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Designing a Smart, Modular Greenhouse for Rural India

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PROBLEM

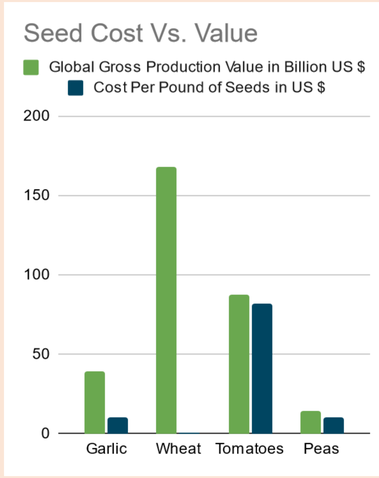
Frame of Reference

Indian citizens have difficulties making money in rural areas. Farming, a popular avenue towards making money in these areas, can be inefficient at times. This issue needs to be addressed promptly or local economies will continue to struggle.

Existing Greenhouses

- Greenhouses are structures that allow farmers to have complete control over their crops.
- Greenhouse efficiency is enhanced through the use of smart systems.
- Smart systems use sensors to monitor conditions. Once conditions are recorded, the data are read, and the system maintains ideal conditions.

Problem Description



The high cost of conventional greenhouse farming limits its use to high-value crops, excluding some farmers. To address this, we propose designing and deploying low-cost modular greenhouses using local waste materials for construction, aiming to make greenhouse farming more accessible and affordable for farmers based in rural India.

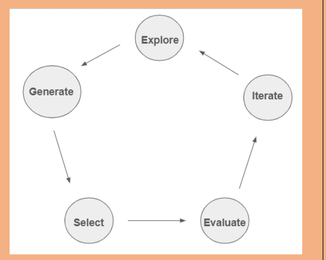
DESIGN METHOD

Initial Steps

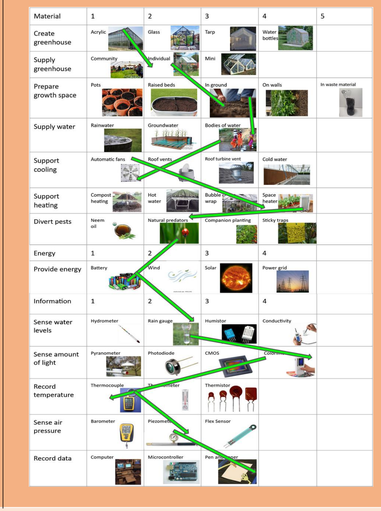
- Design development included dissecting the problem with a requirements list.
- Gathering information about the scope of the project refined our ability to extract knowledge gained from research.
- Pairing the requirements list with a randomized design system allowed us to generate four unique concepts that fit the constraints outlined before ideation.

Table 1: Augmented Functional Requirements

Katy Joyce Timi Oduleye	Requirements List for Project Greenhouse		Issued On: January 25, 2024	
Functional Requirements				
Num	Requirements	D/W	Measurable Objective	Responsible
1	The greenhouse can be scalable, allowing farmers to expand or modify it based on their evolving needs.	W	The structure has several possible configurations.	Katy Joyce



Concept Evaluation



- Concept generation is enhanced through critical thinking.
- Breaking down each design using PMI and PDPC revealed strengths/weaknesses.
- Better iterations were developed as we continued to grow in our research skills.
- Once concepts are fully evaluated, they need to be methodically filtered out based on potential for success in the outlined scenario.

Go/No Go Analysis

Concept 3 (Lean Green Eco Machine): Go/ No Go Analysis

Effective Self-Regulation (7 points)	Prevent Humidity Buildup (6 points)	Allow Sunlight Penetration (5 points)	Provide Water (4 points)	Suitable Growing Medium (3 points)	Regulate Pests (2 points)	Operate Cost-Effectively (1 point)
No Go	Go	Go	Go	No Go	Go	No Go

Go Total: 17 points

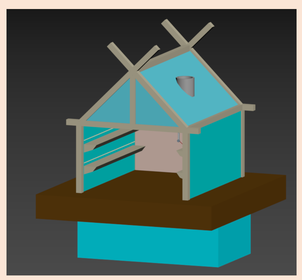
No Go Total: 11 points

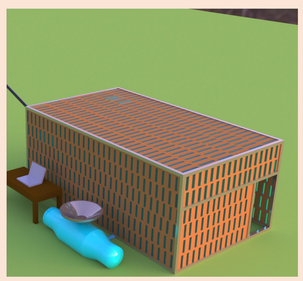
- Go/No Go analyses are used in research to compare designs using certain criteria.
- Chosen criteria are framed and prioritized in the context of providing the greatest yield for rural India (focus on desired modularity).
- If a design received a "No Go", we then identified potential modifications that could be made to better the design.

POSSIBLE OUTCOMES

Concept Comparison

After conducting the Go/No Go Analysis, two concepts fulfilled all functional requirements.





Both designs have their merits, but Concept 4 was chosen due to its ability to remain self-sufficient while enhancing the local community.

Chosen Concept

For our chosen concept, we decided on concept 4. This design exemplifies the balance of "smart" and "modular" defined in the requirements list in several ways:

- Concept 4 utilizes a smart system that is able to properly measure and regulate greenhouse conditions.
- Concept 4 is almost entirely made from reusable materials, making it cost- efficient and eco-friendly.
- Sustainable water collection and heating methods are utilized.
- Companion plants keep bugs away and have the potential to be sold for profit.

Value + Way Forward

There are plenty of ways the project can be developed further, including prototyping and design validation. More research needs to be done regarding monetary feasibility.

Katy's value: I found value in getting to learn more about research and the design process. I loved touring the greenhouses and plan on contributing to other research projects in the future.

Timi's value: I plan to apply the skills learned during this project to research in a different field regarding technological advancement for the benefit of third world countries.

Image Sources (In Order of Appearance):
Row 1, Panel 1: https://c.stocksy.com/a/BOfA00/z9/2542383.jpg
Row 1, Panel 2: https://blog.sensaphone.com/hs-fs/hubfs/Blog/Greenhouse-Sensors-1.jpg?width=1185&height=656&name=Greenhouse-Sensors-1.jpg

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