published as part of the TU Delft thesis repository and may be publicly accessible worldwide. The research data will be stored and managed according to TU Delft research data management guidelines.

Your participation in this study is entirely voluntary, and you may withdraw at any time without any negative consequences. You are free to omit any questions.



Because your face and voice are visible, there is a risk of identification and potential reputational impact.

If you wish to withdraw after the recording has taken place, you may request the removal of your recording before the thesis is submitted, after which removal may no longer be possible due to publication in the TU Delft repository.

By participating in this study, you consent to being recorded on video and to the use of this recording for the purposes described above.

For questions about the research, please contact:

Nova Meijer – Student Researcher, TU Delft
n.h.meijer@student.tudelft.nl

Signatures

Prince Baffour — Name of participant [printed]

Signature

8/05/2026 — Date

Nova Meijer — Researcher name [printed]

Signature

11-5-2026 — Date

Appendix F: AI statement

The development of the GreenPoints app involved the use of AI-assisted software development tools. The application was built using Loveable, a platform that generates and structures code based on user-written prompts. Within this process, AI was used as a technical support tool for implementation and prototyping.

All core concepts, interaction ideas, design decisions, functionality, and project direction were independently developed by the author. The AI tool did not determine the concept or content of the project, but supported the translation of these ideas into a functional digital application.

AI was therefore used as an assistive instrument in the development process, comparable to a digital prototyping or coding support tool, while all critical thinking, creative direction, and decision-making remained the responsibility of the author.