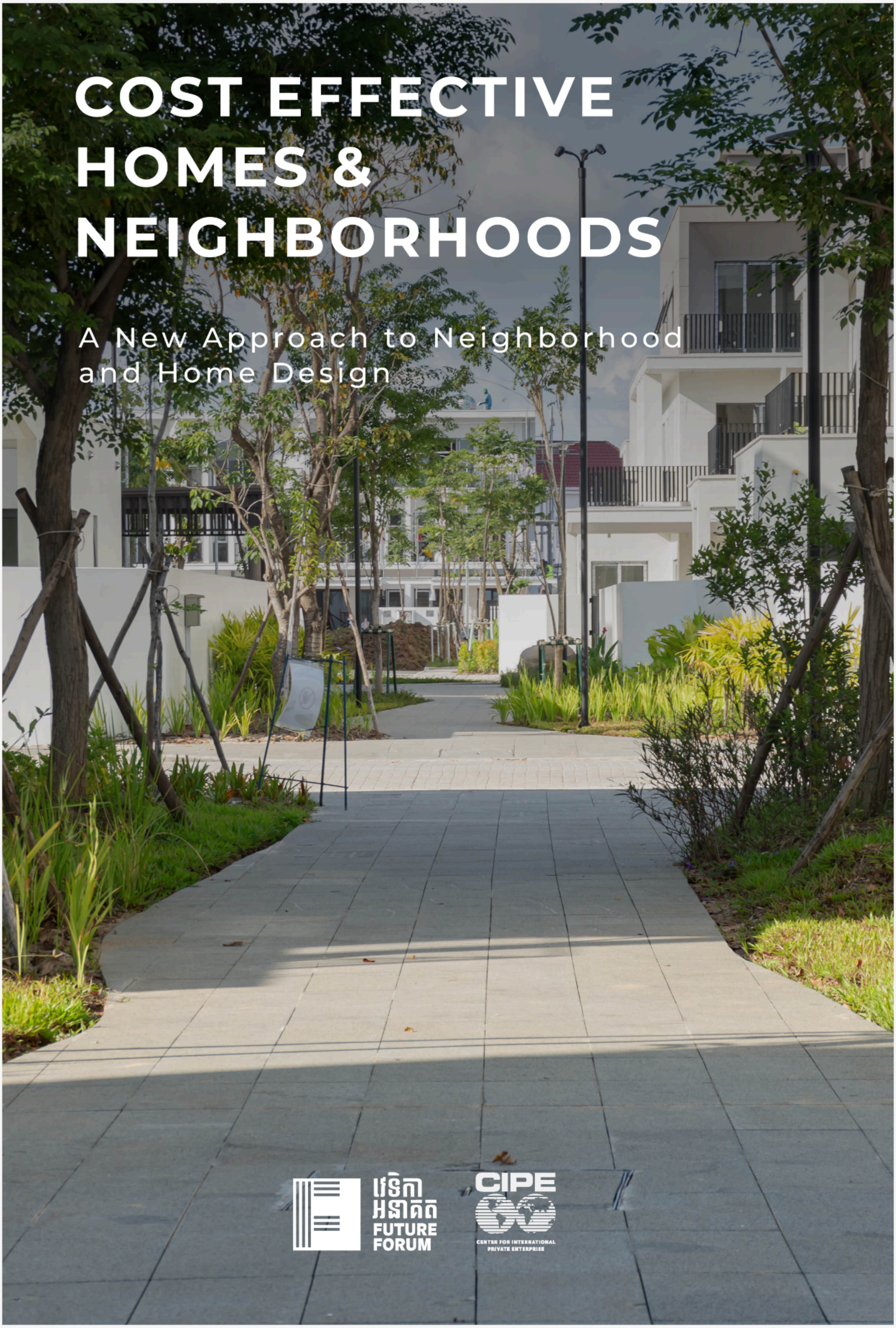
COST EFFECTIVE HOMES & NEIGHBORHOODS

A New Approach to Neighborhood and Home Design



FUTURE FORUM

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CENTER FOR INTERNATIONAL PRIVATE ENTERPRISE

Cost Effective Homes & Neighborhoods

A New Approach to Neighborhood and Home Design

Executive Summary

Phnom Penh is rapidly expanding outward. New residential neighborhoods are of low density, car-dependent construction, which imposes additional living expenses on to its residents. A cost-effective home is not only economical to acquire but also has affordable expenses. Therefore, the planning of the neighborhood to which the home is located must be carefully considered just as much as the design and construction of the homes themselves. Cost-effective homes and neighborhoods require consideration in four areas, neighborhood planning, mobility planning, housing design, and infrastructure.

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Background

Despite making great strides in the past decade, the planning, construction, and operation of housing and residential neighborhoods across Cambodia still left much to be desired. Inefficiency in planning has led to high construction and operational costs, which are then passed on to homeowners.

Providing housing goes beyond a high quality home in isolation, it encompasses the surrounding built environment as well. This means key factors of livability, including mobility, access to critical services, public and civic life, leisure, inclusiveness, and comfortable environment, must all be considered.

Defining cost affordable housing: it is widely accepted utilizes a families average annual income, where an affordable house is defined as houses that do not exceed 4 times the average annual income, with anything above 5.1 considered severely unaffordable (Helble et al, 2020). According to the 2019-2020 socio-economic survey, the average annual income of a Cambodian household is $6,639, or $553 per month (National Institute of Statistic, 2019). Hence, with the price-to-income ratio of 4.0 as maximum, affordable houses should not cost more than 26,556$.

Howere, there are limitations of such a definition that may result in higher cost of living due to distance from the city center, lack of public space, poor mobility options, inadequate access to public services, etc. Thus, defining a cost-effective home should not only be limited to the price of ownership (construction & land), it must also include the cost of living in the house; utilities, maintenance, commute, access to services and functions, etc., mobility options, access to employment, services, and leisure. To address this shortcoming, a supplementary measure considers the net monthly housing expenditure. To stray in the affordable range, monthly household expenditure should not exceed 30-40% of the total household income, which equates to 221.20$ for Cambodian households (UN Habitat, n.d.).

Shortcomings in Neighborhood Planning

Phnom Penh is rapidly expanding outward in the form of low density construction. Its new residential neighborhoods follow a car-dependent development model.

The fundamental nature of low density development means destinations are farther from people's homes. Furthermore, the poorly laid street network of outlying districts is causing neighborhoods to be disconnected, requiring commutes to be circuitous and inefficient (Keithya, 2022; Yen et al, 2021). Thus, demanding the use of private vehicles for even the most basic necessities.

Low density sprawl also makes it difficult for municipalities to maintain infrastructure and services (Trubka et al., 2010). This is because in a low density neighborhood, there are fewer residents to share the financial burden, thus the cost per capita is higher. Contrast this to a high density neighborhood where more residents share the financial cost of maintenance and upgrades, reducing the cost per capita. Road surfaces, electrical lines, clean water pipes, garbage collection, and sewage—just to name a few—are dependent on optimal density.

Car-dependency also pushes urban sprawl deeper into former green spaces including wetlands and lakes, which damages Phnom Penh's nearby natural environment. This is because car usage gives residents the perception that they can commute much further, thus making it seem appropriate to live farther away. This in turn pushes the demand for urbanization farther and farther from the city's boundaries.

A built environment designed for cars, also negatively influences perceptions of other commute options, making them seem less attractive. inhabitants make the decision to use cars as their primary means of commute on the basis of the built environment around them—on factors including their neighborhood's density, availability of mixed-use development, their distance to city center, and availability of parking (Wang et al, 2018).

In the long term, it will be ruinous—in terms of financial losses, environmental degradation, and health implications for Phnom Penh's population. It is clear that policy and design decisions influence the livability and cost-effectiveness of new neighborhood development. Thus, this brief examines four aspects of a neighborhood's built environment; neighborhood planning, mobility planning, housing regulation and design, and robust infrastructure policy.

Key Trends

Neighborhoods Planning

In terms of neighborhood planning, many of its impacts can be traced back to the developer's decisions as well. Among the key trends, we see the continuous construction of "high-rise buildings" and gated communities called "Borey".

It would not take statistics to look across the city skyline to see numerous high-rise buildings left unfinished or mostly unoccupied. Yet many more are still being constructed. Adding to that, the prices of high-rise condominiums remain unsuitable for local customers. On the other hand, Borey's priorities on residents' privacy and exclusivity not only results in high priced units but also creates social divide (David & Emilie, 2020). This social divide does not only happen between Borey and the city but also within the Borey itself. Within the Borey, there would be a cluster of higher income housing on one side and another income group on the other.

Firstly, the issue of residential high-rise vacancy is partially due to the price range of condos or apartments not adjusted for the average Phnom Penh citizen and their lifestyles. So the buyers are typically foreigners as stated by the CEO of Khmer Real Estate in 2020 (Hoekstra, 2020). During the pandemic, many of them returned home while many initially bought these units as an investment or an asset with no intention to live in them.

These factors exacerbate an oversupply of these high-rise residential units. Although it is acknowledged by real estate experts as being a problem to the real estate market. Speaking in 2023, Kim Kinkesa of CBRE Cambodia spoke of improvement of the real estate sector in 2024 but only if there are no more projects added to the market (Pisei, 2023).

Secondly, another urbanization trend is the development of residential neighborhoods in the outskirts. They are characterized by low-density detached housing, separated by large and overused driveways. Often pedestrian infrastructure is an afterthought, with developers wrongly assuming that their affluent client would not need to walk.

Another issue is regarding their social divide between residents within the Borey and outside Borey. As the Borey wall rises up, the neighborhood around it is excluded. But within the Borey, we see 3 layers of wall separating each resident. The wall of the house, the wall around the house, and the neighborhood wall segregating different income groups.

The main reason for that was to ensure safety of the residents within the neighborhood walls. While the parks and roads leading into the Borey are considered as public realm by law, outsiders can use these public spaces; raising safety concerns. So developers would need to segregate certain neighborhoods as private space away from strangers. But what comes out of that is the issue of social isolation and class segregation. Often, these exclusivity and privacy of Borey are advertised as being civilized but this social divide may even lead to loneliness experienced by elderly people who may only stay at home. Or may even create a very desolate image instead of a pristine quiet neighborhood.

Lastly, the pricings of faraway Boreys are lower compared to their inner city counterparts. But considering their distance to workplaces and city centers, it is, in fact, more expensive to live in. Due to spending on commuting to work or accessing other daily necessities can be quite tedious and costly in the long run (UN-Habitat, n.d.).

Both of these trends have a big impact on the walkability of the city (Wang et al, 2018) and citizens' economic well being (Trubka et al., 2010). To summarize, low cost Borey are far away from higher household expenses, and those that are near the city centers are more costly. High-density residential high-rise buildings, however, are mostly vacant and their focus is on e high-end customers.

From an urban planning perspective, optimal urban density has its advantages: it contributes to walkability, better convenience for users, saves on infrastructure construction and maintenance cost, strengthens the tax base for municipal governments, and improves economic livelihood. But reaching the desired urban density does not necessarily mean building high rises exclusively. In fact, optimal urban density can be achieved with low to mid-rise buildings as well. UNEC

(2020) recommends an optimal population density of 15,000 people/km^2 for urban areas.

Case Study: Bakong Village, Cambodia

An example of Borey development with optimal density, but low-rise housings is Bakong Village. Not only does Bakong have a completely pedestrian-only housing area, it also achieves optimal density through an efficient housing layout. Take a moment to calculate its density, Bakong has a total size of 4.7 hectares with total housing units of 317 villa-house and shophouse. As of 2024, Siem Reap household size is 4.6 in the information book by the Ministry of Interior (Ministry of Interior, 2024).

So Bakong residents density = *[(317 houses x 4.6 members-per-household) / 0.047km^2]* = 31,021people/km^2 which is more than twice the UNEC recommended urban area density.

Yet, in terms of proximity to the city center, Bakong is still quite far away. But in its site it is provided with basic amenities such as school and market as well as ample green space and densely packed community.

Additionally, having the correct type of public amenity differentiates a lively Borey from a desolate one. While certain Boreys have their high-end supermarket or malls, they can be quite daunting for certain residents in terms of pricing. Many may prefer a fresh market instead.

A very good case of a Borey having a fresh market instead of its high-end counterpart is Borey Piphup Tmey Chamkar Doung 1 (Zillionhome, n.d.). Such a market led to a more livelier neighborhood with customers from both within and outside the Borey. What's interesting is that the market and its various neighborhood parks act as 'magnet' to residents and customers as well as other businesses.

While other faraway Borey can be seen lacking this 'magnet' attracting residents there. Often, they would build housing first and the amenities such as shops and market are provided way later. This approach not only harms the livability of residentes but also impedes the growth or even the viability of the neighborhood itself.

The liveliness of Borey Piphup Thmey, can also be traced back to its free access for non-residents to facilitate the numerous businesses located inside. While a Borey with exclusionary access may be a safer neighborhood in theory, in practice urban planners agree that a lively neighborhood is actually more safe (Aiyer et al., 2014; Jane, 1961). This is explained by the idea of "eyes on the street," a lively street is one that has residents, pedestrians, and street vendors to watch it. This system of street watching deters crime while assuring street users that it is safe for walking.

All of which led back to the conversation of having a fresh market as a magnet of both residents and businesses that would result in improved liveliness and safety, simultaneously save on residents' transportation cost and daily grocery spendings.

Walkable & Transit Oriented Neighborhoods

Providing safe, accessible, and affordable mobility is a cornerstone of a cost-effective neighborhood. After all, mobility determines an individual's ability to access employment, education, healthcare, leisure, and other services. To ensure mobility for all users, a neighborhood must be planned to be walkable—for short distance commutes—and well connected to public transit— critical for long distance commutes to other parts of the city.

Case Study: Riselfeld

The neighborhood of Rieselfeld—a new district of Freiberg, Germany—was planned and designed from the ground up to around public transit, and has excellent walkability (Daseking, 2015). It is a neighborhood of 4200 families built along a tram connecting it to the city of Freiburg, allowing residents to easily commute to the city.

The main street which contains the tram line acts as the spine of the community, containing shops, businesses, sports facilities, a school, a church and a large plaza. The development utilizes multi-storey and mixed-use buildings To ensure that all critical functions are within walking distance for every resident. Additionally, optimal density (blocks of 5-6 story buildings) allows Riselfield to contain a large and diverse number of homes, businesses, services, and public amenities. Pedestrian paths create shortcuts between the different blocks, allowing for quick access between different areas. Access for private vehicles is allowed on a typical street, although it is centralized in a multi-story parking structure along the perimeter of the site.

Limiting private vehicle access, planning around public transit, and strengthening walkability led to significantly decreased demand for private vehicles. As a result, the strategy has been so effective that the area maintains a ratio of only 290 vehicles per 1000 inhabitants, 30 percent less than the national average of 420 vehicles per 1000 inhabitants for the rest of Germany (Hamiduddin, 2015).

Contrary to the Riselfield example, a car-centric physical environment has a negative influence on perceptions of other modes of transportation, making them appear less appealing. A study in Changchun, China, by Wang et al. (2018) found that residents choose to use cars as their primary mode of transportation based on the built environment around them—factors such as neighborhood density, availability of mixed-use development, and distance to the city center. Moreover, the availability of parking has a substantial impact on household decisions about car ownership, outperforming household income and demographic variables, which are frequently thought to be the primary predictors of car ownership (Guo, 2013).

Moreover, Christiansen et al. (2017) showed that people's behavior changed when the distance from home to the parking space increased: they were seven times less likely to drive, preferring to walk or ride their bikes. Hence, significantly limiting on-street and house front parking from residential streets and sorting vehicles in centralized parking lots or buildings is an effective strategy to discuss car-usage and increasing active commutes.

In essence, a cost effective neighborhood must strive to give residents commuting options which are safe, accessible, and affordable. This is achieved through implementing transit oriented principles, maintaining optimal density and mixed-use, and elevating walkability above motor vehicle access.

Housing Design

The current example of affordable housing in Cambodia has yet to achieve resounding success, in terms of numbers and usability, and despite government subsidies. Currently, residential housing with prices ranging below 35,000$, Arakawa residences and Worldbridge homes are two prominent affordable housing projects.

Firstly, affordable housing tends to search for low cost land which means it is further away from work, education, transportation and health care. Remote locations also incur additional infrastructure cost, developers often having to directly extend roads, clean water pipes, sewage, and electricity lines to their project locations. This cost is then passed back onto home buyers. Moreover, construction quality tends to vary significantly where some projects use durable materials, others fall behind with very low quality material that will have to be replaced much quicker. Lastly, these projects have inadequate public infrastructure and facilities further reducing resident's livability.

Poor construction quality, remoteness of location, poorly planned infrastructure, and inadequate public facilities holds back current projects. Residents incur additional housing costs due to these decisions.

Conversely, a well-designed house should provide comfortable living at an efficient expense. Most of the developers faced issues like the complex subsidy schemes, building infrastructure, expensive labor and material costs, and a satisfactory profit margin, etc. However, a well-thought-out design will reduce the associated development costs as much as possible while maintaining comfortable living.

Take Samroang Village and Worldbridge Homes as a comparison. Samrong Village's cheapest option cost 67,000$ (a two floors structure of 4 meters by 14 meters, giving a total indoor area of 97m^2), twice above the accepted definition while Worldbridge's units cost around 34,000$ (a two floor structure of 4 meters by 7 meters, giving a total indoor area of 56m^2). Therefore, Worldbridge Homes has a price per square meter of 607$, in comparison to Samrong Village's price per square meter of 690$.

Despite a relatively close price per square meter, Samrong village offers higher build quality, and excellent public facilities including public greens spaces. In comparison, Worldbridge homes offer worse build quality, and very basic public facilities. It should be noted that Samrong Village is 20.1 kilometers and Wordbridge Homes is 18.2 kilometers from the Independence Monument, the center of Phnom Penh, so land price difference is a minor factor.

This is to say that in construction timers, on a cost per square meter basis, high level of build quality, livability, and public amenities can still be maintained. Achieving such an outcome requires careful planning that considers human needs and design strategies to efficiently use resources.

Case Study: Villa Verde

Elemental, led by architect Alejandro Aravena, is known for its innovative approach to affordable housing design. Their initiatives usually revolve around empowering individuals and making use of available resources to create dignified and sustainable living spaces. Important concepts of Elemental's affordable housing design are: incremental housing, half-house concept, flexibility and adaptability, and community participation.

Figure 1: Affordable housing projects by Elemental.

The half house concept has the first floor of the finished half made up of unfinished concrete floors, and the second is covered in unfinished plywood. Everything that families wouldn't have an easy time building alone, such as concrete foundations, plumbing, and electricity, has been finished for them. The main focus is to make the houses inexpensive, functional, and well-insulated. Roads, drainage, sewage, garbage collection, buses, and any other infrastructure that is required for a livable community are all funded by the Chilean government.

For later upgrades, residents can take part in building workshops facilitated by Elemental, and every house comes with a manual covering possible ways to expand using standard building materials, avoiding the need for anyone to buy expensive custom resources. Residents will spend their time, labor, and any extra materials to upgrade their units. The goal is for homeowners to have a far nicer home than they could have with regular state funding or something they could have built entirely themselves.

Hence, cost-effective housing must not result in low-quality housing. Achieving these results requires design concepts that are incremental, flexible, and human-centered.

Decentralized Infrastructure For Neighborhoods

The residential project development has significantly increased, and Phnom Penh is undergoing urbanization. Public infrastructure for water & energy supply, sewage pollution, and waste management are being outpaced, especially in new residential developments along the outskirts.

Currently, the centralized infrastructure approach is not suitable anymore, as urban centers undergo rapid-development. Therefore, to ensure livability in demanding circumstances, a decentralized infrastructure approach for neighborhoods is necessary. In this approach, a decentralized wastewater treatment system (adopting DEWATS model) with separated storm water drainage is recommended.

DEWATS is a low-cost, bio-based, decentralized wastewater treatment approach that is well-suited to use in densely populated urban communities in developing countries. The passive design of this system uses physical and biological treatment mechanisms such as sedimentation, floatation, and aerobic and anaerobic treatment to treat both household and industrial wastewater sources. Crucially, DEWATS is designed to be low-maintenance, to use local materials, and to meet environmental laws and regulations (Borda, n.d.).

In a DEWATS system, water flows through a series of tanks that work in combination. For example, when water flows through a DEWATS Settler tank, scum floats to the surface, and waste is sedimented at the bottom. With the proper infrastructure in place, the DEWATS system could generate usable renewable energy in the form of biogas, which residents can use for cooking and lighting (Borda, n.d.).

In areas lacking public infrastructure, where the current alternative is to let contaminated water flow directly into the canal without treatment, DEWATS is the most appropriate solution to eliminate waste water contamination.

Case Study: DEWATS in Cambodia

62 DEWATS systems are already operational across many contexts in Cambodia (Borda, n.d.). DEWATS have been installed in Cambodia to provide water filtration primarily to school sanitary facilities and hospitals. The system popularity is due to many advantages over traditional centralized wastewater treatment systems:

- Simplified and low-cost maintenance
- Non-sophisticated construction that can rely on local laborers to build or fix
- Low construction cost that makes its implementation scalable
- Can provide treatment for organic wastewater flows from 1-1000 m^3 per day
- DEWATS units once installed are reliable, long lasting and tolerant towards inflow fluctuation.
- Small physical footprint makes it suitable for dense urban areas as well.

Complementary to the DEWAT system, a separate stormwater system should be designed. This is to ensure the DEWAT system is not overwhelmed during heavy rain storms. Having it also benefits in reusing the captured rainwater or greywater to irrigate green spaces, cleaning streets, etc.

A decentralized approach to wastewater management is necessary to address the demand of a rapidly urbanizing city. DEWATS is suitable for a decentralized public infrastructure approach.

Recommendations

Neighborhood Planning

As mentioned above, the physical characteristic of a neighborhood determines the livability of its inhabitants. Starting with the most prominent aspect of the neighborhood, the blocks, it is recommended to:

- The maximum side dimension of city blocks should not exceed 150m, meaning that a single block should be bounded by streets or pedestrian paths every 150m or less, thus creating a dense network of paths. This is to ensure good walkability and permeability for pedestrians and cyclists.
- Streets should be predominantly aligned on an east-west axis, streets that align north-south should be minimized in length.
- To achieve optimal urban density of 15,000 people per square kilometer or above, the neighborhood block should be constituted by a combination of detached housing and low-rise shophouse, with enough space left over for infrastructure and public amenities.
- To facilitate the inclusion of housing units of different income levels, within a block planners should include at least three price points for houses (low, medium, and high), with each type's amount not exceeding 50% of the total; to avoid creating a majority. While the high-end unit sales also help alleviate the upkeep of the construction and maintenance of the neighborhood.
- Inclusion of at least one public green space (micro gardens) throughout every block, making them accessible to residences in close proximity. Ideally, these green spaces should be linked with active commuter exclusive avenues, serving as an alternative path or shortcut for users. multiple gardens and parklets are in close proximity should be consolidated by pedestrianizing paths, creating a continuous and coherent public space.

DISTRIBUTED SPACE SPACE

INCONJUNCTION WITH ACTIVE COMMUTE NETWORKS

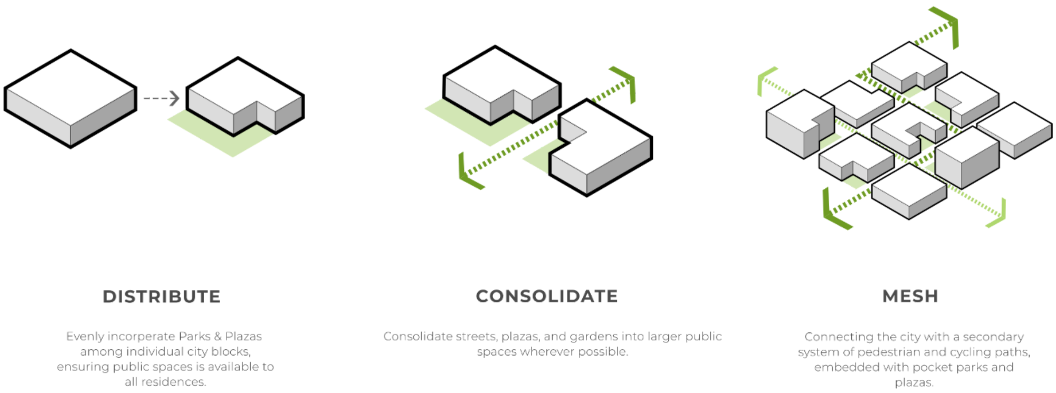

Figure 1: Allocation and placement of green spaces in neighborhood blocks.

Land-use planning should utilize a Form Based Zoning methodology which carefully regulates building form through Floor Area Ratio (FAR), street to building ratio, open facade ratio, and a mobility profile according to street types. The following are criterias applied to buildings in each respective zone:

Floor Area Ratio: controls the total size (floor area of the building compared to the land plot) and therefore the neighborhood's overall population density.

Street to Building Ratio: links the height of the building to the street width. This allows the management of building height to maintain a comfortable, well lit, and well ventilated streetscape.

Open Facade Ratio: helps maintain openings (doors, windows, and permeable surfaces) allowing the street which improves safety and social interaction.

Gap Ratio: stipulates the size of gaps between buildings line to allow for ventilation and natural lighting.

Parking Regulation: manages the total number of off-street parking available. This impacts mobility choice and should be used to encourage active commuting and public transit usage.

Freight Access: decide the size of freight vehicle access to a given zone. This controls function of the building

Zone Type & Street Type	Floor Area Ratio (Maximum)	Street to Building Ratio (Maximum)	Open Facade (Minimum)	Building Gap Ratio (Minimum)	Parking Regulation (Maximum)	Freight Access	Freight/Garbage delivery points
Restrictive Zone Pedestrian Avenue	3.0	1:1.5	30%	35%	Only provide parking facilities for bicycle and mobility devices.	Freight access at freight delivery point. Solid waste collection point	Have one freight/garbage point for every 60 household
Light Zone Residential Street	4.0	1:2.5	40%	50%	A maximum of one car per $120m^2$ and one motorcycle per $80m^2$ In addition to limited on-street parking.	Requires small freight trucks (cargo rickshaw - 1 ton cargo vehicles) access	Have one freight/garbage point for every 60 household
Transit/Multimodal Zone Transit Boulevard	6.0	1:3	80%	5%	A maximum of one car per $150m^2$ and one motorcycle per $80m^2$ In addition to limited on-street parking.	Medium freight trucks (1.5 - 2 ton cargo vehicles) access.	Have one freight/garbage point for every 40 household
Heavy Zone Arterial Street	3.0	1:2	50%	5%	A maximum of one car per $250m^2$ and one motorcycle per $100m^2$ In addition to on-street parking.	Heavy freight access for large vehicles (container truck/tanker truck).	Have one freight/garbage point for every 60 household

Table 1: Summary of building regulations specific to each zone.

Buildings on busy mains street are permitted to reach higher FAR (increasing density), have a high Facade Opening Ratio and high Street to Building Ratio to accommodate pedestrian comfort and improve physical connectivity, and parking requirements that discourage private vehicles and encourage public transit.

Residential streets emphasize smaller buildings with lower FAR limit (lower density), have a lower Facade Opening Ratio and lower Street to Building Ratio to maintain privacy of residences. However, accommodating pedestrians' perception of safety requires a 30% opening requirement to eliminate blindspots where crime can take place. Parking requirements and Freight Access reflects the usage of limited private vehicle usage amongst local residents, but does not oversupply vehicle infrastructure to the point of harming active commuting and public transit usage.

Areas that require heavy vehicle traffic and their associated arterial roads have more generous parking requirements, allows for heavy freight access, and much lower Street to Building Ratio.

In essence, the buildings are shaped to reflect the volume and type of traffic to be expected on a particular type of street.

As a whole, successful neighborhood planning requires a number of characteristics to be planned and implemented ahead of time. Relying purely on the private sector may not produce the desired result. Thus a more considered approach for new project should be adopted:

- Public sector should annually project the number of new housing needs and roughly where their location should be.
- Private developers can then propose residential neighborhood schemes accordingly.
- The government will select winning schemes and approve them for further detailed studies.
- The government will plan and build public infrastructure like (street network, electrical lines, wages lines, clean water supply, etc.) according to the selected scheme.
- The private sector will then build the neighborhood's blocks and units.

Neighborhood Mobility

A cost-effective neighborhood should seek to provide people with safe, accessible, and affordable commute options. This can be done through the following principles:

Transit Oriented Approach: plan and build neighborhoods around public transit lines and provide necessary infrastructure to support this.

Optimal Density and Mixed-use: maintain a population density of at least 15,000 people per square kilometer and mixed-use of functions and building size.

Prioritizing Walkability: in all locations pedestrian access must be elevated above motor vehicle access to ensure excellent walkability, thus ensuring that active commuting is the main mode of commute.

In conjunction with land-use planning recommendations, it is recommended to have four types of streets to reflect the four zone types. Each street type has its own corresponding zone which restricts building form, parking, freight options (refer to previous section for details).

Pedestrian Avenue is suitable for small residential units and stores, only accessible by active commute. Here detached single family homes might share pleasant walkways and lively plazas.

Residential Street is suitable for both shops and homes should be designed to prioritize active commuters but would still allow necessary vehicle access, get supplies and for public services like garbage collection, and emergency services, etc.

Transit Boulevard is suitable for building which generates a high amount of foot traffic.

Arterial Street is suitable for buildings which generate high amounts of vehicular traffic.

Zone Type & Street Type	Right of Way	Commute Mode	Freight Access	Parking	Recommended Functions
Restrictive Zone Pedestrian Avenue	8.00 meters	No vehicle traffic. Exclusively for foot and bicycle traffic.	Freight access at freight delivery point and solid waste management at collection point. One location for every 60 household	Only provide parking facilities for bicycle and mobility devices.	Row houses, small restaurants, bars, streetside markets, cafes, small grocery shops, barber shops, clothing stores, pharmacists, studios, etc.
Light Zone Residential Street	15.00 meters	Light amounts of vehicle traffic, less than 1500 cars per day. Heavy foot and cycling traffic.	Requires small freight trucks (cargo rickshaw - 1 ton cargo vehicles) access	A maximum of one car per $120m^2$ and one motorcycle per $80m^2$ In addition to limited on-street parking.	Shophouses, apartment buildings, convenience store/mart, medium size shops, medium size restaurants, medium size tourist hot spots, clinics, banks, schools, offices, etc.
Transit/Multimodal Zone Transit Boulevard	30.00 meters	Moderate vehicle traffic and Influx of volume during rush hours, Augmented by public transit and active commute.	Medium freight trucks (1.5 - 2 ton cargo vehicles) access.	A maximum of one car per $150m^2$ and one motorcycle per $80m^2$ In addition to limited on-street parking.	Department stores, supermarkets, fresh produce markets, office complexes, cultural buildings, apartment complexes, etc.
Heavy Zone Arterial Street	25.00 meters	High volume of motorized traffic Dangerous freight traffic.	Heavy freight access for large vehicles (container truck/tanker truck).	A maximum of one car per $250m^2$ and one motorcycle per $100m^2$ In addition to on-street parking.	Large workshops, technical offices, big box stores/malls, convention halls, furniture/hardware stores, gas stations, warehouses, factories, car repair shops, car dealerships, etc.

Table 2: Summary of mobility profiles of each zone and their associated street types.

Transit Oriented Approach

A newly planned neighborhood should incorporate a public commuter line running through its center. This can be achieved by extending existing lines into new developments, forming a spine for new neighborhoods and acting as its main street.

This main street would be the center of commercial and civic activities in the neighborhood. Where architects could locate multi-functional blocks composed of mid-rise buildings which contain shops, offices, restaurants, public facilities, etc. Just behind the main street, residential units would be more dominant but maintain some businesses on the ground floors.

Optimal Density and Mixed-use

Firstly, requiring optimal density of at least 15,000 people/km^2 or higher ensures a diversity of functions and close proximities between homes and destinations.

- FAR and building height limit should reflect and permit optimal density, being highest on boulevard with public transit lines and diminishing on smaller roads.
- Construction of row-houses, townhouses, and twin houses are most appropriate for residential units, while minimizing the construction of single family dwelling.
- Rental housing should be built in higher density, multi storeys buildings with FAR ranging from 4.0 to 5.0, and include commercial units on the ground floor.

Mixed-use should not only aim to create a variety of functions, but it must also ensure a range of prices for goods and services, creating a social mix, and encouraging residents to explore their neighborhood.

- Utilized a Form-based zoning methodology to determine land-use (Moughtin & Shirley, 2016).
- The construction of buildings along the transit boulevard and collector streets must have a mix of functions and a mix of price point.
- Avoid building barriers, walls, enclosures, etc. which creates segregation between differing social economic levels of residents. Instead neighbors

should share walk paths, micro-garndes, and playgrounds to encourage social interactions.

Prioritizing Walkability

Lastly, ensuring excellent walkability within neighborhoods requires elevating pedestrian access above motor vehicle access in all areas.

- To encourage active community within the neighborhood it is recommended to have a criss-crossing network of tree-lined, foot and cycling paths, connected to the gardens and playgrounds throughout the neighborhood.
- The placement of footpaths should be continuous and use the most direct route and shortcuts to connect important destinations.
- Remove front-door car parking and replace it with centralized along the perimeter of the neighborhood, away from living areas in secured locations next to exit points from the neighborhood.
- Limit car-based entrance to only major arterial roads which can handle large volumes of vehicle traffic.
- Create multiple entrances for active commuters by connecting footpaths to existing neighborhoods.

The above recommendation will create a neighborhood layout to dissuade car usage for short trips, moves car-centric spaces away from the heart of the neighborhood, and freeing up space to be used for more productive purposes to benefit inhabitants. These choices allow residents to actively commute, to enjoy leisure activities, facilitating opportunities for social interactions and allowing children to safely wander around and explore.

Housing Design

The general direction of cost-effective housing design and construction should be shaped along the following recommendations:

- Apart from private sector development, housing programs should adopt a municipal housing corporation or similar organization model to manage construction and operations.

- Establish rental control mechanisms to keep housing rents stable and prices from rising by accounting for variables including housing size, location, household expense, and public facilities.
- Emphasize cost effective and long-lasting materials for construction which keeps operational and maintenance cost low for homeowners while maintaining high livability.
- Integrate green spaces to encourage well-being of the community and to mitigate climate impact.
- Optimize unit layout design and proportions for flexibility in case a change of usage is needed in the future.
- Minimize expense on vehicle infrastructure by minimizing or eliminating driveways, vehicle lanes, and car parking.

Two categories of housing should be built. The first option is for homeowners who want to own property, and second option is for tenants who want to rent housing.

For the first housing option, it is recommended to build either shophouses (attached units) and detached homes to the following considerations:

- Thermal insulation should be a priority to help save on housing expenses. The facade is the primary thermal barrier in a structure, affecting air flow, passive lighting, therefore influencing energy consumption and environmental impact.
- Incorporate ample windows and openings with permeable materials to ensure airflow and passive lighting. Avoid placing large openings on the western facade to avoid the most intense thermal gain.
- The roof should be well insulated to minimize thermal gains and have easy access from the bottom to allow for regular maintenance.
- Use the setback space to include greenery to act as a thermal buffer and provide privacy.
- Openings can incorporate translucent materials or be placed higher to avoid direct view from outside, protecting privacy, while still maintaining eyes-on-the-street to improve communities safety.
- Stairwells should include a carefully angled skylight to admit indirect light into the center of the house.
- Extended roof structure to cover front or backyards should be carefully considered as to not cover existing openings.

For the second housing option, it is recommended to build low-rise, apartment style building by observing the following recommendations:

- Building multi story buildings (4-5 story) is recommended to maximize land utilization and accommodate families in an optimal manner.
- Build mix-use buildings that have shop space on the ground floor and residences on the second floor and upwards.
- Include multiple types of rooms, of differing size catering to different family sizes, in each floor to more efficiently use floor space and create social mix.
- Minimize the floor area stairways and corridors space by sharing stairways and corridors. While shared facilities, such as stairwells, corridors, and plumbing/electrical vents, elevators, mechanical, electrical, and plumbing rooms should be efficiently placed to minimize piping and wiring distances to all units.
- Accommodate accessibility needs by including units with larger bathrooms and located on ground floor.
- To further save cost, the ceiling should not be installed. Instead cables and wiring, embedded in conduits, and likewise plumbing should be exposed for easy maintenance.

Despite financial limits, it is possible to prioritize cost-effective design and construction without sacrificing quality. Focusing on form and material selection provides the best chances for balancing costs and performance goals. Doing so ensures that inhabitants have access to both aesthetically beautiful, functional, and cost-effective homes. This method promotes thriving, sustainable communities that cater to the different requirements of its residents.

Public Infrastructure

To ensure residential neighborhoods preserve livability while also minimizing expenses on infrastructure, it is recommended to approach infrastructure construction and management in a decentralized manner. The following recommendations focus on waste water management and solid waste management.

Firstly, wastewater management must follow a decentralized water treatment system by implementing DEWATS. One system has a flexible capacity to support 20 to 100 families, with a filtration capacity of $5m^3$ per day and costing 5,000$ to construct. The system consists of toilets and bathrooms within each household. The wastewater is directed to DEWATS by shallow, enclosed sewer lines.

Secondly, the stormwater drainage should be separated from the waste water lines into its own system, a gray water system. This is necessary to prevent overflowing the DEWATS during rainstorms and allows for gray water to be resumed in gardening, street cleaning, and for firefighting.

To ensure successful implementation of the system the following recommendations should be observed:

- Involve residents, government agencies, NGOs, and other stakeholders in the planning process to ensure transparency and buy-in. This is crucial in not only the construction process but in the long term operations of the system.
- Based on the assessment of needed capacity, water quality, community size, maintenance capabilities, financial resources available, and future demand projections, choose appropriate system capacity and future expansion possibilities.
- Ensure the chosen technology and implementation plan comply with local regulations and water quality standards to meet regulatory compliance.
- Utilize standardized designs and components for easier maintenance and access to spare parts.
- Regularly monitor water quality, system efficiency, and energy consumption to ensure effectiveness and identify potential issues.

Secondly, solid waste management can be improved through the implementation of dedicated garbage collection points incorporated into on-street parking lanes.

- Garbage collection points can be carved out from on street parking lanes.
- Sufficient space for garbage trucks requires the correct dimension, being large enough for trucks and large garbage bins. And must be protected from encroachment by bollards.
- Maintaining access to vehicles providing public services should be maintained by incorporating a mobility through zone with a minimum width of 3.00m that is wide enough for service and emergency vehicles to pass through.
- For every 200 meters stretch of street, there must be one garbage collection point for all residences and shops.

- Recycling management should be implemented by requiring residents to practice garbage separations.

Key Takeaways

A cost-effective home is not only economical to acquire but also has affordable expenses. Therefore, the planning of the neighborhood to which the home is located must be carefully considered just as much as the design and construction of the homes themselves. Cost-effective homes and neighborhoods require consideration in four areas, neighborhood planning, mobility planning, housing design, and infrastructure.

Neighborhood planning should strive to reach optimal urban density, mixed-use buildings, and incorporate public amenities. This can be achieved by utilizing a form based zoning methodology which thoughtfully conforms buildings to their context. Secondly, mobility planning must seek to provide residents with safe, accessible, and affordable commute options by adopting a Transit Oriented Approach, prioritize walkability, and minimize vehicle infrastructure. Thirdly, housing design and construction should be cost effective and quality architecture which keeps operational and maintenance cost low, design with climate and weather in mind, and optimize layout for efficient use of space. Lastly, infrastructure for the neighborhood should follow a decentralized model by adopting the usage of DEWATS for waste water management, a separate storm water drainage system, and the implementation of dedicated garbage collection points along with waste sorting.

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