Applying Biomimicry in the Design of Temporary Shelters in the Wake of the Climate Refugee Crisis

An International Crisis

Previously referencing those fleeing their country due to war and political instability, the word "refugee" has evolved in the wake of the climate crisis to include those displaced from the effects of climate disasters that include unprecedented heat waves, flooding, and fires. As the effects of climate change become more tangible and present, everyone on Earth, even those in first-world countries are vulnerable to being forced out of their homes without adequate protection and shelter to protect them. A crisis in and of itself, the lack of efficient temporary shelter for climate refugees requires urgent action from designers as scientists predict the world to exceed beyond the global warming 1.5° C cap.[1] Currently, NASA reports many regions to have surpassed this temperature threshold, with 20% of humans living in those areas.[2] While such areas, such as the Philippines and Vietnam have seen harsh typhoons in recent years, other countries that have strived to maintain gas emissions have not been excused from similar disasters. Examples include Canada's British Columbia fires of 2017 and 2021 that displaced over 45,000 people each.[3]

On left: A family seen evacuating a flooded area in Manila, Philippines on July 24th, 2021, by creating shelter out of an umbrella, metal poles, and chairs.

On right: Plastic made, crowded, individual tents set up in an open field in 2017 near forests susceptible to fire after wildfires in B.C., Canada evacuate many.

[1] Zeke Hausfather, "Analysis: When Might the World Exceed 1.5C and 2C of Global Warming?," Carbon Brief, October 11, 2021, https://www.carbonbrief.org/analysis-when-might-the-world-exceed-1-5c-and-2c-of-global-warming.
[2] Alan Buis, "A Degree of Concern: Why Global Temperatures Matter – Climate Change: Vital Signs of the Planet," NASA Global Climate Change (NASA, June 19, 2019), https://climate.nasa.gov/news/2865/a-degree-of-concern-why-global-temperatures-matter/.
[3] "More than 45,000 People Displaced by B.C. Wildfires | CBC News," CBCnews (CBC/Radio Canada, July 18, 2017), https://www.cbc.ca/news/canada/british-columbia/bc-wildfires-tuesday-1.4210370.

Call to Action

Interested in temporary shelters, I am eager to explore what it constitutes and ways it can be redesigned to be more efficient. With the current solution for displaced people consisting of a commercial tent or a military truck that does little in providing sufficient shelter, I aim to look to nature for design solutions to increase their efficiency or substitute them entirely.

On left: Flooded camp and tents in Santa Cruz, California on Dec 13, 2021, after a major storm.

On right: Military truck sent to pick up individuals from flooded area. Difficult to maneuver on water and limits number of belongings an individual can bring.

Finding a Solution in Biomimicry

This emerging field, titled biomimicry, at its root consists of "taking a design challenge and then finding an ecosystem that's already solved that challenge, and literally trying to emulate what you learn".[4] Having undergone years of evolution, nature has fine tuned its response to the environment to ensure its survival. As a result, when faced with inadequate man-made designs, it can be rewarding to look to nature for answers. Successfully seen in Eastgate Centre in Harare, Zimbabwe, the building was inspired by termite mounts for their self-cooling feature, allowing it to forego conventional air-conditioning and heating as well as, save 10% of its energy.[5]

[4] Janine M. Benyus, *Biomimicry: Innovation Inspired by Nature* (Perennial, 2009).

[5] Gertie Goddard, "Biomimetic Design: 10 Examples of Nature Inspiring Technology," BBC Science Focus Magazine, n.d., https://www.sciencefocus.com/future-technology/biomimetic-design-10-examples-of-nature-inspiring-technology/.

Architect Mick Pearce in the biomimetic design of the Eastgate Centre in Harare, Zimbabwe utilized both the region's indigenous and local masonry as well as the self-cooling feature of African termite mounds.

In addition to biomimicry being a sustainable and innovative field, its essential identity that depends on nature makes it an optimal design solution for temporary shelters in the context of climate disasters. Having evolved to address climatic factors, certain organisms have the ability to survive the worst—a trait that can be replicated in temporary shelters.

Currently, temporary shelters such as standard tents are made entirely of plastic, must be imported, and are not the most efficient in the wake of natural disasters. Inspired by how various species seek shelter and live in various climates and weather conditions, a new design that reduces the use of plastic, can be constructed with found materials, and increases efficiency through considered structural design can be created. From the radiolarian, which optimizes and attunes its structure to its environment, to the caddisfly that strategically constructs its shelter using locally available materials, the possibilities for shelter are bounteous and insightful.

On left: Image of a Radiolarian, a protozoa that constructs an intricate structural mineral skeleton.

On right: Image of a caddisfly's larvae.

Research Steps

Presented with three overlapping crises: climate change, large numbers of displaced people, and the lack of effective temporary shelter, my research question is as follows: Applying biomimicry, how can architects redesign temporary shelters in the wake of the climate refugee crisis?

In addition to its relevance to this century's greatest calamity—climate change—the application of biomimicry in temporary shelter design is unprecedented as most biomimetic endeavours focus on buildings. Utilizing the computational and parametric procedures and programs architects use to generate designs and input parameters to test out various natural models, an optimal, efficient, and appropriate temporary shelter design will be proposed.

An exceptional opportunity to apply this promising field to a crisis that will soon seize the attention of all designers, conducting this research under the Laidlaw Scholars program is most benefitting. Under the guidance of my supervisor, Dr. Brady Peters, an Assistant Professor of architecture at the University of Toronto, his experience in computational design, computer programming, and digital fabrication is attested by his role as the Director of Smartgeometry, an organization that leads a global initiative in the use of computation in architecture.

In the first summer, the six weeks of research will consist of the following:

- In-depth analysis and research on common climate disasters and shelter concerns that arise from each.
- Selection of one to tackle and create a solution for.
    - Selection will be guided by both its impact on Canada and internationally.
- Identification of design challenge and shortcomings of current temporary shelter solutions for chosen climate disaster.
    - Example:
        - Chosen climate disaster: Flooding.
        - Current temporary shelter: Individuals displaced and scattered on non-flooded areas in tents (if available).
        - Design challenge: Creating a shelter that centralizes the displaced in one area for optimal food and supplies distribution.
- Exploration of various organisms that have responded to this challenge.
    - Elaborating on the previous example, various organisms offer promising solutions:

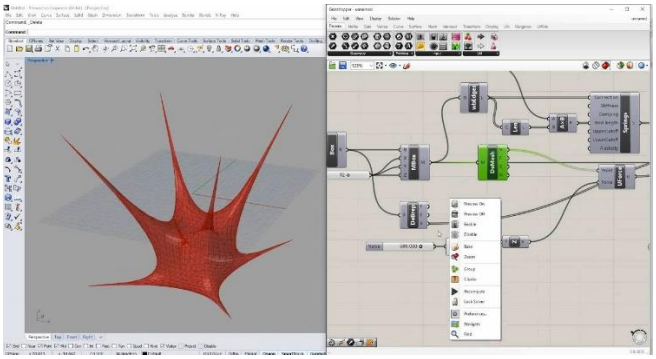
On left: Sociable weaver - Modular organization of its nest provides communal benefits.

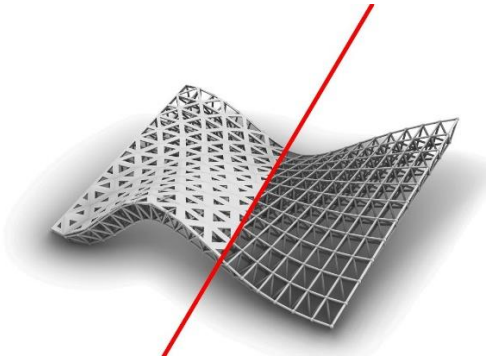
In middle: Cassin's malimbe: Structural integrity of nest derived from its woven and adaptable construction.

On right: Leaf stomata: Changes shape in response to moisture.

In the following summer, current plans include creating a computational design prototype of a biomimetic temporary shelter using the programs Rhino, Grasshopper, and Python (of which I have experience in). Using digital simulations such as Kangaroo, a Live Physics engine, and structural analysis

plugins like Millipede and Lunchbox, the design will be further analyzed. Not only integral to architectural design but biomimicry, digital fabrication will play an important role by testing different versions of the prototype, bridging between the digital model and its physical reality. With Dr. Brady Peters offering UofT's Robotic Prototyping Lab facilities to 3D-print and test out the prototype, a promising temporary shelter can be created. In the case of Covid-19 not permitting in-person activities, digital simulation will play a larger and more extensive role, substituting for printing and modelling.





On left: Example of the Grasshopper interface with the physics plugin Kangaroo utilized.

On right: Example of the structural and design possibilities of parametric and computational architecture.

Outcomes

At the end of this two-year endeavour, the outcomes of this initiative will include a comprehensive application of biomimicry to temporary shelters, as well as, a digital biomimetic prototype that can be applied and manufactured, refined through fabrication and simulation tests. In addition to the former acting as a precedent and source of knowledge for future designers, this initiative is a crucial response to solving the displacement crisis arising from the effects of climate change.

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