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PARAMETERS OF URBAN EXPANSION IN OMAN

SAMPLING URBANISATION PARAMETERS

After studying the patterns of urban expansion, namely the dynamic processes, the establishment of specific parameters is useful to systematically evaluate the the type of urbanisation. The case study site Al Khoud phase 6 had an area of approximately 2 km² and similar development sizes occur all over Muscat Capital Area, for instance in the other phases of Al Khoud (1-5), Mabaila, Bowsher, As Seeb etc. Sampling an area of 1 km² allows to frame a distinct part of these developments, namely the center that develops first. It also excludes edge conditions affecting the observation area that might be subject to external parameters or adjacent development forces. At the same time the sampling area is large enough to enclose a significant amount of plots and roads to validate the data.

The urban expansion process in Oman can be quantified by measuring lengths, areas and ratios in combination thereof over a 1 km² sample area. A key ratio used by researchers interested in sustainable urbanisation is density. (Berghauser Pont and Haupt 2009) Distribution of houses, inhabitable surface areas or number of inhabitants are compared to a certain area to establish a specific density. Many researchers argue that denser urban fabric corresponds to a more efficient use of land, infrastructure and natural resources. (Global Compact Cities 2010) UN Habitat uses density as a proxy to measure sustainable urbanisation patterns altogether. (UN HABITAT 2015) Finally, these areas and ratios reveal the 'footprint' of an urban expansion process. (Baccini 2012) Roads, infrastructure and services typically form networks that can be analyzed in terms of segment length, node count, connectivity, accessibility etc. These network parameters have recently been integrated into the discourse on sustainable urban design.(Axhausen 2013) In comparing these various aspects, networks can be classified in terms of efficiency. Network efficiency and spatial density become key parameters for a future sustainable urban design model.

Since urbanisation is a dynamic process and the development of government planned urban expansion areas such as Al Khoud can take several years, if not decades, one cannot measure the 'final' stage of the masterplan but has to assess several timestamps. The base for comparison is samples taken in April 2012 with projections on the hypothetical fully built state (in brackets). The derived quantitative data in time can be interpreted to reveal a dynamic picture of the urbanisation process. Next to quantifiable parameters, sustainable urbanisation is characterized by aesthetic, social and cultural parameters. Those specific to the case-study Al Khoud are listed in the last part of this chapter.

PARAMETERS OF URBAN EXPANSION: LENGTH

A key parameter to measure is the total road length. The Al Khoud sample area features more than 20 km road length for 1 km² area. On a more detailed level the road-network can be described by measuring its segments and nodes. Those differ significantly across the sampling area and reveal an uneven if not unfair connectivity and accessibility for the residents. By assigning road classes corresponding to road diameters of up to 20 m, the total surface required and the land-consumption for roads can also be established. This surface can be compared to the overall land utilization. Since roads are provided by the government they contribute to a development costs born by the public.

Other infrastructure such as electricity cannot be traced by remote sensing. Since water and sewerage connections do not exist, these cannot be represented here either. The road network is analyzed below in detail.

PARAMETERS OF URBAN EXPANSION: AREA

Building footprints: A first numeric indicator is the surface a building occupies on the site, also referred to as building footprints. The number of building footprints in the sample area is 325 (812) units. The total area of footprints is 88693 (221723) m^2 with an average footprint area of 273 m². In April 2012 merely 8,8% of the site were covered with building footprints. The projected area, once finished, will be 22,1%. By comparison with traditional settlement patterns in Oman and even with residential developments of the 1990s like Al Khuwair 15 km to the East, these figures are extremely low. It needs to be examined what the remaining 77,9% of space are used for. The average plot area of 600 m^2 is much larger than the building footprint of approximately 200 m². The rules governing the site dictate set-backs of 3 m to all sides and of 5 m to the front side. The self-standing villa, whether single, twin or "XXL-villas", is the only possible building type here. 39,4% of the area is devoted to a doughnut-shaped space in between houses and plot lines. 16,3% of the area is proper circulation space taken up by roads. The remaining 22,2% are allocated to another buffer zone in between street and plot lines and for 'Sikkas' (small alleyways) behind the houses. This space is totally neglected as it is neither appropriated by the house-owners nor taken care of by the government planning the roads. If housing is the main purpose of the residential scheme then 22,1% of the land actually used for Sikkas is a massive waste of space.

Outdoor Space: The urban design of Al Khoud does not foresee the design of common outdoor spaces such as public gardens, areas for children to play or for neighbours to socialize. The urban environment can be characterized by built-up space on the one hand, and by non built-up space on the other. Buildings and open areas or the space 'in-between' both complement each other. This distinction is helpful as it coincides with the dichotomy of public and private spaces. Its ratio is a valuable indicator for density, in return an indicator for sustainability. The quality of outdoor spaces largely determines the quality of the urban design. In Al Khoud, the outdoor spaces are governed by regulations regarding the plots and regulations regarding the street network. The quality of the outdoor spaces can be characterized in terms of sealed ground, shaded areas and green areas. Given



Figure 2.2.1: Al Khoud 1 km² area sample map, drawn by the author, 2012. the extreme climatic conditions of the site, the total sealed are is an indicator for the existence of the so-called 'heat island effect', storm water drainage and possible areas of vegetation. Sealed surfaces are irreversibly lost for other uses like agriculture or natural (wild) development. In April 2012, 252168 (385208) m^2 were sealed. The plan does not provide for common green space, nor shaded outdoor space. Green and shaded spaces occur only within the donut shaped private space surrounding the houses.

Private outdoor space: Open space allowed by the standard plot dimensions of 20×30 m and the set-backs of 3 m to the side and 5 m to the front side is meant as distance space towards the neighbours and is kept according to the plot owners preferences. It is not accessible to the public and is protected against views towards all sides. This leaves a constructible area of 308 m² on a 600 m² plot. If the desired floor-area ratio is respected, a two-story house would have a building footprint of 180 m^2 leaving 420 m² of private outdoor space. Even the larger XXL-villas will leave almost half of the plot empty. The plot is walled with a 2-3 m tall brick wall. Due to their corridor-like proportions these private outdoor spaces can hardly be used for anything but to keep one or two cars parked on the plot. In consequence they do not contribute to a more sustainable urban design.

Sealed surfaces: Large open areas are sealed with asphalt, concrete or tiles. Next to asphalted streets, ramps on the curbside space are made of concrete elements. The residential open space is covered with stone tiles. Sealed space is not available for greening. Moreover dark sealed surfaces contribute to heat increase by solar radiation, so called urban 'heat islands'. Light sealed surfaces contribute to reflection and glare, making the outdoor space uncomfortable during the peak hours of the day. Dust and dirt accumulates on sealed areas and need to be washed off or else contribute to further dust pollution.



Figure 2.2.2: Non-maintained and non-usable street and curbside space in Al Khoud, 2013. **Shaded areas:** A key strategy to reduce the heat gain is to reflect, capture or fence off solar radiation before it hits the ground. Combined with ventilated roofs, narrow alleyways or smart configurations of buildings (a so called 'chimney effect') can naturally carry the hot air away from the settlement. There are no planned shaded areas in Al Khoud. Streets, curbsides and plots are exposed directly to the sun. Houses stand freely on their plots without a significant shading effect during mid-day, when the impact is biggest, since the sun is at the zenith on the latitude of Muscat (tropic of cancer).

Green spaces: Green spaces provide both shade and improve the micro-climate by means of natural evaporation through the leaves of the plants. The effect is cumulative and requires a consistent approach across the settlement in line with the urban design. At present, there is no green space implemented in Al Khoud and none of the public spaces feature green yet. The masterplan does not indicate green areas. The curbside space could in future contain trees. Until the road-network is complete, no trees can be planted. Greening only parts of this space is very expensive and will use a lot of water, which has to be trucked in as re-used waste water from the water treatement plant in Ghala. Drip irrigation could lead to a sustainable greening and a favourable micro-climate, but has not been implemented. Residents cultivate ornamental plants on their plots. These plants contribute little to the improvement of shading and micro-climate. This contrasts the desires of the inhabitants. When children in the area were asked to imagine their neighbourhood¹ according to their preferences, the majority of their drawings showed big trees and other green and natural areas as part of their desired future living area.

Street and curbside space: As one can see in the street section profiles, the curbside space in between plot-lines and the streets is substantial. While the streets are between 8 m to 12 m wide, the cross-section from plot to plot is between 20 m and 36 m. Dotted with basic urban furniture such as light posts, trash bins and electricity boxes, the curbside space is conditioned by the roads. Since the roads are only built up to 40% across the site, the majority of the street and curbside space is left unattended.



Ground floor + maximum 2 stories = 3 stories

Figure 2.2.3: Setback rules providing for exposed non-public outdoor spaces in Al Khoud, 2013.

Setback min 3m to the sides and back

Footrint max. 14 x 22m

Setback min 5m to

Curb Space

TRC 5

Oman Muscat Municipality - Local Order No. 23/92 Butter Regulations for Muscat



PARAMETERS OF URBAN EXPANSION: RATIOS

The floor-area-ratio (FAR) divides the net floor area by the plot size and is 0.31 (0.77). The sum of net floor areas is 191125 (477812) m². These figures takes the 3-dimensional development of the settlement into account. While these figures ranges within mid-dense urban fabrics, they pale when the actual site is taken into account. The built-up area ratio would compare the 3-dimensional density across the site. In April 2012 the density was 0,07 (0,22). This figure underscore the inefficiency of land use identified by looking at the 2-dimensional land utilization.

	Building Foot- prints / total	Sealed Surfaces / total	Shaded Outdoor- space / total	Total Area
2012	8.8%	25.2%	0.2%	100.0%
Fully built	22.1 %	38.5%	3.0%	100.0%

Next to FAR and built-up surfaces, the sample area has been examined for housing, public space and road-network density. The figures were measured based on GIS maps. These samples stand for a sample area of 1 sq km with approximately 2800 (7000) inhabitants and a number of 7,2 persons per household.(Oman Census 2012) Density is not just a criterion for land consumption but also an indicator for energy consumption and efficiency of use of infrastructure. Land development requires necessary infrastructure such as roads, electricity and water / sewerage provided by the state, in return consuming more space and energy to build. Accordingly, a less dense neighbourhood is proportionally less sustainable.

	Building Foot- prints / total	Sealed Surfaces / total	Inhabitants / km ²
2012	8.8%	25.2%	2800
Fully built	22.1 %	38.5%	7000

Density on the micro scale of the plot is driven by the layout of the masterplan and the pace of development of the plots. The planning standards and building regulations to be followed

Figure 2.2.4: Area parameters computed by the author for 1 km² sample based on Ministry of Housing plan for Al Khoud stage 6, 2010.

Figure 2.2.5: Ratio parameters computed by the author for 1 km² sample based on Ministry of Housing plan for Al Khoud stage 6, 2010. in the masterplan concerning the hierarchy and the width of streets, as well as the set-backs create huge areas of low densities with high consumption of land. Land however has to be considered as a limited non-renewable resource. The irregular and extended process of development decreases the density of Al Khoud even more. Some plots might never be developed at all. The XXL villas found recently overbuild the plots but hardly contribute to a higher density.

PARAMETERS: ROADS, INFRASTRUCTURE AND SERVICES

Infrastructure and services in the forms of roads, electricity, water and sewerage disposal are provided by the government. The planning of land subdivision, connection to the electric grid and the road-network are the essential conditions for the construction of buildings by the private sector. Electricity is crucial for the development and habitation of the houses, since all need to be airconditioned. A connection to the larger road network is desirable but not often the case. Improvised dirt tracks make up for the lack of proper roads. Water and sewage disposal are not connected to infrastructure. Both are provided by trucks and have become decentralised and mobile. The provision of services is delayed by several years due to the huge amount of simultaneous constructions sites in Greater Muscat Area. Pioneer residents have to live with sub-standard infrastructure for long periods of time.

Regional road connection: As described above, Al Khoud is well connected to the larger road network of Greater Muscat Area by the new Southern Expressway, the Seeb road and further on Sultan Qaboos Highway in the North. The highways structure the territory with spacious interchanges and exit ramps. The speed limit on the 6-lane highway is set to 120 km/h near Al Khoud, the maximum speed allowed in the Sultanate. The higher the cruising speed, the larger the turning radius' and the longer the exit ramps. The Nizwa road interchange is 6 kms to the East, while the Mabaila exit is 10 kms to the West. The clover-leaf Al Khoudh exit on the Southern Expressway covers an area of 281600 m². The highway has a diameter of 48 m including the slip lanes and median spacer. The interchange diameter is 600 m wide. While it serves several communities to the North and the South, it is in comparison about 1/8th of the







Figure 2.2.6: Al Khoud road hierarchy map, drawn by the author based on Ministry of Housing plan from 2010 and guidelines based on "Physical Planning Standards" developed for Supreme Committee of Town Planning, Oman, by Atkins Int. 1991 size of Al Khoud. Residential construction started in 2008. The Southern expressway was opened only in the fall of 2011. During these 3½ the construction of the highway had a negative impact on the settlement in terms of noise and dust pollution. The site was reachable by the Seeb road only. A third parallel road in between the Southern Expressway and Sultan Qaboos Highway is under construction. The semi-highway will run North of Al Khoud and connect the neighbourhoods of Bowsher, Al Khoud, Mabaila and further West. One remaining obstacle is the crossing of wadi Al Khoud which is planned as a massive bridge with high impact on the eco-system of the wadi. Highways and semi-highways are closed road systems as their entry and exit points are regulated and spaced every 6 to 10 kms in order not to disturb the transit traffic. They form a barrier that, in the case of Wadi Al Khoud, can only be crossed with fly-overs or under bridges. A secondary system of roads is necessary to service the areas in between these nodes. These secondary roads run in parallel with the highways, de facto adding another 4 lanes to the highway system. The cruising speed on these secondary roads is 100 km/h. They have a cross-section of 28 m. Junctions are resolved in roundabouts of 70 m in diameter. These roundabouts occur every 2 to 3 km and form the entry points to the residential neighbourhoods. Al Khoud has one entry point located at the southern end of the site. Local road layout: The entrance roundabout to Al Khoud leads towards the central spine of mixed-use taller commercial and residential buildings. From there several circumferential roads service the symmetrical wings of low-rise residential buildings to the East and West. Finally the road network branches into smaller lanes with more frequent bends and cul-de-sacs. The road-network within the site follows a strict hierarchy of 3 internal road types. Main roads (type 1) structure the sites and create clusters of plots. These clusters are entered from few sides by a second road type. Type 2 roads branch into the clusters and do not cross them in a straight line. These roads are followed by a third type of road deserving 10 to 20 plots and ending in a cul-de-sac. The total length of the road system inside Al Khoud is 39.7 km. Compared with the plot number of approximately 2000 plots (some plots have not clearly been subdivided yet awaiting decision whether to become residential or remain industrial), this figure is more likely a target to be reached. At closer look, the service by roads to plots is not equal across the site. Some houses are grouped in clusters of 6 plots with type 3 roads running all around them, while others are placed in rows of 36 houses. This uneven distribution questions the layout of type 3 roads. The same can be said for type 2 roads, as the larger clusters vary in size and road-to-plot ratio. Overall, the local road-network is very dense. The network of inner roads consequently performs well in terms of car-friendliness. A high share of access area in the overall built up surface area is evident. The distribution and pattern of roads built by April 2012 of 40,1% is as random as the pattern of residential development. Roads of all three types randomly parse the site and end without notice. Parts of the site are still not served by roads.

	Road length	Roads built	Road surface / total	Road surface + Buffer-zone / total
2012	8.82 km	40.1%	6.6%	15.5 %
Fully built	22.0 km	100.0%	16.3%	38.5%

Road width and circulation areas: The area consumed by roads in April 2012 was 66207 (163475) m^2 for the whole site. The total road length in April 2012 was 17,036 (39,650) km. The inner road network is determined by the size and shape of the whole area, allowing for access by car of each individual plot. Plots are arranged in a linear way, mostly of 30 x 20 meters (600 m²) as a standard plot size and shape.

Figure 2.2.7: Road parameters computed by the author for 1 km² sample based on Ministry of Housing plan for Al Khoud stage 6, 2010. Like the plot layout, the street-network does not take any local geographical conditions into account but seems to follow an internal closed logic of servicing plots and respecting the building regulations. As described above, 16,3% of the area will be proper circulation space, covered by asphalt. Yet another 22,2% of the space is allocated to the buffer-zone between street and plot lines. This space is not sealed, but neglected as nondescript open space. Together, 38,5% of the space is non-private and directly occupied by the roads. This space cannot be used for residential purposes, as it would block the way to the buildings behind, nor does it offer any valuable public space. Greening the overall 40 km of corridor-like space is both financially and ecologically impossible. At present it serves as gratuitous parking and storage space for construction materials. Road width varies according to the types of roads from 8 m to 12 m. The cross-section taken at various samples within the site reveals that the distances from plot line to plot line is significantly larger with 20 m (type 3) to 36 m (type 1). The distance from building to building (including the private walled outdoor space) across the streets ranges from 30 to 48 m. Streets become a driving factor for less dense urbanisation.

Construction of roads does not seem to follow a distinct pattern. The central spine around the mixed-use functions was completed with some roads branching out into the residential quarters with no apparent logic.



Some residential clusters are fully serviced, while others are only reachable by improvised dirt tracks. The final road network will have 40% primary roads, 50% secondary roads and 10% cul-de-sacs. The road construction was done by the government in one push in 2008. Road width corresponds directly to cruising speeds. Considering the space available next to the present roads and the distances to cover (40 km!), drivers speed with up to 80 km/h across the site, making pedestrian movement very hazardous.

Other infrastructure such as electricity, water and sewerage forms invisible or intangible networks. While these are not expressed in Al Khoud, they form an important element to be assessed in order to establish a sustainability framework. The lack of formal planning of such infrastructure leads to over-consumption of commodities and environmental degradation. In the absence of sewerage and waste management, makeshift waste dumps and illegal drains contaminate the environment, as waste containers are only provided along the main access roads. Waste trucks collect the garbage on a regular basis. Recycling is non existing. Waste is carried to open waste dumps as in Halban. The area is just fenced off with 2 m wire-mesh fences. Waste is not compacted or buried. Occasionally, waste is burnt in the open. Winds and rainfall will distribute the waste across the landscape.

The wadi is also seen as an unofficial waste disposal place. Construction waste is often left alongside the roads and outside of the plots. Fresh water is still provided through trucks that pump desalinated water into cylindrical tanks on the roof top terrace. These plastic tanks are exposed to direct sunlight and heat. Water can be polluted quickly in these circumstances. Grey water is not re-used as all the waste water is stored in septic tanks next to the buildings. Waste water is stored in septic tanks. These tanks are emptied by a particular sewage service. To avoid costs, many residents illegally drill holes in the tanks. Waste water drains into the underground and contaminates the water reservoir.

Electricity: As the area is still under construction, electricity is one of the basic services available. The area is provided with electricity blocs connecting and increasing number of houses. Dwellers tap



Figure 2.2.9: Diversion to optimal solar and wind orientation of plots in Al Khoud, computed by the author with "ecotect" software and historic weather data from Seeb international airport weather station (ca. 1984-2010 with gaps). electric lines where the governmental connection is not existing. These improvised lines are particulary hazardous during storms and rains. During the summer days and in peak hours the net-work breaks down regularly. Buildings are not insulated and heat up within minutes once the air-conditioning systems fail. Electricity is generated by burning fossil fuels (natural gas) in various stations along the coastline.The electric power grid is highly centralized. Large electric lines cross the country. A mayor line parallels the highway adding a stark silhouette of masts and lines to the Hajar mountains in the South. The location of the larger electric lines suggest that the planning of roads, electric power lines and settlements has not been coordinated.

The development of infrastructure follows two complementary strategies: Road-system and electric grid expand to a massive network with centralized nodes close to the cities. Water and sewage, being handled by trucks, are potentially independent from a centralized infrastructure. This development opens the possibility to settle anywhere in the country. Limits to growth are set by the increasing costs to serve and maintain this expansive infrastructure grid. At present these costs already outgrow the cost for housing.

Non-quantifiable aesthetic, social and cultural parameters: Responsiveness is a major criterion for resilient and sustainable urban design.(Newman 2009) The following non-quantifiable aesthetic, social and cultural parameters have been looked at to establish the responsiveness in urban form, organization, topographical appropriation, climatic and social consideration.

Urban form: The nature of the masterplan dictates freestanding single buildings in a linear arrangement. These types of urban arrangements are predominant in all of the residential areas under construction in Greater Muscat Area. The size of the development derives from target figures set by the Ministry of Housing and not from the needs of an organic urban growth. The organisation separates functions. The urban form is closed as there are no connections to outside settlements and just one entry and exit point to the South.

Topography and climate: The urban lay-out of Al Khoud disregards the particularities of site topography. The same street grid is implemented over and over again in Bowsher, Mawaleh or in Al Khoud. Natural features such as wadi Al Khoud or the hilly terrain on the Al Khoud plateau call for site-specific design. As seen in the topographical map these features could have determined and balanced the urban design. Moreover, the wadi offers a unique natural space. This space could have been integrated to provide designed recreational spaces, while preserving the eco-system. As seen in the map, the northern edge of the development dissolve. Houses orientate towards the development and not towards the wadi. Since the space of the wadi is not seen as worth integrating into the scheme a gradual deterioration and signs of pollution are becoming visible. The former hills on the site have already been levelled.

The urban pattern features plots orientated in various angles. The climatic analysis based prevailing winds and solar radiation indicates that there is consideration for climate responsive design within the urban design. The typology of selfstanding houses is the least suitable for the local climate as there is no self-shading possibility and all concrete walls are exposed during the day to solar and heat intact. The resulting energy loads and the respective carbon footprint are huge. **Social considerations:** The typology of the walled and selfstanding building, the lack of programmatic diversity, the long commuting distances and the lack of designed public space have a strong negative impact on the social life within Al Khoud. These aspects are built into the design and will hardly improve over time. The constant construction makes appropriation of public space almost impossible. The inhabitants are randomly brought together as their plots are assigned by lottery. One could almost say that this system aims to break up traditional tribal structures. Due to the reliance on cars, large social groups are isolated, amongst others children, teenagers, people without drivers license, economically deprived, handicapped and elderly people.

These aspects illustrate the fact that the settlement lacks a comprehensive urban design. A carefully developed urban design of neighbourhoods would include the entire urban environment, relate built-up space to open space in a way that the arrangement of buildings creates shade and ventilation, care for public green and quality of outdoor space, and integrate space for commuting into the overall residential environment.

Cultural considerations: Despite the proximity to the old village of Al Khoud and a planning for Omani citizens, the settlement of Al Khoud does not follow social and cultural habits of the Sultanate. The old village of Al Khoud consists of smaller houses that partially shade each other. It is designed with the landscape features (hills and wadi) and caters to the traditional farming in the oasis. The vernacular architectural design and the seemingly organic urban pattern reflect centuries of local adaptation to the specific climate in the Batinah region. The planning of new Al Khoud features individual houses with a generous spacing in between. Perimeter walls need to be erected to account for privacy. These self-standing villas are exposed to the sun the whole day, making outdoor activities impossible in the summer heat. The linear building structure does not stimulate social contact among neighbours either. Social networks within the neighbourhood are difficult to establish, as the open space is not made for socialising, and public space – apart from streets and parking lots - is practically inexistent. As a consequence there are no social spaces or meeting spaces except for small shops, coffee shops, barbers, laundry and internet cafes, all subject to commercial use.



Figure 2.2.10: Ubiquitous AC-Units in Al Khoud, 2012.

The procedure of random land allocation by lottery fosters a random distribution of plots to residents that are arbitrarily mixed together. Neighbours don not know each other. Within a tribal society such as Oman, strangers will never gain the same trust as members of the clan. If the house was seen as the place of interaction for an extended family, a nucleus family will be literally lost in these huge mansions. The demographics of the Sultanate point towards nucleus families, in particular in the urban and sub-urban regions. The closed character of the plots and the sheer size of the houses discourages social interaction. The self-standing villa is a typology exclusively aimed at families with children. Others parts of the population such as teenagers, singles, elderly or foreigners are excluded unless they find a place within a family home. Even a traditional society such as the Omani one has a diversity of social habits that cannot possibly be reflected with one house type.

Ecological considerations: The urban design layout of Al Khoud was planned without considering ecological or climatic conditions. The predominant natural feature – the wadi to the North – appears as an inconvenient obstacle to expansion. The wadi still carries water occasionally and represents, despite the alarming pollution, an extraordinary ecosystem connected to the Royal Botanical Garden projected upstream. This wadi could have been integrated into the planning stage of the

project. Unfortunately, streets randomly end where the wadi's steep walls drop into the riverbed 10 meters below. Housing plots reach dangerously close to the unstable wadi walls. An analysis of the orientation of plots towards the optimal wind direction and minimal exposure to solar energy shows no such particular pattern. Most of the plots are not oriented according to favorable climatic and energetic principles. The energetic balance of these free-standing houses is therefore alarming. Since the cost of energy is subsidized by up to 90% of the international market rate, house owners have no incentive to build in a sustainable manner.(US Energy Information Administration 2013) Simple measures such as wall insulation, double glazed windows or shading of the roofs and facades are not implemented. Most of all the typology of the self-standing villa exposed to all sides to solar radiation and heat gain the is least sustainable building type possible. The buildings need at least one air conditioning device per room. This corresponds to 15 AC units for a house of 300 m² usable surface. Electricity consumption is extremely high and falls into the peak hours of electric consumption in the country.

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