Incremental Development Manual: The Ger Innovation Hub, Mongolia

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The traditional Mongolian dwelling or ger has evolved in direct correlation to the demands of nomadic life. However, its mobility, affordability and reproducibility have contributed to a rapid urbanization process in the city of Ulaanbaatar, resulting in the creation of sprawling districts with no basic infrastructure that house over 70% of the city's population.[1] During the cold winters, each household uses coal as their main heating source contributing to toxic atmospheric pollution. The lack of water and sanitation infrastructure is coupled with a lack of community provision in the form of kindergartens, schools and play spaces.

As the ger districts gradually transform into more permanent forms of settlement, they are beset with ever increasing sets of problems that have no easy fix. The implementation of large-scale infrastructure and housing development is unfeasible due to the extent of the settlements and the fact that the majority of residents own their land.[2]

The aim of the project is to create an Incremental Development Manual as a strategic framework for sustainable and affordable district upgrading. This paper will report on one component of this Manual, The Ger Innovation Hub, a prototype for a community centre that demonstrates a methodology to engage the climate crisis through the intersection between research, design practice, and education. The process includes fieldwork, household surveys, environmental modelling, community workshops, student design-build courses, event programming, financial planning, and in-use performance testing.

The paper will explain how the project innovated with passive environmental strategies to provide a low-cost solution to reduce energy consumption and the reliance on coal as a heating source. Operational since January 2020, the article will report on the effectiveness of the prototype in terms of its environmental performance and its capacity to become a model for community provision that can be replicated across other ger district areas.

Figure 1.Chingeltei Ger District looking towards the city. 2019. Image credit, Rural Urban Framework.

The ger is designed for portability and all of its component parts are prefabricated and can be bought at everyday markets. A ger costs between 600USD-1000USD, making it the most economical form of housing in the city. Whether in the city or the countryside the ger itself is the same: a simple room for all activities of the 4-5 person household, heated with simple coal burning stove. Prior to an all-out ban on the use of coal in March 2019, ger district households would consume over 600,000 tonnes of unrefined coal during the winter, contributing to toxic air pollution reaching in Jan 2019 of PM 2.5 levels 30 times higher than the World Health Organization (WHO) guideline.[3]

The enforcement of replacing coal with charcoal briquettes has reduced the amount of particulates in the air by approximately half, however it has not resulted in lowering carbon emissions, with each household using on average 370kg/ month or approximately 3 tonnes every winter from September until April. Even though some families live in detached brick houses, or baishins, most are poorly built with 93% having less than 100mm of insulation, exacerbating heat loss and fuel consumption.[4]

The majority of residents do not have direct access to water supply and 95% use pit latrines. Ger district residents have been living on their plots for an average of 8 years and build a pit latrine every 2-3 years, which means most households have dug at least two pit latrines on their plots.[5] Given that this waste is untreated, this results in 88% of the total settlement area of the capital city having microbiological contamination exceeding standard levels .[6]

This presents a risk to Ulaanbaatar's source of drinking water which comes from government protected aquifers along the Tuul River.[7] These supply water trucks which deliver water to two thirds of the city's water kiosks. Ger district households each make at least 8 trips per week to the kiosks to collect water.

In terms of community resources, only half of the 146,000 children between the ages of two and five in the ger districts will get a kindergarten place.[8] Many are oversubscribed and districts organize 'lotteries' to see who can be allocated a space. In Songino Khairkhan 43, the Khooro governor reported that of the district's 2,000 children between 0-11 years there is only one kindergarten that has the capacity to serve just 80 kids. According to our survey of 39 households; schools, kindergartens, and play-spaces are identified as the most needed services in the district.

In these respects, the ger districts are deleterious settlements with polluted soils, acrid air, poor sanitation, with over stretched community facilities for childhood education. Young children are the most at risk: children living in the city have 40% lower lung function than those in the countryside .[9] Without childcare, it reduces the potential income earnings of parents as mothers stay at home to care for their young children. There is also limited opportunities for children to interact socially with each other as there is a lack of safe places for them to play and learn together, particularly during the winter.[10]

Given that 35000[11] new migrants move to the city each year, the issues are being compounded and the ability to ameliorate the situation through the provision of new infrastructure and housing becomes increasingly expensive and difficult to implement.

OBJECTIVES

The aim of the project is to create an Incremental Development Manual as a strategic framework for sustainable and affordable district upgrading.

The current model for ger district upgrading is undertaken through the Asian Development Bank, (ADB). The ADB conceives and initiates redevelopment plans through collaborations with government bureaus, international consultants and local partners.

Following approval of the project in parliament, the ADB will provide preferential loans to the Mongolian government and will assist in the project implementation and coordination of different specialist consultant teams.

The strategy for ger district upgrading is to create subcentres, connect them to infrastructure and to high speed bus routes and to increase the household density of each plot by 3.6 times by building 5-6 story town houses.[12]

This will increase the current population of subcentres from 23,440 to around 70,000 and includes affordable and market-price housing. The intention is to stimulate the housing market by assisting developers to prepare the land for development. This includes confirming land exchange agreements with land-owners, funding infrastructure, and negotiating preferential mortgage rates for consumers.

However, the plan is still contingent on residents exchanging their 500-700m2 plot of land for a 37-42m2 apartment. Economic recession has meant income levels of ger districts are low – on average 1,157,500 MNT (406 USD) per month[å] – and the promised low interest rate mortgages are much higher than expected (8-16.8%). This means that the success of the market-rate housing component of the scheme is uncertain, which puts off developers as their profit margin on the cost of redevelopment versus return becomes increasingly risky.

Even if successful, the current tracts of development (Bayankhoshuu, Selbe, Dambadrjaa, and Denjiin subcentres) will only provide housing capacity for approximately 70,000 of a total ger district population of 840,000.[14] Additionally, based on household surveys with 59 families[15] , 63% of these residents wish to improve their housing whilst remaining on their existing khashaa plot. These observations suggest that there is an urgent need for an alternative development strategy that can be applicable to all ger district residents (not just those in selected areas); that allows residents to stay on their own plot; and is not reliant on developer or government funding to be implemented.

INCREMENTAL DESIGN MANUAL

The Incremental Design Manual is intended as an alternative mechanism of development that can complement the existing ADB projects. The Manual will provide options on how each household can improve their living situation based on their needs, family structure and income. It will provide strategies for households in neighbouring plots to share the costs of infrastructure to benefit multiple families and to create a system that allows for growth. It includes housing typologies for multi-family occupancy allowing plots to densify.

The target is to provide the same density of population as the ADB proposal but through an entirely different approach. It is distinct as follows:

- The upgrading takes place in situ and land ownership is retained by the residents themselves.
- It is incremental and gradual, allowing each family to improve their house when they are in a financial position

Figure 2A. Engaging residents in household surveys, January 2020. Image credits, Rural Urban Framework

Figure 2B. Student design build workshop, June 2018 Image credits, Rural Urban Framework

to do so. This reflects the actual financial capacity of residents but also recognises that income from families can vary from a low of 400,000 MNT (140USD) to a high of 2,000,000 MNT (704USD).

- The manual will offer a choice of different house types including multi-family occupancy, single family occupancy and houses with shared facilities between different generations. In this way it relates to the specific family structures and how they currently occupy their plots.
- Conceptually, the Manual works with the idea of prototypes that can be iterated upon based on feedback and performance criteria. They are designed to evolve and adjusted and for new prototypes to be added to the Manual as needs change.
- During our surveys with residents many have indicated that they are unhappy with the lack of progress and slowness of the ADB project and on the most part cannot see how it will benefit them. The Manual works by starting small, with low risk projects that are achievable and inexpensive. By receiving feedback quickly on these test models, we can improve thermal performance and buildability which can inform new iterations, scalability and the increased chance of success for the long-term impact of the project.

METHODOLOGY

The methodological approach of the Design Manual has been to intersect research, including fieldwork, mapping and analysis, with design practice and education, through studio projects and design build workshops. The project has involved collaboration with key NGOs such as Ger Hub and the Asia Foundation who have experience working in the districts to conduct household surveys and organise community engagement workshops. As we develop the underlying knowledge of the districts, including the population structure, income, house type, and how they transform over time we also conducted design studios bringing students to site. As well as providing the students with a unique learning experience, our continued involvement and series of consecutive actions demonstrated our commitment to the community and helped build trust. As well as receiving input from the residents on the design proposals, specialists were consulted in the fields of construction and environmental engineering. The environmental consultant provided models to predict and improve thermal performance. Once a prototype design was completed, funding for construction was sought from multiple sources to initiate the build. After construction each prototype has been fitted with data loggers to measure the actual thermal performance to compare to our predictions and improve next versions. In order to scale up the projects and make it more affordable for residents to implement the projects in the Manual, we have worked with local banks and financial institutions to access lower rate green mortgages. This is an essential part of the process for the Manual be implemented at scale.

The Design Manual is still work in progress however we have completed and tested one housing prototype- the Ger Plug-In which meets the criteria as stipulated by the banks to be eligible for green mortgages[16] and one community project- The Ger Innovation Hub which was completed in January 2020.

GER INNOVATION HUB

In a culture which has no word for “community”, the aim of the project is to enable residents construct a collective identity and forge new methods of collaboration. The demand for kindergartens and childcare in Songino Khairkhan 43 was evidenced in our interview with the district leader on 21 Nov 2019[17] who described it as a persistent issue that they have been petitioning to the District Office to resolve for many years as the current kindergarten is oversubscribed.

Working with NGO Ger Hub the building was conceived as a space for events and programs that would respond to the changing needs of residents. Ger Hub will operate and manage the building organizing workshops on education, sustainability and vocational training. For example: the use of charcoal

Figure 3. The Ger Innovation Hub, winter 2019. Image credit: Rural Urban Framework

briquettes that was made mandatory by the government in March 2019, composting toilets, or methods to prevent heat loss. They will hold kids play sessions and after-school clubs and bring the community together for discussions, events and performances. It will offer an alternative place to go in winter, when due to the extreme cold, most residents are confined to their households.

Inspired by the ger as a structural and material system of wood, felt and canvas, we pulled these layers apart to create a room-within-a-room. The inner space made of mud bricks is wrapped with an outer layer of polycarbonate. Timber trusses structure both envelopes, allowing light to filter through both layers, maximizing solar heat gain and warming the thermal mass of the interior. The in-between space acts as a buffer to trap radiant heat and to mediate between the extreme differences in temperature between the interior and the exterior. In winter, this outer layer will be still warmer than the outside, allowing kids to run around and for plants to grow.

According to our initial environmental modelling, at the winter solstice when average daytime temperature is -21°C, the outer layer is predicted to be 8° warmer at -12°C and inner would be 24° warmer at -3° C. This means to reach comfort levels in the inner room of +15°C we are using energy to heat the room by a differential of +18°C rather a differential of +37°C. This means an estimated saving of energy consumption during the winter by 50%.

ENVIRONMENTAL PERFORMANCE

The project was completed in January 2020 and three data loggers were installed in different areas of the building.[18] Due to COVID-19, the building was unoccupied, and heating was left switched off, allowing us to record the temperatures as a direct result of our passive thermal strategies.

Over a four-month period during the day in winter, the inner layer temperature was on average 6.7 °C higher than the external temperature. At night, the inner layer was on average 13 °C warmer than the external temperature. This shows that the outer buffer zone regulates the temperature and prevents the inner layer from reaching both hot and cold extremes. Even without heating, the lowest temperature recorded of the inner layer was still 20.9°C higher than that of the outside.

The buffer zone has rapid fluctuations in temperature with a range of 22.9°C during the first ten days of January 2020 compared to the 3.7°C range of the inner layer. Both the inner layer can be ventilated to the outer layer and the outer layer to the exterior. In this way, the occupants can balance the

Figure 4. The Ger Innovation Hub, first community engagement workshop January 2020. Image credit: Rural Urban Framework

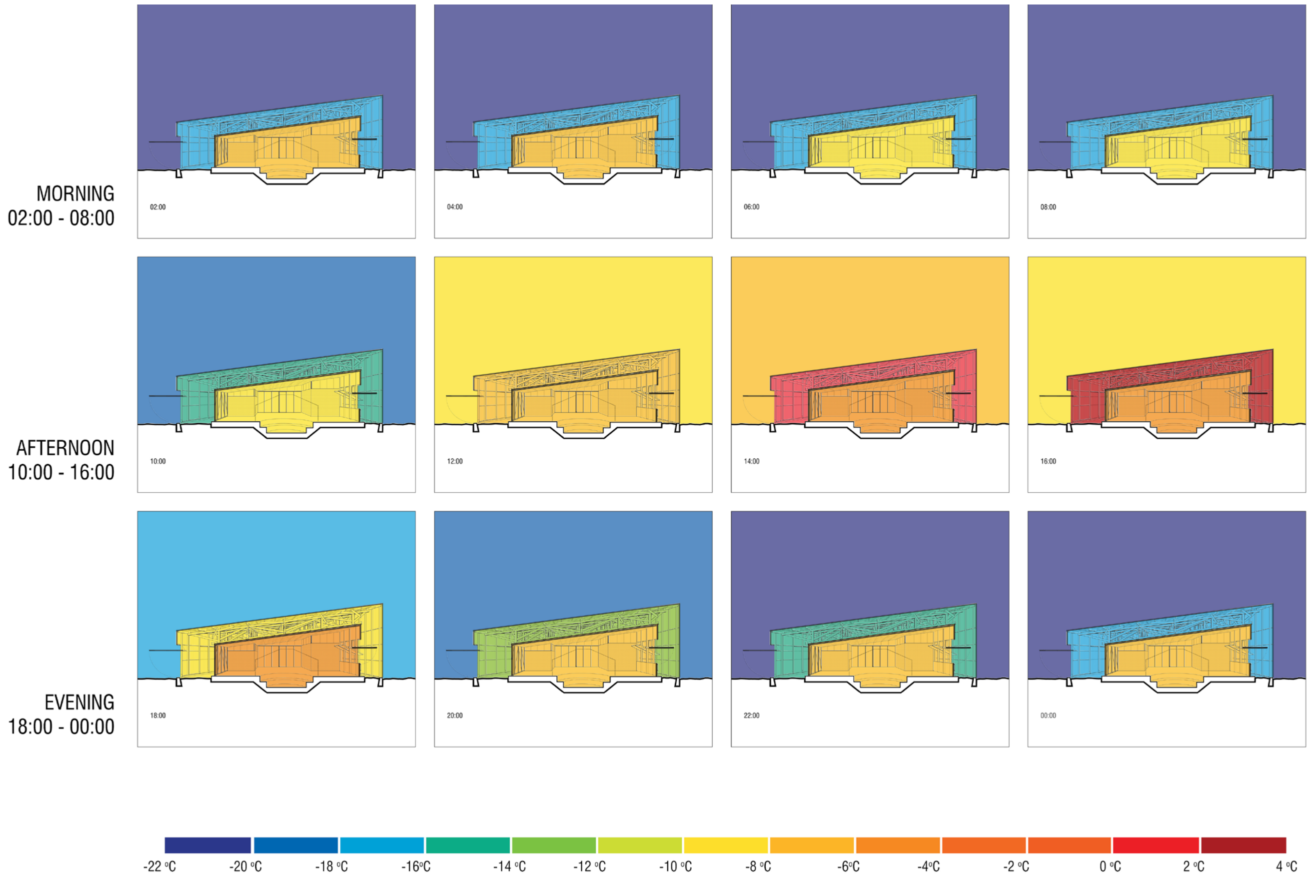

Figure 5. Daily temperature fluctuations within different spatial layers. Image credit: Rural Urban Framework

temperature between the different spatial layers. The outer layer reacts to external temperature changes much faster compared to the inner layer.

However, it gains heat more rapidly than losing it. This demonstrates the effectiveness of the "greenhouse" effect, maximizing solar gain and trapping that heat within the interior of the building. Additionally, the stability of the inner layer suggests that the increase thermal mass of this layer through using mud brick walls also helps retain heat for longer.

In the winter months, heat gains from the morning bring the temperature to their highest around 14:00-16:00. This performance data can assist in the programming of activities of the building. For example: in the winter months it makes sense to conduct activities in the afternoon and early evening to benefit from the daily heat gains and reduce energy consumption and costs. Unfortunately, we have not been able to retrieve data from January onwards due to travel restrictions, however this data will also assist us in evaluating how the layers perform during the warmer spring and summer months. It is expected that the buffer zone will reach high temperatures and so the design allows each skin to open-up to maximise cross ventilation. However, it is hoped that the thermal mass of the interior space will still prevent overheating and maintain a more stable temperature.

The innovation on the project is the deployment of passive environmental strategies at a low cost together with the creation of the useable buffer space around the building. The cost of the building was $67,500 USD for 160m2 or $420 USD/m2. The Mongolian standard for house construction varies from $630 USD/m2 for a well-insulated house with infrastructure[19] and yet a standard baishin is $100 USD/m2. This demonstrates the huge gap between what constitutes an effective building and what is affordable by residents. The challenge for all projects in the ger districts is to try and close this gap: to produce buildings that reduce energy consumption with high thermal performance at a low cost.

FUTURE DEVELOPMENT

The next stage is to monitor the impact human activities will have on the performance of the building but also to evaluate how the building has been received by residents. In particular, the effectiveness of Ger Hub in organising events, managing and operating the building and galvanising all sectors of the community to use the building. Given that the concept of community is one which is not familiar to traditional

Mongolian nomadic culture, it will require a gradual process to foster and enable the sense of collective responsibility and the common good.

As a model for a Hub, the building was designed as a district focus. If the project is considered as a model for other districts, the successful implementation of such a model is predicated on careful management, programming and funding for both the initial construction and for maintenance costs. This would require the input of an international NGO or would require funds from government or from development agencies such as the ADB. However, the role of the GIH could operate more as a "mother-ship" as the key node within a network of smaller scaled child-care facilities.

Our current idea is to work with four adjacent households and create a 4-Plot Family Centre at the intersection of individual landholdings that contains a community space, has its own sanitation facilities, and provides infrastructure for each participating household. This means that each household can benefit from a shared septic tank and water tank thereby saving upfront costs for each family. By choosing to work together they can benefit from improved sanitation and share a community resource. Although each household still maintains their own domestic private space, they now share a collective space for their children to learn and develop. Initially, an NGO with expertise and knowledge in child-care could train parents at the GIH to become teachers. The NGO could manage the first phase of use until the households are ready to become owners and operators themselves. At this point it could become a sustainable enterprise, offering childcare to other residents in the nearby vicinity to cover costs and provide additional income. As a nexus within a network of smaller family centers, the GIH could offer a space for continued training and workshops to disseminate new innovations in construction, sanitation or energy efficiency. It could also be used to hold engagement sessions to introduce the 4-Plot Family Centre idea to other families or local leaders from other districts.

CONCLUSION

Although a singular building, the Ger Innovation Hub demonstrates how the methodological approach of the Incremental Design Manual can be applied. It shows how the synergy between teaching, practice and research conducted by a lab within the University can lead to multiple forms of impact on a range of different stakeholders. It also shows how the process of testing, evaluating and feedback can produce new approaches and allow concepts to evolve.

The tectonic strategy to pull layers apart to create a buffer zone within a translucent skin has proved to be effective, resulting in significant savings in energy consumption and thereby carbon emissions. This can be applied to other building scenarios such as housing, schools or workplaces. The strategy also provides programmatic opportunities in the creation of different layers with different temperatures, offering the possibility of semi-exterior play areas even during the harshest winter conditions.

Following the approach of the Incremental Development Manual that will contain multiple elements of different scales, the GIH can be considered as a node within a network of neighbourhood 4-Plot Family Centres that work together as part of an integrated system. The aim is to create a model that is economically viable for residents and that can be replicated in multiple districts to reach as many children and communities as possible.

The next steps for the future development of the project is to realize the network potential of the scheme by building a 4-Plot Node Family Centre. If successful, we will be able to demonstrate how the Incremental Development Manual can provide a strategic framework for sustainable and affordable district upgrading that offers an alternative model to current ger district development plans.

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