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Outcome-focussed urban planning and design

Nur-Sultan 2030 Masterplan

ED PARHAM, JOSE LUIS KRUG, OSCAR MCDONALD, & SANDRA WILMOT,

SPACE SYNTAX LIMITED, LONDON, UK

ABSTRACT

Recent development of methodologies by Space Syntax, such as Integrated Urban Models (IUMs), have enabled us to better explain how the configuration of city systems including the spatial network, land use, density and public transport, work both individually and interact in combination. Outputs from an IUM include “composite” measures, such as SSx’ Walkability Index, or Car Dependence, to explain where the city brings together mixes of use in a configuration that is easy to reach within a defined journey time by specific modes of transport. The way these urban systems combine in the built environment makes particular daily behaviours possible, such as walking to work, and these behaviours can contribute to long-term outcomes. In the UK, these models are associated with travel behaviour (reflected by commute to work mode and car ownership), and longer-term, more complex outcomes (including obesity). Because these outcomes are the result of multiple interactions between additional, socio-economic, demographic and genetic factors, it is impossible to guarantee positive outcomes, but it is at least possible to identify the characteristics of the built environment where they happen. With this better understanding of the impacts of place, we can approach design and planning to create conditions that enable positive outcomes.

This enhanced capability raises questions of how to apply these tools as part of a wider “outcome-focussed” design process. Using real-world examples from Space Syntax’s portfolio of recent work, this paper documents a wider design process that made use of these models. We explain how Space Syntax lead a multi-disciplinary design team to prepare the 2030 masterplan for the capital of Kazakhstan, Nur-Sultan, using IUMs, Generative and Data Driven techniques to win an international design competition, then deliver the masterplan. The key to unlocking the potential of these techniques was to set them within a series of wider “so what” questions. These included reviewing local and national policy, and engaging stakeholders to discuss their high-

level aspirations and ambitions for what it should be like to live in Nur-Sultan in 2030. With these objectives defined, ways to measure both how the city performs against these were identified, along with analysis of the configurations of urban systems that contribute to these outcomes. Including these urban system requirements allowed the city to be analysed in 2019, to see where these systems create problems, and the city requires intervention. A range of proposals were developed to accommodate population growth, while addressing these issues. Throughout the process of developing proposals space syntax modelling and analysis were used, and once all proposals were complete the IUM of the entire city was updated to understand whether it created the built environment conditions required to enable the objectives of the design.

These questions are not new, but explicitly structuring the project in this way enabled a shift of mindset by client and design team to move beyond meeting the short-term requirements of a brief, to consider the long-term impacts of planning and design decisions across domains and scales. This approach also raised a set of wider questions reflected on here, including: how to consider potential outcomes influenced by the behaviour of individuals within a complex system; who could be involved in defining objectives and intended outcomes, and how modelling tools can help improve the practice of urbanism.

This paper presents a real-world application where techniques were applied within the practical constraints of time, cost and practicality for a high-level client. For these reasons this paper has been written to help feed back some of the questions emerging in practice, rather than as a technical description of the modelling processes and methodologies.

KEYWORDS

Outcome-focussed design and planning, Integrated Urban Modelling, Walkability, Data-informed Design and Planning, Generative Design and Planning

1 INTRODUCTION

This paper presents a real-world application of space syntax techniques as the core element of a masterplan design process. It explains how emerging techniques were applied across multiple scales, to help inform contextually important decisions around issues such as the local economy, environment, liveability, and stakeholder engagement.

From 2019-2020 Space Syntax lead a multi-disciplinary design team to develop the 2030 masterplan for the capital of Kazakhstan, Nur-Sultan. This team included Expedition Engineering (covering energy, water and waste), Mobility in Chain (transport and mobility), and Gustafson Porter + Bowman (Landscape design).

The project was won through an international design competition for a 2050 concept masterplan which ran from late 2017 to early 2018. In both the 2050 and 2030 masterplan, the objective was to accommodate forecast population and jobs growth while addressing existing issues in the city and improving liveability.

During the competition stage our higher-level strategy was to first improve the city for existing residents, then to intensify it where spatial conditions allow, and finally to extend it. After spatial analysis was used to identify suitable locations for urban extension, generative techniques were used to grow a masterplan, space first, based around the sequential creation of foreground and background networks. Land ownership plots were then defined, with analysis of the spatial network used to assign typologies governing land use mix, density and massing to each plot.

The masterplan outputs at this stage combine organic and planned spatial characteristics, with the foreground network made of fewer, longer lines that finish on open angles, and a background network made of more lines, which are shorter and finish on perpendicular angles.

Figure 1 Aerial view of 2050 concept masterplan produced as part of 2018 competition submission.

Starting the masterplan project proper, the 2030 growth forecasts were significantly different from 2050, negating the need to extend the city and focussing the masterplan on improving and intensifying the existing city.

The project was extremely eventful, overlapping with the careers of two presidents, three mayors and requiring a shift to remote working in response to the covid 19 pandemic. Despite this the project has been very successful, winning the 2021 ISOCARP Award for Excellence (ISOCARP 2021) and being commended in the 2021 Architectural Review Future Projects award. A description of the project and its outputs can be found online (Space Syntax 2020).

This paper provides an overview of how Space Syntax' approach to the 2030 masterplan was able to help address conceptual, practical and governance aspects.

2 NUR-SULTAN

For a large part of the twentieth century, Nur-Sultan was known as Akmola with the city of Almaty in the South-East of the country seen the historic capital of Kazakhstan. During the mid-twentieth century Akmola's role was as an agricultural producer for the wider Soviet Union.

Kazakhstan declared independence in 1990, and in 1997 the capital was moved to Akmola and renamed Astana. Nur-Sultan is roughly in the geometric centre of Kazakhstan located within the steppe. The area experiences extreme changes of climate, with temperature during winter dropping as low as -35◦C, while in the summer reaching as high as +30◦C. This presents major challenges in terms of transport behaviour, seasonal snow melt, and provision of a comfortable public realm. The city itself sits either side of the Ishim river. The older centre, Tselinograd, sits to the north of the river with more recent urban extension taking place to the south of the river. During the late 1990's a masterplan for the new capital was developed by Kisho Kurokawa around ideas of the city as an open system and an organism that evolves and changes, however his ideas were severely compromised after elements of infrastructure were delivered outside of this plan (Meuser 2015). Since then, to help establish a global image the city has invested in iconic buildings by signature architects, who have built facilities to hold prestigious events including the 2011 Asian Winter Games and the 2017 Expo. Perceptions around these projects are not universally positive within the country, with smaller cities unhappy not to have received funding to implement infrastructure projects.

President Nur-Sultan Nazarbayev stepped down in May 2019. In his honour the city was renamed Nur-Sultan, causing both local consternation and disruption, with residents unhappy not to be consulted before the change was announced, and placing an administrative burden on local businesses to re-name and update details. This is indicative of a poor history of citizen engagement during both the Soviet-era, and post-independence, with experience of combined decision- making processes rare on both the population and administration sides. This makes genuine engagement in a plan making process very difficult; to provide a heavily simplified overview, the local population splits along generational lines with one group prevented from engaging, and now not expecting or attempting involvement in planning processes, and a younger, digitally connected group unhappy and vocal about local decision making across multiple areas. This creates difficulties for local politicians, under pressure from the President to establish and present a successful global city, and also from the local population who are concerned about issues including day-to-day liveability and transparency and which sometimes surface in local (and social) media.

Elements of the Soviet planning system remain, with a regularly updated general plan produced for the city defining development allowances on a plot-by-plot level. The role of the 2030 masterplan is to provide a set of proposals to update the next general plan. Since becoming capital, the dominant model of urban growth has been greenfield development, with the majority delivered by a small group of large developers who often sell units off plan to owner investors from outside the city. Responsibility for connecting development to infrastructure lies with the city itself, making greenfield land costs extremely low and highly profitable for developers, but meaning developments can be occupied before proper connections to utilities or public transport are made, and creating fragmented pockets of city which are difficult to service efficiently and inconvenient to live in. The current 2030 general plan increases the urban footprint of the city by an area of 90% for a population increase of 60%, meaning that there is no incentive to move away from this model of development, and likely to create further urban sprawl with its associated negative impacts.

There are multiple complications to resolving this issue; urban development is a major part of the city's local economy with many residents employed at various levels in developers, construction companies or suppliers; and even though many of the city's new housing units are bought by external investors, the supply of housing is very close to outstripping demand and creating a local property bubble. Continuing the current speed of growth risks bursting this bubble, leading to a local recession and resulting in people from across the sector losing jobs, however slowing growth too quickly, could also result in a similar impact on jobs, with careful decisions needed to both slow physical growth of the city and consider re-purposing existing employment skillsets.

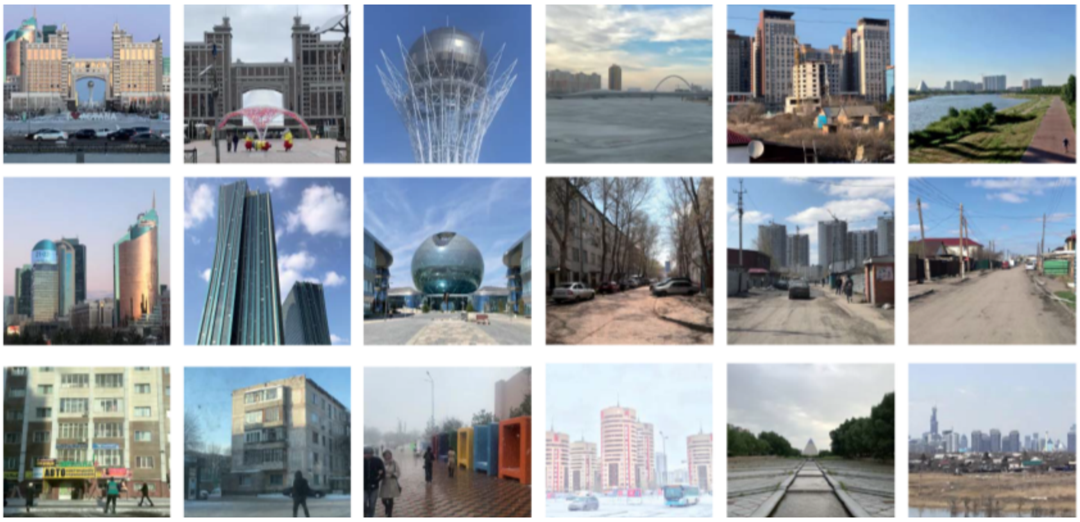

Figure 2 Images showing urban conditions in Nur-Sultan (2017-2020) ranging from iconic new buildings in car dominated settings, to dilapidated Soviet-era housing at a more human scale, to informal and under-developed areas.

In terms of the urban characteristics across the city, areas can be categorised into three rough groups:

- Newer parts of the city include impressive buildings by global architects, however they often do this in settings which are dominated by cars; wide roads, tall buildings and large setbacks, increase distances for people to walk, provide no shelter from the cold or sun, and channel wind into pedestrian spaces. From a syntactic point, many of these areas lack a multi-modal background network to the city, with buildings often occupying entire urban blocks with the spaces between them used to access car parking or service yards.
- Older, ex-soviet parts of the city are smaller scale, and provide more shelter, but follow modernist planning approaches which create discrete, complex, over-permeable spatial networks with unclear definitions of public and private space. Panel system construction of these buildings is outdated and many buildings are in poor physical condition.
- Across the city are a number of informal areas which are poorly built, lack access to services and which may have a local spatial structure but are isolated from the wider city.

In addition to this, across the city there is a shortage of local facilities including schools, clinics and parks.

3 APPROACH

The focus of this paper is not to discuss technical aspects of the methodologies in detail but to consider how these tools and techniques shift our design thinking and approach. Fundamental to the masterplan design process was the use of Integrated Urban Models (IUMs). These models have been developed by Space Syntax over a number of years, and exploit the ability to link multiple datasets (recorded on different geometries including points, lines or choropleths) through the spatial network (Acharya et al 2015, Karimi et al 2015, Karimi et al 2013).

The benefit, and reason for developing these models, is that they can take account of the combined effect of systems in addition to the spatial network. This was important in Jeddah, Saudi Arabia, where a street network had been built in some parts of the city but had not yet been developed with buildings. Using Segment Angular Choice as an analytic measure, these segments over perform because in the graph they create the same number of journey origins and destinations as a segment that may be highly developed. However, in reality they only allowed movement through them but did not create new trips. Linking land use data to these segments meant they could be weighted to allow movement through them, but not to generate or receive trips.

In the time since this initial application, IUMs have developed further to use time as a cost to move through the network by multiple modes of transport, to calculate access to specific land use categories (and the distance to the closest land use in each category), and to create composite indices (such as a Walkability Index) which show how the combination of spatial network, urban block size, and land use work in combination. In the UK there has been an increasing number of stories in the mainstream press on the way the built environment affects daily behaviour (BBC 2018), the way that these behaviours influence long term outcomes (Flint et al 2014), and the secondary impacts to society of these (Gosling et al 2019). The IUM allows the specific characteristics of the built environment to be characterised, to see how these relate to daily behaviours.

In approximately the last five years, IUMs have been applied to a range of projects across the UK, and to further understand these relationships between the built environment, daily behaviour and long-term outcomes. Across the Thames Valley, the IUM was combined with census data and used in multi-variate regression modelling to create predictive transport mode share models. Three models at MSOA level, describing car ownership, active commuting and public commuting, were developed to very high levels of description (Pearson's correlation coefficients from 0.88 – 0.76). Although developed separately, each model included the same components of the built environment (access to employment in 15 mins and access to retail services within 15 mins). To address questions around socio-economic impacts, census data (Income Deprivation) was included, however this correlation (0.24) was not as significant as against elements of the built environment (0.52 for employment within 15 mins, and 0.36 for retail services within 15 mins). This indicates that although higher levels of deprivation are present in Thames Valley city centres, there are also people living in these areas who could own a car but who choose not to. This is possible because the built environment makes it viable and convenient to walk or use public transport.

In Exeter, working on the NHS Healthy New Town of Cranbrook, the city's Public Health department wanted to know whether a new masterplan proposal created conditions that enabled healthy lifestyles. To understand where people in Exeter were more healthy, and what urban conditions were associated with these areas, an IUM was provided to Public Health, who identified relationships between higher levels of obesity in less walkable areas (Chant et al 2018). There is an issue to consider around causation and correlation. The lens of health outcomes provides a good example of the way many systems, actors, behaviours and influences combine in a complex system to affect an outcome. The Built Environment is only one of these elements, and by itself cannot guarantee a positive outcome. However, through the use of modelling, based on a consistent description of the way spatial networks, land uses and densities work individually and in combination, it is at least possible to see what shared physical characteristics are present where outcomes are positive and negative. Our experience looking at the Thames Valley, and Exeter, suggests that it is not possible to guarantee a positive outcome solely through the design of the built environment, but that it can at least make it possible. There are many examples of 20th century planning where the built environment makes certain behaviours and outcomes very difficult, if not almost impossible.

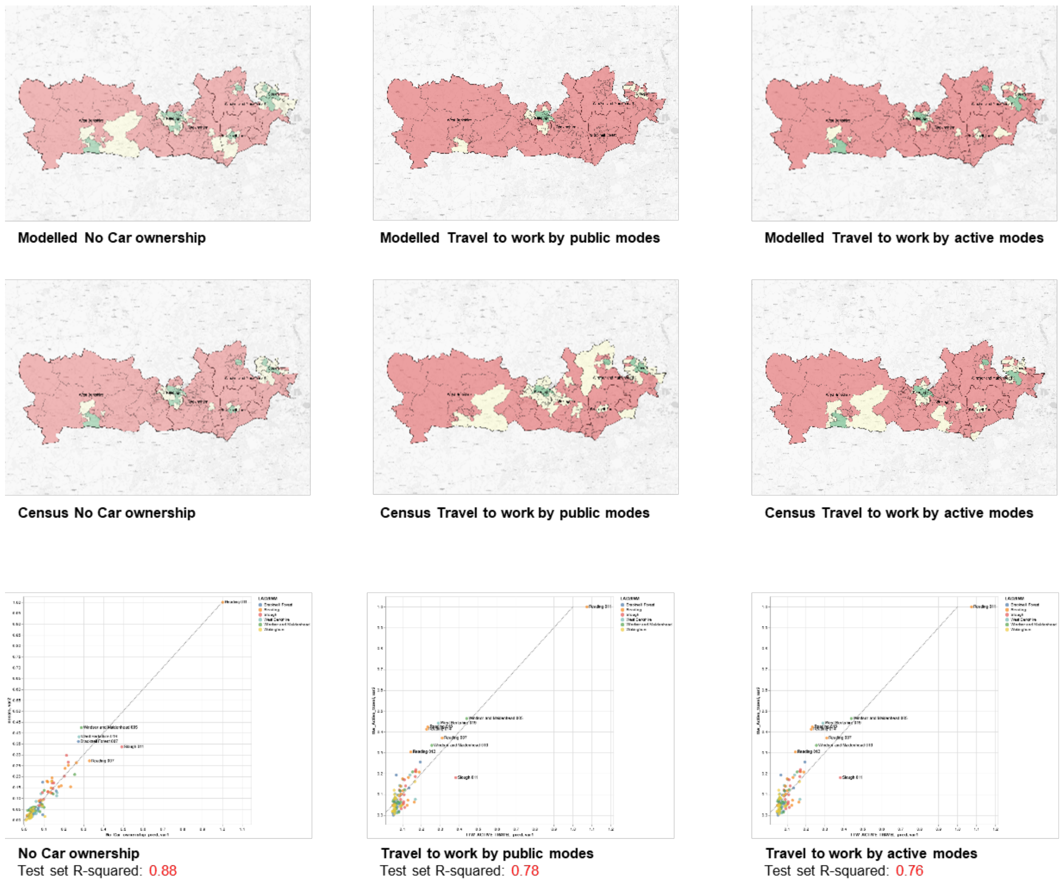

Figure 3 Comparisons between predictive travel behaviour models and actual data across the Thames Valley.

This means that we are better placed than ever to configure the physical systems that we can influence through design and planning to enable particular outcomes. It follows that if this is possible, the most important question is what outcomes a project focuses on (and who should define these). This was key to the Nur-Sultan 2030 masterplan and formed the first of four design stages summarised in the following pages:

- What should the city be like in 2030?
- What is the city like now?
- How can the city change?
- Do these changes work?

4 WHAT SHOULD THE CITY BE LIKE IN 2030?

A set of objectives for the masterplan were set by the city, however these were relatively functional and focussed on addressing a set of shorter-term requirements, such as how to accommodate forecast population and employment growth. There are multiple ways to achieve this, however each will create different long-term impacts.

To define the outcomes the masterplan should support, a series or exercises were run in coordination with each other. These included reviewing national and local policy, studying global best practice, and engaging with local stakeholders (including local politicians, city staff, developers and residents) to understand what outcomes are important locally. Based on these exercises, a set of connected outcomes were identified which focussed on creating: A Liveable City that prioritises people; A Sustainable City that slows and mitigates climate change, and; A Healthy City that promotes active lifestyles. Measurable key performance indicators (KPIs) were identified for each objective to define an existing benchmark, prioritise the need for intervention and measure impact over time.

KPIs however are only half of the equation, and at this point it is useful to define a logic model that helps position them. A KPI shows data on the outcomes that occur in the city. The KPI itself does not explain why this happens though, only that it happens. As discussed earlier, outcomes in cities are the result of interactions between multiple systems, of which the built environment is one. The configuration of urban systems - the spatial network, land use, density, public transport network – affect daily behaviours and in turn outcomes. Without understanding how these input systems work individually, and in combination with each other, it is not possible to understand why an outcome occurs, nor logical to expect the design of a system to change it.

Figure 4 Extract from summary presentation setting out 2030 objectives.

The role of the IUM in the process was to use it alongside KPI data and better understand why outcomes occur. Cities that perform well against KPIs can be modelled using the IUM, and the characteristics of their city systems better understood. For example; the range of urban block sizes that should be designed, how the spatial network should be configured, or where land uses should be distributed etc. This then provides a set of benchmark measures to analyse the existing city systems against and identify where it sets in place the conditions to support intended outcomes, and where it creates problems.

To make sure the city allows people to live healthy lifestyles, the IUM was used to analyse Car Dependence of the existing city (defined as the ratio of jobs with 30 mins by car to jobs within 30 mins by public and active transport), changes were then targeted to poorly performing areas (by improving physical connections, improving public transport services or increasing the land use mix), and the design proposals re-analysed using the IUM.

At the end of this stage of the masterplan, there was a clear answer to what the city should be like in 2030, but also how to measure the success of the city in delivering them, and what to consider when designing the physical systems.

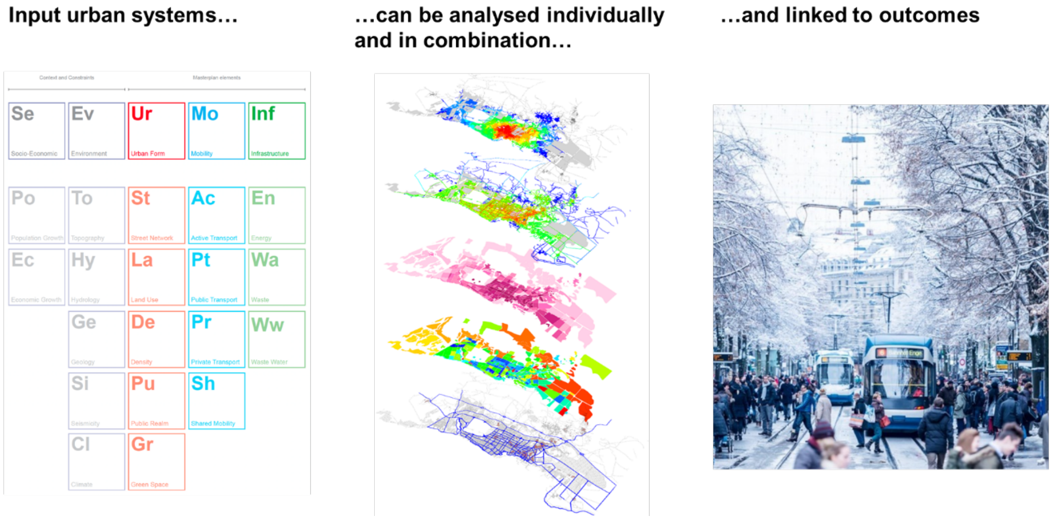

Figure 5 Extract from summary presentation to the Mayor of Astana, setting out a logic model for considering the city - the urban systems which can be controlled through planning and design can be consistently described and analysed in combination, then related to daily behaviours and longer-term outcomes that occur.

5 WHAT IS THE CITY LIKE IN 2019?

To understand if and how the city needs to change it was modelled using an IUM combining spatial networks, land use data (showing multiple land uses per building) and public transport (created from GTFS datasets). In the case of Nur-Sultan, it was identified that the city in 2019 was a long way from delivering its objectives: Only 27% of residential plots are within walking distance of a school; 20% are within walking distance of a GP; the city is a long way from meeting its energy and waste targets (0% renewable energy production, 15% waste recycling), and; many parts of the city are highly dependent on cars (on average owning a car provides access to at least eight times more jobs).

Using the IUM, and by analysing some of the individual built environment systems, the reasons contributing to this under-performance could begin to be understood. In terms of the spatial network, the city is physically large, low density, and based around an expansive road network with a high amount of road per person. There is no continuous, consistent background street network, and as a result wider scale movement is concentrated on a few foreground network streets, many of which do not work at the pedestrian scale. This combination of spatial factors leaves streets with little pedestrian activity, creates traffic congestion, discourages walking, and leads to the North and South of the city being distinctly different areas. Furthermore, at the smaller scale, the treatment of streets and the public realm does not prioritise people, it is dominated by space for cars, has not been adapted to the climate, pedestrian spaces are not protected from the extreme cold or wind in the winter, and this is exacerbated in some places by unnecessarily wide streets (eight-lanes plus two-lane slip roads to each side) lined by taller buildings that channel the wind.

Analysis of the Public Transport system, individually and as part of the IUM showed that although coverage and access is good the service can be poor. In most parts of the city it is possible to walk to an enclosed (and heated) bus stop, but buses may be infrequent with only one or two buses an hour.

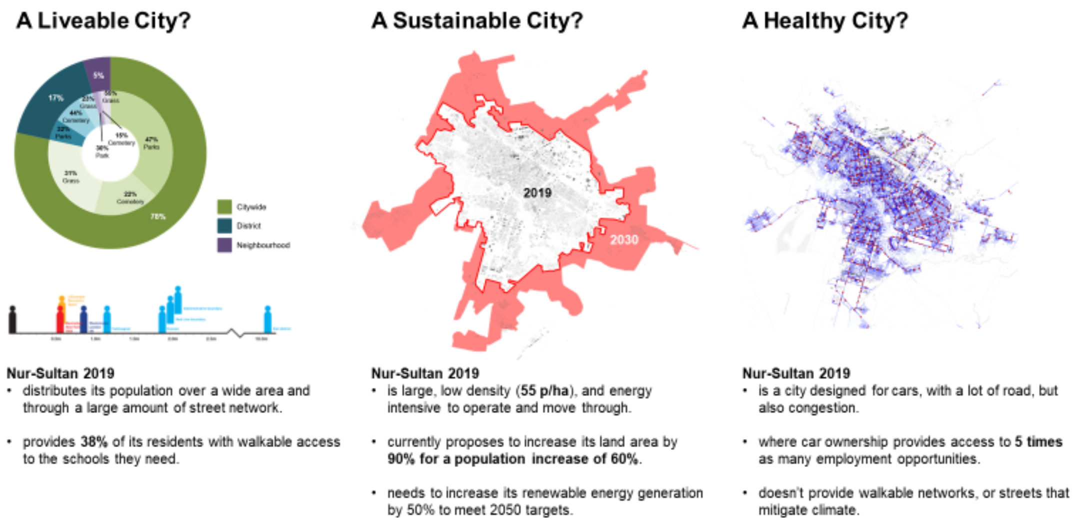

Figure 6 Extract from summary client presentation showing how well the city currently performs against its agreed 2030 objectives

Finally, land uses and density generally follow the theory of the Movement Economy, with more commercial, higher density uses distributed in more accessible, more integrated places, however there are exceptions with some landmark or iconic developments, positioning very tall buildings in places which are more difficult to get to and increasing pressure on the surrounding movement infrastructure.

6 HOW CAN THE CITY CHANGE?

By identifying the gaps between what the city should be like and what it is like now, a strategy to focus interventions was developed. This requires a series of interventions to work across multiple scales simultaneously:

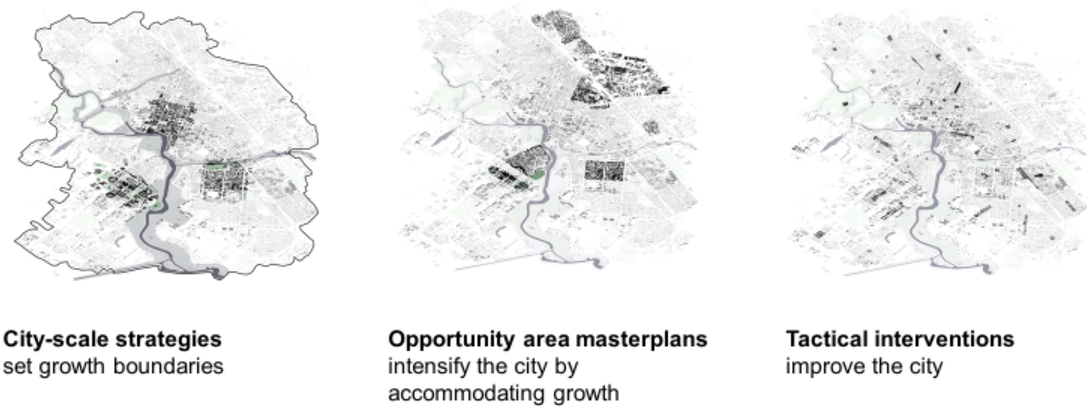

Figure 7 The 2030 masterplan proposed a set of interventions across multiple scales.

6.1 City-scale strategies

Strategies were developed to define growth boundaries, considering environmental constraints, and population growth. These need to be considered alongside economic strategies, such as how new sectors of activity can be accommodated in the parts of the city best able to support them, and where they can stimulate a wider regenerative effect. They also considered how to connect these different parts of the city for all mobility modes, and how these can work with green infrastructure, energy and waste strategies.

Integration was used to help identify existing centres, and these were analysed against their current levels of land use intensity to make high level allocations of forecast employment (more detailed street-by-street and plot-by-plot allocation took place at the Opportunity-area scale). Normalised Choice was used to identify connections between these centres, with Multi-Scale Choice (segments appearing in the top 10% of both Normalised Choice at 10km and 2km) used to identify areas with higher degrees of overlap between different scales and types of movement, in order to allocate uses and public realm treatments.

Over the next 10 years the city must improve living conditions for its existing population, and it must accommodate forecast population growth. To address existing issues without increasing the city's urban footprint, new models of development need to be adopted to do this - specifically they must move away from greenfield development to intensify, regenerate and improve parts of the existing city with capacity. This requires new models of development in the city and a series of potential redevelopment and regeneration areas were identified. In combination with development already approved by the city, these areas have capacity to accommodate the 2030 population growth.

6.2 Opportunity-area masterplans

A set of more detailed masterplan proposals were developed for opportunity areas to provide examples of new models of brownfield re-development, regeneration and improvement.
These areas were selected by identifying large vacant or underused areas, then assessing them using spatial analysis that considered available land, size, location and their potential to be catalysts for larger scale change. They provided six masterplan areas of different sizes, with the largest proposals accommodating up to 27,000 additional residents and up to 80,000 jobs. These masterplans introduced combinations of private- and/or public-lead redevelopment, regeneration or improvement.

Masterplan proposals were developed "space first", by designing spatial networks that create clear local structures while responding to patterns of existing land ownership and integrating with surrounding areas. Proposals aimed to create walkable, street-based urbanism, distributing land use, density and massing in relation to location and accessibility. Parametric tools, such as Grasshopper, were used to allocate development allowances from the area level (based on city level forecast population and employment growth) to the plot level. Plot typologies which set the land use, density, massing, and set back allowances/requirements were assigned to each proposed plot based on analysis of proposed street networks using Local (2km) and Global (10km) scales of Normalised Choice.

In defining the allowances associated with each plot typology, the massing of buildings was carefully developed to create streets that will be comfortable throughout the year. This was enabled by environmental analysis in the form of wind modelling and solar exposure (carried out by Expedition Engineering) to understand whether the public realm would be comfortable, and whether proposed urban form provided the required access to daylight. To begin, a general rule of thumb was used to set a height to width ratio of 1:2 in streets and public spaces so that cold winds would be deflected from the public realm by buildings. Set-backs at roof level were also used to direct wind away from public spaces rather than in to them. Once an initial design had been generated following these rules it was tested and refined by detailed environmental analysis. The design of public space and landscape proposals also focussed on trying to mitigate the extreme climate conditions, reflected in their positioning on particular sides of a street, and their planting. Evergreen trees were positioned to shelter public spaces from prevaling winds in the winter while still allowing sunlight in to spaces, while deciduous trees were positioned to provide shade in summer.

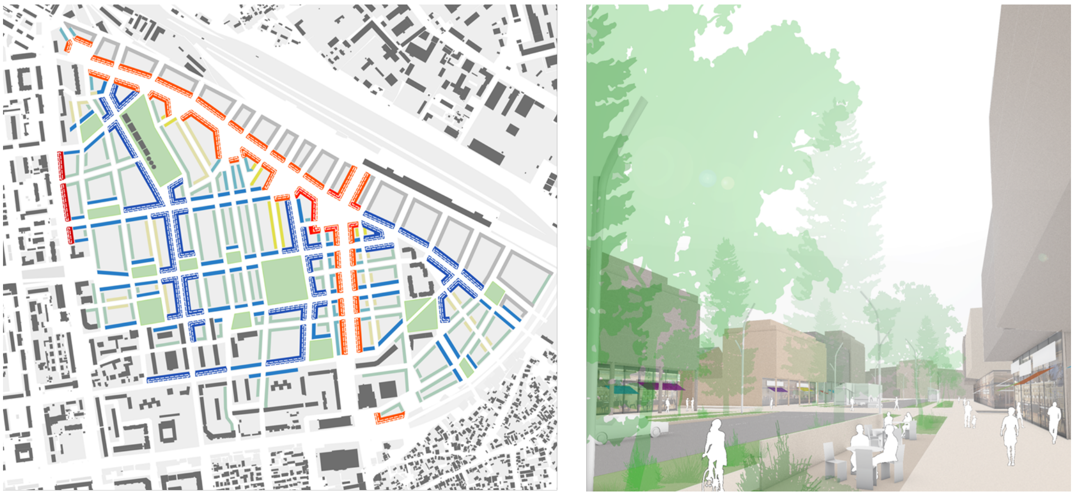

Figure 8 Summary images showing masterplans developed for one of six opportunity areas.

In areas requiring improvement and upgrading it was proposed that a retro fit programme be followed to upgrade soviet era building stock and simultaneously address issues of dilapidated building fabric, the need to reduce energy loss, and the need to re-purpose an existing sector of the local economy from greenfield to brownfield development.

Specific studies were carried out in these areas which suffer from issues of over-permeability and lack of definition of publicly accessible spaces. It was proposed that publicly accessible space became assigned to communities in the adjacent residential blocks, and that these communities could contribute to the landscape and public realm design of them. To define these spaces, segment and VGA analysis were used to identify the strongest local routes, and to understand how these interacted with patterns of visual integration. New edges of shared garden or courtyard space were defined to retain and respond to key points of visual integration and the local scale, informal, pedestrian network. New active edges could be defined by infilling missing social infrastructure facilities, such as nurseries or GP surgeries, between existing building footprints while in other areas, these edges were defined using landscape interventions.

6.3 Tactical improvements

Finally, to improve living standards across the entire city, a set of standard repeatable interventions were required. These included changes such as adding social infrastructure, improving public realm or retro-fitting existing buildings.

As there are so many of these small improvements to make across the city, instead of designing all of them individually, a framework and set of tools were provided to enable the city to deliver tactical improvements at sub-municipality level. The SSx' IUM of the city was provided to the city along with a custom QGIS Plugin that enabled pre-calculated analyses to be consistently visualised. In combination with a training programme, local city staff were taught how to prioritise districts for improvement (using the vision KPIs and urban system data), to identify where there was a shortage in existing facilities, where there are gaps in coverage, and where potential sites are available.

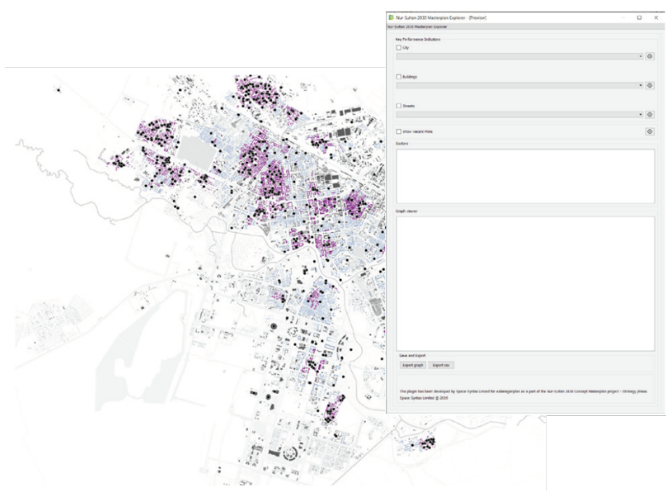

Figure 9 Nur-Sultan Integrated Urban Model and custom QGIS plugin made available to the city to implement tactical changes.

By making changes across a series of scales, the 2030 Masterplan sets in place the foundations to deliver a step change in liveability, sustainability and health. The 2030 population and employment growth can be accommodated within the city's current footprint, by improving, intensifying and regenerating opportunity areas to create a city that focuses on people.

7 DO THESE CHANGES WORK?

To assess whether these proposals put in place the conditions needed to deliver intended outcomes, the IUM was updated with design proposals and re-run. This included updating street networks, adding land uses and public transport stops.

The analysis showed that the approach and multi-scale design creates measurable benefits: average Walkability across the city has increased by 10%, with all areas able to access more land uses within a 10 minute walk and 20% more residents within walking distance of schools and GPs clinics; average Car Dependence has decreased by 25%, with the advantage of owning a car in peripheral areas reduced by 5%, while in more central areas there is almost no advantage in owning a car.

Energy and Waste strategies prepared by Expedition Engineering outline multiple ways for the city to meet its 2030 carbon emission reduction target of 45% and to deliver its 40% recycling rate by 2030.

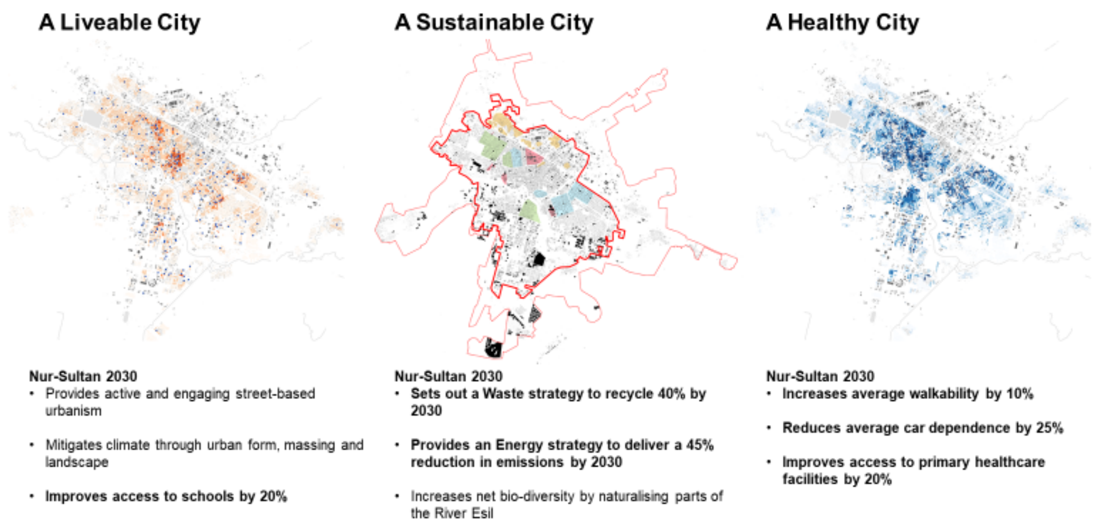

Figure 10 Extract from summary presentation showing combined impact of proposals against 2030 objectives.

8 LIMITATIONS

As with any real-world project a series of compromises and balances were required to ensure the project was delivered on time and budget.

Some data, for example on existing transport mode share, was not available. This meant that IUM measures such as Car Dependence and Walkability developed in the UK were used as a starting point. As mentioned during the introduction, the Kazakh climate can be extremely inhospitable to activities such as walking or cycling which potentially questions the validity of these measures, however desktop studies and document review gave confidence in our approach:

- The City of Edmonton in Canada has a very similar climate to Nur-Sultan. In the city's winter design guidelines (City of Edmonton, 2016), they suggest that daily walking and cycling are possible for a large proportion of the year, and that outdoor leisure activities are possible in the most extreme times of year where the local environment supports it. This document provided valuable guidance in how events can be programmed to engage with cold weather, and how physical massing of buildings can shelter pedestrians at ground level by deflecting wind up and away from the street.

- In Jeddah, Saudi Arabia, the climate is at the other end of the extremity scale, however analysis of pedestrian movement in the historic parts of the city provides transferable lessons. Pedestrian movement in Al Ballad is low during the hottest time of the day, but reaches levels comparable to many other cities when it is more comfortable, with peak movement recorded close to midnight. Al Ballad grew around a human scale spatial network, based around narrow streets and small urban blocks. This contrasts with much of Jeddah which is designed around the car, large urban blocks, narrow mixes of use, and dominated by road infrastructure. Significantly higher levels of walking occur in the historic core where the urban form makes it possible, and the shift in behaviour compared to cities around the world is the time it takes place.

Ideally the project would have included time to collect data first-hand, validate models and develop custom measures, however the time pressures involved in a project that was reported directly to the President did not allow for this.

Considering the role of the built environment as part of a larger complex system, and as illustrated through example of health outcomes, it is reasonable to infer that the most the masterplan can do is make it possible to walk or cycle. The masterplan used this starting point to define urban block sizes, spatial networks, land use and density distributions, and refined it to allow for shorter journeys (and less time spent outside in winter) and combined it with smaller scale design principles around building massing.

A second limitation arises from the differing speeds of city development, economic and political cycles. In Nur-Sultan this was seen most acutely in the form of continuity of staff in the city. During the project (from competition stage to completion) three mayors were involved, each of whom had different levels of awareness of urban and/or technical issues, was interested in prioritising different aspects of the city and was under pressure from the president to deliver improvements.

Considerable time was spent discussing why the city works the way it does and explaining complicated processes and techniques behind the masterplan. The major risk in this context is that once the mayor moves on the work loses its momentum and is not implemented as it could or should be. To try to avoid and mitigate this, capacity building programmes were carried out with city staff and tools made available beyond the end of the project.

The final masterplan document itself focussed on presenting evidence on agreed masterplan outcomes, existing performance against these outcomes and presenting design outputs. By including detail on design processes and methodologies in separate appendices the intention was that users could access design information without being distracted or confused by technical detail.

9 CONCLUSIONS

The Nur-Sultan 2030 Masterplan was a landmark piece of work for Space Syntax, with the company leading a multi-disciplinary team to first win an international design competition then deliver the masterplan, placing space syntax techniques and theories at the heart of the design process.

A series of "soft" benefits were provided which helped the design team, client and stakeholders interact. The intended outcomes of masterplanning became both explicit and specific. This moves conversations forward from development outputs to development outcomes; instead of talking about how many housing units will be delivered, population accommodated, or kilometres of cycle network built, it made it possible to discuss, for example, how the masterplan makes it enables people to be active everyday through walking to work, and in turn how this can impact on health or sustainability outcomes. Using visual outputs of intuitive metrics such as Walkability or Car Dependence, the performance of existing and future scenarios could be communicated to non-experts, in turn making it easier to select or support specific design options.

Within the design team, the use of IUMs provided technical benefits to better understand the combined impacts of the design of multiple physical infrastructure systems. While each profession or discipline has its own way of working and tools to support this, the approach enabled better integration between them as the potential combined effect of multiple infrastructure systems could be understood, against a set of clear, measurable objectives.

Whilst long-term outcomes are the effect of complex interactions between multiple systems, influences, and individual decisions, the built environment is a part of this wider picture, affecting where specific behaviours are possible or not. Better understanding the role of the built environment (and the contribution of individual urban systems within this) provided by IUMs cannot guarantee a positive outcome, but it can at least help to put in place the physical conditions that enable daily activities and support positive outcomes.

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