

# Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



## Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners ([Examencommissie-BK@tudelft.nl](mailto:Examencommissie-BK@tudelft.nl)), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Coco de Bok
Student number	4807928

Studio		
Name / Theme	Global Housing - Architecture of Transition in the Bangladesh Delta	
Main mentor	Rohan Varma	Architecture
Second mentor	Rocio Conesa	Building Technology
Third mentor	Frederique van Andel	Research
Argumentation of choice of the studio	I was drawn to global housing in Bangladesh because it allowed me to use architecture as a problem-solving tool in a vastly different context. A key factor influencing my choice was the complexity of the task at hand. The challenge extended beyond creating affordable housing to learn from the people and culture and understand the different definitions of a home in a different context. Another aspect that interested me is climate, and the climate challenges Bangladesh faces. By choosing this studio, I sought to tackle a multi-layered design problem that demanded a balance of cultural sensitivity, affordability, and environmental resilience.	

Graduation project	
Title of the graduation project	Optimizing Local Materials
Goal	
Location:	Hawkers Market, Sylhet
The posed problem,	Bangladesh faces the dual challenges of rapid urbanization and severe climate vulnerability, with rising sea levels and flooding displacing millions and intensifying housing demand in lower-risk areas often urban centers like Sylhet. This means a need for affordable, climate-resilient housing. Affordability can be achieved by innovative use of materials.  Summarizing the key problems addressed in this research :

	1.Increasing housing demand in cities due to urbanization 2.The threat of natural disasters such as frequent flooding. 3.The depletion of materials due to flooding, rising sea levels, and unsustainable industrial practices.
research questions and	How can locally sourced, sustainable building materials be utilized to address the housing crisis in Sylhet, Bangladesh, through affordable housing and climate-resilient solutions?
design assignment in which these results.	The aim of this design assignment is to develop a housing solution that is both <b>affordable</b> and <b>climate-resilient</b> , using locally sourced and optimized materials to enhance <b>social</b> and <b>environmental sustainability</b> . The design should showcase innovative and realistic ways to use traditional and waste-derived materials to address the challenges posed by rapid urbanization and climate vulnerability, specifically within the context of Sylhet, Bangladesh.
<p><b>Problem Statement:</b></p> <p>Bangladesh ranks ninth in the World Risk Index 2023 for climate disaster vulnerability, with projections indicating that 17% of the country could be submerged by rising sea levels by 2050, resulting in a possible 30% loss of farmland (World Risk Index, 2023). This loss will make resources, particularly raw materials, even scarcer. Additionally, annual monsoon flooding prompts migration from rural and coastal areas to urban centers, further straining the housing market and emphasizing the urgent need for affordable, resilient housing for both current and future populations. (Chowdhury et al., 2012)</p> <p>Environmental sustainability combined with affordable housing is often an even more uphill battle than it already is. There is a logical reason behind this challenge: people who need affordable housing usually face greater immediate concerns, such as securing a roof over their heads and surviving day-to-day. (Bredenoord et al., 2014) These pressing needs leave little room to consider environmental factors or how to build their homes sustainably.</p> <p>This same urgency is why individuals who rely on cottage industries like fishing or salt production—occupations tied closely to rivers and flood-prone areas—often rebuild in the same high-risk locations after a disaster (van Lohuizen, 2019). This is why it’s crucial to find ways to seamlessly integrate sustainability into affordable housing.</p> <p>When sustainability becomes a natural by-product of affordable solutions, it no longer stands as a separate challenge. This research would lose much of its value if it focused solely on optimizing materials for sustainability in climate-resilient housing. By combining it with affordability, the housing solutions are aligned with the real priorities of the people in Sylhet, who often face more immediate needs. This is why my focus is on optimizing locally available materials for affordable, climate-resilient housing. Using local materials enhances sustainability in both environmental and social ways, supporting local industries. (Bredenoord et al., 2014) (Heringer et al., 2019).</p>	

Another area I aim to explore in depth is the potential within Bangladesh's waste streams. For instance, the ship-breaking industry in Bangladesh, the largest of its kind globally (Sujauddin et al., 2016), presents an opportunity to repurpose materials salvaged from decommissioned ships. The river sludge is also a waste product that could have potential in building materials (Fatema & Hossain, 2022). By transforming low-value waste products into optimized building materials, these interventions could help make affordable housing more feasible and sustainable in Bangladesh. (Fatema & Hossain, 2022).

### Key Deliverables:

1. **Design Concept:** A prototype for scalable, affordable housing that incorporates local and waste-derived materials to ensure resilience against flooding, temperature extremes, and other climate risks.
2. **Material Optimization Strategies:** Detailed research and analysis of how to optimize traditional materials (e.g., brick, bamboo) and integrate waste products (e.g., ship-breaking materials, river sludge) into construction.
3. **Sustainability Integration:** The design should include passive strategies for climate resilience, such as natural ventilation, rainwater collection, and solar orientation.
4. **Community Impact:** The design should consider the social and cultural needs of Sylhet's residents, ensuring that the housing solutions are culturally appropriate and empower local communities.

Research question : How can **locally sourced, sustainable building materials** be used to address the **housing crisis** in Sylhet, Bangladesh, by creating **climate-resilient**, and **affordable housing solutions**?

1. What are locally available materials in Bangladesh and how do they perform in terms of environmental sustainability, affordability, and climate resilience?

This question lays the foundation for understanding the existing materials and how they align with your goals of sustainability and resilience, to also see where there are opportunities to optimize.

2. What traditional building techniques are commonly used in Sylhet, and how can elements of these practices be integrated to create affordable and resilient housing solutions?

This question explores the traditional construction methods specific to Sylhet, aiming to understand how they can be adapted or incorporated into modern designs. The goal is to blend the benefits of cultural relevance and cost-effectiveness with modern needs for climate resilience, ensuring that these techniques can be used in affordable and sustainable housing solutions.

3. How can waste materials be repurposed to create affordable and climate-resilient building materials for housing in Sylhet, Bangladesh?

This sub-question explores the potential for waste streams to contribute to affordable and climate-resilient housing, focusing on repurposing waste as valuable building materials.

## Process

## Method description

### PART 1: MATERIAL STUDY

The first part of the research focuses on evaluating the materials used in construction in Bangladesh, especially those that are locally available in Sylhet, and comparing their properties to alternative sustainable options. The methodology for this stage includes:

#### 1. Data Study

The data study will consist of three components:

- **Study on Raw Materials in Bangladesh:** This will explore locally available raw materials, including traditional ones and those currently in use for construction in Sylhet, such as bricks, bamboo, mud, reed, and concrete. Concrete, while not traditional, is widely used in Sylhet.
- **Market Study:** This study will identify the most relevant materials for construction in Sylhet by mapping their availability, cost, and prevalence.
- **Sustainable Material Alternatives:** A study will focus on sustainable materials, such as compressed earth blocks, rammed earth, river sludge bricks, starch-stabilized clay, sea shell concrete, cow dung mud and potential waste streams. A thorough comparison of their environmental sustainability, affordability, and performance will be conducted. I will also look at if it is suitable for larger scale housing projects.

#### 2. Mapping Raw Materials

This method will visually map where and how raw materials are sourced in Bangladesh, identifying key regions that produce these materials. A geographic analysis will help connect material sourcing with local economic practices.

#### 3. Spider Diagrams

Spider diagrams will be developed to compare material properties based on several parameters:

- **Strength:** Compression strength, tensile strength, and density
- **Thermal Properties:** Moisture content and specific heat capacity
- **Sustainability:** Climate impact, lifespan, and environmental footprint
- **Affordability:** Cost, availability, and locality
- **Climate Resilience:** Resistance to moisture, temperature fluctuations, and other environmental challenges

These diagrams will provide a clear, visual method for comparing materials in a way that highlights both traditional and innovative sustainable materials.

#### 4. Site Visits

I have been on several site visits in Bangladesh, to brick fields, bamboo shop, and existing vernacular houses and high rise buildings. The aim is to observe the material sourcing process, building techniques, and the current state of construction practices in Sylhet. This firsthand observation will offer valuable insights into the practical use of these materials and techniques.

#### 5. Interviews

### PART 2: AFFORDABLE & CLIMATE-RESILIENT HOUSING STUDY

The second part of the research will focus on the application of the selected materials and building techniques to create **affordable, scalable, and climate-resilient housing solutions** in Sylhet.

1. **Data Study on Affordable Housing**

This study will look at case studies of affordable housing models, examining what makes housing affordable and sustainable in a local context. This will include economic factors, resource availability, and social conditions that impact affordability.

2. **Climate Resilience and Building Techniques**

This is a preventive design aspect as the location is a low-risk site. This will focus on the building properties required to withstand environmental challenges, particularly flooding and high temperatures. This will look into construction techniques and materials that enhance climate resilience, especially in flood-prone areas like Sylhet. A deeper investigation of global case studies will help identify the most effective strategies and materials used for climate-resilient architecture. Lessons from these cases will be integrated into the local context.

3. **Ethnographic Fieldwork**

The fieldwork component will focus on direct observation of building materials, techniques, and existing structures in Sylhet. This will involve:

- **Sketching:** Recording building styles and material applications.
- **Photography:** Documenting existing architecture, materials in use, and any signs of climate adaptation.
- **Interviews**

This ethnographic approach will provide an understanding of how local communities interact with materials and construction techniques, as well as the challenges and opportunities they face.

Result :

The final stage of the research will involve synthesizing the findings into a **design toolbox**. This toolbox will combine the most suitable materials and building techniques into scalable design solutions for affordable and climate-resilient housing. The design toolkit will serve as a practical guide for developing affordable housing solutions that can be widely adopted in Sylhet and similar contexts.

## Reflection

This research aligns with the Master track in Architecture by focusing on affordable housing, a global issue. The challenge lies in balancing quantity and quality—addressing the housing crisis while ensuring good living conditions. The study seeks to design scalable, sustainable housing solutions tailored to Sylhet's context but with potential relevance in contributing to the ongoing discourse on affordable, climate-resilient architecture. By optimizing local materials and integrating traditional techniques, it not only tackles the demand for housing but also responds to broader challenges in architecture, such as resource efficiency and the environmental impact.

**Housing Crisis and Local Materials:** This research focuses on local materials and sustainable building practices to address the increasing housing crisis in Sylhet, Bangladesh. Aiming to map the local materials available, and analyse their properties concerning environmental sustainability, climate resilience, and affordability. Then looking at how to optimize local materials, by either incorporating waste streams or adaptation of construction to be used in larger scale housing projects. The study aims to achieve sustainability through locality while also addressing the housing crisis through affordable housing solutions.

**Creation of a Practical Toolbox:** The study's relevance is evident in the development of a pilot building that meets specific criteria: 1. the use of material must be locally available, 2. Materials must be most suitable regarding sustainability, climate resilience, and affordability. 3. Constructed to be scalable and affordable. The pilot will demonstrate how these materials can be applied in construction, resulting in a toolbox for my own housing design in the city of Sylhet.

**Focus on Materials :** This focus on material analysis is important as the choice of materials influences the overall environmental and social impact of the building. Beyond construction impact, the materials used in a building also affect the quality of living conditions,

**Making Sustainable Alternatives Accessible:** To make sustainable alternatives more accessible, this research will use visual tools like spider diagrams to compare materials. To also compare the sustainable alternatives to a conventional material to show the advantages.

**Limitations and Real-World Challenges:** The research recognizes certain limitations, such as the difficulty of incorporating sustainable materials into established construction practices in Bangladesh. This can be due to traditional methods being deeply rooted and limited funding for change. Additionally, some sustainable materials are still in the early stages of development globally, which may pose risks. This study encourages sustainable alternatives while understanding that broader changes require supportive policies.

**Methodological Constraints:** This research relies on data collection and analysis rather than physical prototypes due to the context being Bangladesh. While combining materials and construction methods is explored theoretically, there must be a balance between innovation and reliable data to ensure that the suggested

methods are feasible. The research aims to provide enough information for informed decisions, even though real-world testing is outside its current scope.

**Cultural Sensitivity and Ethics:** The ethical vulnerability of researching a country where the culture is completely different from where you are from is to try and minimize the influences of our own biases. This is especially important in designing a home as the definition of what makes a home is completely different per culture. The same can be said for how to build a home as they have much more knowledge on the climate and materials that are available. It is therefore important to find a balance between combining knowledge from both backgrounds. Exchanging knowledge is very valuable as we learn from each other and can then make a result that hopefully fulfils their definition of a home and the ability to withstand climate obstacles.

## Literature and general practical references

### References

Ahmed, K. I. (2005). *Handbook on design and construction of housing for flood-prone rural areas of Bangladesh*. Shelter Cluster. Asian Disaster Preparedness Center. Retrieved from <https://sheltercluster.org/bangladesh/documents/handbook-design-and-construction-housing-flood-prone-rural-areas-bangladesh>

Alam, F., & Hossain, N. (2020). An analysis of alternative building materials in the coastal rural areas of Bangladesh. *FUAD ALAM KTH Skolan för Industriell Teknik och Management*. Retrieved from <https://kth.diva-portal.org/smash/get/diva2:1461682/FULLTEXT01.pdf>

Bredenoord, J., Van Lindert, P., & Smets, P. (2014). *Affordable housing in the urban global south*. Routledge.

Chowdhury, I. A., Haque, N., Kamal, M. M., Islam, T., Khan, M. M., Islam, M. N., & Uddin, I. (2012). Internal migration and socio-economic status of migrants: A study in Sylhet City, Bangladesh. *American Journal of Human Ecology*, 1(4), 123–133. <https://doi.org/10.11634/216796221504183>

Department of Environment Bangladesh, Ministry of Environment and Forests, & Government of the People's Republic Bangladesh. (2017). *National strategy for sustainable brick production in Bangladesh* (pp. 1–41). Retrieved from [https://www.ccacoalition.org/sites/default/files/resources/2017\\_strategy-brick-production-bangladesh.pdf](https://www.ccacoalition.org/sites/default/files/resources/2017_strategy-brick-production-bangladesh.pdf)

Fatema, K., & Hossain, I. (2022). Utilization of riverbed silt and subsoil of Gopalganj for masonry bricks incorporating internal fuel and comparison of their construction properties with commercial bricks. *Innovative Infrastructure Solutions*, 7(2). <https://doi.org/10.1007/s41062-022-00745-8>

Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance, Frankfurt School of Finance & Management gGmbH, Alam, M. N., & Barman, S. (2019). *Bangladesh Brick Sector Roadmap 2019-2030*. Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, 2–38. Retrieved from [https://www.ccacoalition.org/sites/default/files/resources/2019\\_Report\\_Bangladesh%20Brick%20Sector%20Roadmap.pdf](https://www.ccacoalition.org/sites/default/files/resources/2019_Report_Bangladesh%20Brick%20Sector%20Roadmap.pdf)



Gomes, E., & Hossain, I. (2003). Transition from traditional brick manufacturing to more sustainable practices. *Energy for Sustainable Development*, 7(2), 66–76. [https://doi.org/10.1016/s0973-0826\(08\)60356-7](https://doi.org/10.1016/s0973-0826(08)60356-7)

Global Carbon Budget. (2023). Per capita consumption-based CO<sub>2</sub> emissions. *Our World in Data; Global Carbon Budget*. Retrieved from <https://ourworldindata.org/grapher/consumption-co2-per-capita?tab=chart&country=~BGD>

Google Earth. (2024). Sylhet historical view. *Google Earth*. Retrieved from <https://earth.google.com/web/@24.89213502>

Gupta, R., Vahanvati, M., Häggström, J., & Halcomb, J. S. (2021). *A practical guide to climate-resilient buildings & communities*. Retrieved from <https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/36405/Adapbuild.pdf>

H. M. A. Mahzuz, Ahmed, M., Dutta, J., & Rose, R. H. (2013). Determination of several properties of bamboo of Bangladesh. *Journal of Civil Engineering Research*, 3(1), 16–21.

Haque, A. K. E., Mukhopadhyay, P., Nepal, M., & Shammin, R. (2021). *Climate change and community resilience: Insights from South Asia*. Springer.

Haque, M. O., Munzarin, B. U. T., & Saikia, S. (2021). Implementation of alternative affordable materials in sustainable rural housing design. In *Proceedings of 3rd International Conference on Smart Villages and Rural Development*.

Heringer, A., Howe, L. B., & Rauch, M. (2019). *Upscaling earth: Material process catalyst*. Gta Verlag.

ICIMOD & Department of Environment Bangladesh. (2019). *Fact Sheet: Brick Sector in Bangladesh* (pp. 1–8). The International Centre for Integrated Mountain Development.

Iftekhar Ahmed, K. (1991). *Up to the waist in mud! The assessment and application of earth-derivative architecture in rural Bangladesh*. MIT.

Mallick, J., Towab, A., Shahriar, Md., Rashid, A. K. M., & Munira, S. (2024). Aspiration picture and climate adaptation: Households' incremental strategies in climate-resilient housing in rural coastal Bangladesh. *Ku.ac.bd*. Retrieved from <https://kus.ku.ac.bd/kustudies/article/view/1012/1895>

Ruhr University Bochum. (2023). *WorldRiskReport 2023 Focus: Diversity*. Retrieved from [https://weltrisikobericht.de/wp-content/uploads/2023/10/WRR\\_2023\\_english\\_online161023.pdf](https://weltrisikobericht.de/wp-content/uploads/2023/10/WRR_2023_english_online161023.pdf)

Siddique, R. (2009). Utilization of waste materials and by-products in producing controlled low-strength materials. *Resources, Conservation and Recycling*, 54(1), 1–8. <https://doi.org/10.1016/j.resconrec.2009.06.001>

Sujauddin, M., Koide, R., Komatsu, T., Hossain, M. M., Tokoro, C., & Murakami, S. (2016). Ship breaking and the steel industry in Bangladesh: A material flow perspective. *Journal of Industrial Ecology*, 21(1), 191–203. <https://doi.org/10.1111/jiec.12423>

Tourtlot, J., Duc, M., Mertz, J.-D., Bourgès, A., & Keita, E. (2023). Strengthening mechanisms of clay building materials by starch. *Construction and Building Materials*, 405, 133215–133215. <https://doi.org/10.1016/j.conbuildmat.2023.133215>

Uddin, G. T., Mia, Md. B., Sadman, T., & Hossain, Md. A. (2021). An assessment on waste management practices in the construction sites of Sylhet City. *Journal of Materials Science Research and Reviews*, 1–14. Retrieved from <https://www.researchgate.net/profile/Md-Altaf->

[Hossain/publication/356022561\\_An\\_Assessment\\_on\\_Waste\\_Management\\_Practices\\_in\\_the\\_Construction\\_Sites\\_of\\_Sylhet\\_City/links/6189ce7d3068c54fa5c1a1f4/An-Assessment-on-Waste-Management-Practices-in-the-Construction-Sites-of-Sylhet-City.pdf](https://www.researchgate.net/publication/356022561_An_Assessment_on_Waste_Management_Practices_in_the_Construction_Sites_of_Sylhet_City/links/6189ce7d3068c54fa5c1a1f4/An-Assessment-on-Waste-Management-Practices-in-the-Construction-Sites-of-Sylhet-City.pdf)

van Lohuizen, K. (2019, November). *Na ons de zondvloed* (M. Blekendaal, Ed.; No. 3) [Documentary]. NPO. Retrieved from <https://npo.nl/start/serie/na-ons-de-zondvloed/seizoen-1/na-ons-de-zondvloed/>