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Developing urban models to address population growth impacts and assisting with future urban planning in Kuwait and other Arabian Gulf countries

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Abstract

Modern cities around the world have been shaped over time through different political, economic, sociocultural and geographical factors. While each city has grown in ways unique to its environment and historical context, there are common patterns of urban growth. For instance, many Western cities grew from centralised markets to form modern economies and a diverse society with population growth fuelled by migration from rural areas. Research on the dynamic aspects of urban change and growth were developed as a system model to explain urban structure and interactions with transport and land uses. People's preferences for liveability also factored into urban system research to influence land development and growth patterns. In contrast, Arabian Gulf cities exhibit a range of unique urban system traits different to those of Western cities. Urban growth took place only recently and over a relatively short period. The economy was almost completely driven by a single industry, namely oil extraction and exports, and the countries were governed by a central authority. Urban growth was organised to support the citizen population, but the oil wealth also supported a large population of foreign workers. This led to a distinct urban structure, population densities and land use patterns with separate regions for citizens and the foreigner workforce. With highly centralised planning control, people's preferences on housing and future land development policy were limited. This has led to negative urban impacts and social segregation in some Arabian Gulf cities. There is also a lack of planning models suited to Arabian Gulf countries and research on urban dynamics to inform future land policies.

This research thesis aims to address this gap by developing urban growth models suited to conditions and the changing dynamics of Kuwait, an Arabian Gulf city. The models address aspects of urban system dynamics for urban forms, growth impacts, new city development, internal population migration and social segregation by nationality. In order to do so, three different urban models have been developed:

- i) A model that simulates the state of urban systems already in place to 2050 and assesses the effects of continuing with a business as usual approach,
- ii) A model that simulates the development and impacts of creation of new cities as proposed by Kuwait's latest master plan according to the State planning authorities,
- iii) A model that simulates the effects of people's participation in developing the new cities and the infrastructure, social and spatial systems associated with them.

The urban modelling in this thesis has been designed on Agent Based Modelling (ABM) and Geographical Information Systems (GIS) frameworks.

The contribution of this thesis is twofold. Firstly in terms of theory, it has enhanced the understanding of urban systems for modelling population growth, population distribution and urban issues in Arabian Gulf countries. Secondly in terms of methodologically, the thesis has implemented a set of novel elements in urban modelling of Arabian Gulf countries including: the collection and integration of data directly from the public through surveys, and the modelling of the differences in expectations of citizen and non-citizen groups, as well as residents and decision makers.

The outcomes of the research provide strong evidence towards the development of new cities as opposed to the continuation of expanding existing urban areas in Kuwait. In addition, the findings have shown that the potential success of new cities may be bolstered by the direct consideration of public opinion, and the timely development of new infrastructure. Apart from the case study for Kuwait city, the findings may be generalised to other Arabian Gulf cities.

Declaration by author

This thesis *is composed of my original work, and contains* no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, financial support and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my higher degree by research candidature and does not include a substantial part of work that has been submitted *to qualify for the award of any* other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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Table of Contents

Abstract ... 2

Declaration by author ... 4

Publications during candidature ... 5

Publications included in this thesis ... 6

Manuscripts included in this thesis ... 7

Contributions by others to the thesis ... 7

Statement of parts of the thesis submitted to qualify for the award of another degree 7

Research Involving Human or Animal Subjects ... 7

Acknowledgements ... 8

Financial support ... 9

Keywords ... 10

Australian and New Zealand Standard Research Classifications (ANZSRC) ... 10

Fields of Research (FoR) Classification ... 10

Table of Contents ... 11

List of Figures ... 15

List of Tables ... 18

Abbreviations ... 19

Chapter 1 : Introduction ... 1

1.1 Background ... 1

1.2 Research questions ... 6

1.3 Research objectives ... 7

1.4 Summary of research and its significance ... 13

1.5 Thesis outline ... 14

Chapter 2 : Literature Review ... 17

2.1 Urbanisation and urban growth ... 17

2.1.1 Urbanisation causes and consequences 18

2.1.2 Urban growth impacts 20

2.2 Urban development process 22

2.2.1 Urban Development Types 23

2.2.2 Urban planning 24

2.3 Differences between Urban systems in Western and Arabian Gulf Countries 28

2.3.1 Urban systems in Western countries 28

2.3.2 Urban systems in Arabian Gulf Countries 30

2.4 Urban modelling 33

2.4.1 Top-down modelling 34

2.4.2 Bottom-up modelling 36

2.4.3 GIS in urban modelling 39

Chapter 3 : Kuwait case study 46

3.1 Study area characteristics 46

3.2 Urban history of Kuwait 49

3.3 Urban growth impacts in Kuwait 53

3.3.1 Traffic congestion 54

3.3.2 Housing problem 56

3.3.3 Nationality segregation 59

3.4 Future urban development 60

3.5 Urban modelling in Kuwait 63

3.6 Data sources 64

3.6.1 Primary data sources 64

3.6.2 Secondary data sources 65

3.7 Conclusion 67

Chapter 4 : Modelling future impacts of current patterns of urban development in Kuwait with the use of ABM and GIS 68

Chapter outline 68

1. **Introduction** 70

2. **Background** 72

2.1 Case study site 72

2.2 Agent based modelling 74

3. **Data and Methodology** 75

3.1 Data types and sources 75

3.2 Disaggregation of district data 76

3.3 Analysis of historical data 78

3.4 Agent Based Model parameterization 82

3.5 Simulation algorithm 86

3.6 Calibration 89

4. **Results** 92

5. **Discussion and conclusions** 97

Chapter findings 100

Chapter 5 : Projection for new city future scenarios- A case study for Kuwait 101

Chapter outline 101

1. **Introduction** 104

2. **Materials and methods** 108

2.1 Interviews with key decision makers 108

2.2 Survey with people 110

2.3 The urban model 114

2.4 Data preparation and disaggregation 117

2.5 Suitability weights for new cities 120

2.6 Traffic Congestion Index 121

2.7 Parameters and assumptions for simulation algorithm 123

2.8 Simulation steps 124

3. Results 127

3.1 Traffic congestion 127

3.2 Housing Shortage 130

4. Discussion and conclusion 132

Chapter findings 135

Chapter 6 : Accounting for peoples' preferences in establishing new cities: A spatial model of population migration in Kuwait 136

Chapter outline 136

1. Introduction 138

2. Background 140

2.1 The value of participatory planning in urban development 140

2.2 Modelling internal migration to new cities 141

2.3 Case study background 142

2.4 Modelling urban development in Kuwait 144

3. Data and Methodology 146

3.1 Resident surveys 146

3.2 Model and Scenario Design 153

4. Results 161

5. Discussion and conclusions 167

Chapter findings 170

Chapter 7 : Conclusion 171

References 178

Appendices 201

Appendix A: Ethics approval letter for the interviews and surveys in this research 201

Appendix B1: Participant Information Sheet for the government authorities and developers 202

Appendix B2: Completed survey by the government authorities and developers representatives 206

Appendix C1: Participant Information Sheet for citizens and non-citizens – Electronic 330

Appendix C2: Completed survey by residents (Kuwaitis and non-Kuwaitis)........... 334

Appendix D: Supplementary material for the 1st scenario- Chapter 4...................... 409

Appendix E: Supplementary material for the 3rd scenario – Chapter 6.................... 415

List of Figures

Figure 1-1: Research plan overview 9

Figure 1-2: Outline of the three key chapters, their scenarios and research activities........... 11

Figure 1-3: Schematic of the interactions between agents and their environment in the simulations.. 12

Figure 2-1: Urbanisation ratios around the world (Statista 2015) 18

Figure 2-2: The different dimensions of urbanisation (Knox & McCarthy 2012) 19

Figure 2-3: The principles of good governance (UNESCAP 2009) 29

Figure 3-1: Kuwait location map 47

Figure 3-2: Land distribution in Kuwait 48

Figure 3-3: Kuwait population growth 1955-2015 (United Nations 2015) 49

Figure 3-4: Kuwait first master plan 1952 (Kuwait Municipality 2009) 50

Figure 3-5: Kuwait city, Jahra and Shuaiba locations 51

Figure 3-6: Comparison of greenfield and intensification development in Kuwait (1995-2005) 53

Figure 3-7: Distribution of residential areas in Kuwait 1950–2012 (Alshalfan 2013).......... 54

Figure 3-8: Comparison of registered vehicles, population and accidents for the period 1975-2013 in Kuwait (Koushki et al. 2003; KCSB 2015) 55

Figure 3-9: Comparison of accidents, injuries and fatalities for the period 1975-2013 in Kuwait (Jadaan 1990; Koushki et al. 2003; KCSB 2015)... 56

Figure 3-10: Housing demand and supply in Kuwait between 1975-2015 (Alshalfan 2013) 58

Figure 3-11: District Population composition according to nationality in Kuwait 60

Figure 3-12: Population distribution by nationality in 2015 60

Figure 3-13: Kuwait new master plan 2030 (Kuwait Municipality 2009)............................ 61

Figure 3-14: Silk city location and Jaber Al-Ahmad Bridge (Kuwait Municipality 2009) ... 62

Figure 4-1: Kuwait land use distribution 72
Figure 4-2: Annual numbers of accidents and registered vehicles in the period 1975-2014 in Kuwait (Jadaan 1990; Koushki et al. 2003; KCSB 2014) 73
Figure 4-3: Sharq one of the mixed use districts in Kuwait 76
Figure 4-4: Qurtuba, one of the residential districts in Kuwait 77
Figure 4-5: Classification of Kuwait's districts according to land use and development status 78
Figure 4-6: Comparison of greenfield and intensification development in Kuwait between 1995 and 2015 79
Figure 4-7: Correlation of population growth (citizens) and pending applications for housing according to historical data 80
Figure 4-8: Comparison of new applications and housing shortage for each year between 1980 and 2014 80
Figure 4-9: Accidents rate distributed on police regions in 2014 81
Figure 4-10: Agents interactions 83
Figure 4-11: Parcels grid of developable areas after split using Fishnet tool 84
Figure 4-12: Simulation flowchart, including the adaptive step for the government reaction 89
Figure 4-13: Kuwait land use classification in 1995 90
Figure 4-14: Kuwait land use classification in 2015 (real data) 91
Figure 4-15: Kuwait land use classification in 2015 (simulation outputs) 91
Figure 4-16: Comparison of population distribution and land use for 2015 and 2050 (projected) 92
Figure 4-17: Kuwait land use map on 2050 (1st scenario output) 93
Figure 4-18: Kuwait land use map in 2050 (2nd scenario output) 93
Figure 4-19: Population difference between 2015 (real data) and 2050 (simulation outputs) for 1st scenario 94
Figure 4-20: Population difference between 2015 (real data) and 2050 (simulation outputs) for 2nd scenario 95
Figure 4-21: Projection of public housing demand in Kuwait to 2050 for both scenarios 96
Figure 4-22: Accidents projection from 2014-2050 for both scenarios 96
Figure 5-1: City types based on urban growth types adapted from (Petersen 2002). 105
Figure 5-2: Kuwait map and new cities locations. 107
Figure 5-3: Simulation algorithm flowchart. 116
Figure 5-4: New land use classification. 118

Figure 5-5: New train network and stations. 119
Figure 5-6: New road network.. 119
Figure 5-7: Traffic congestion level per district in 2016. 122
Figure 5-8: Population distribution in 2015. 127
Figure 5-9: Population distribution in 2050 in scenarios 1-2. 128
Figure 5-10: Population distribution in 2050 in scenarios 3-4. 128
Figure 5-11: Population distribution in 2050 in scenarios 5-6. 129
Figure 5-12: Comparison of TCI in scenarios (1 and 2) without construction delays. 129
Figure 5-13: Comparison of TCI in scenarios (3 and 4) with construction delays in the major city. 130
Figure 5-14: Comparison of TCI in scenarios (5 and 6) with construction delays in the minor cities. 130
Figure 5-15: Housing demand and supply in case of no delays and with delays in 4 minor cities. 131
Figure 5-16: Housing demand and supply with delays in the major city construction. 131
Figure 5-17: Population distribution average (citizens and non-citizens ratio) in 2050 in scenarios 1- 6. 132
Figure 6-1: Kuwait regions and proposed new cities locations 143
Figure 6-2: Kuwaitis/ non-Kuwaitis distribution in 2015 144
Figure 6-3: Migration destinations preferences from survey (Question10) 153
Figure 6-4: The model flowchart 156
Figure 6-5: Framework of involving residents in future plans model 160
Figure 6-6: Model's results differentiations 161
Figure 6-7: Agent group distribution in 2050 163
Figure 6-8: 1st scenario population distribution 164
Figure 6-9: 2nd and 3rd scenarios population distribution with differences 164
Figure 6-10: Nationality segregation levels in different scenarios 165
Figure 6-11: 1st scenario segregation outcome map 166
Figure 6-12: 2nd and 3rd scenarios segregation outcome map with differences to 1st scenario 166

List of Tables

Table 2-1: Urban form types through history (Anderson et al. 1996) 25
Table 4-1: Summary of model parameters 85
Table 4-2: Parameters used for calibration and respective weights for best fit iteration 90
Table 5-1: Summary of interview key findings 108
Table 5-2: Survey respondents' data sheet 111
Table 5-3: Summary of survey key findings 112
Table 5-4: Resident behaviours according to the survey responses................................... 113
Table 5-5: Agent groups used in the simulations.. 115
Table 5-6: Details of simulation scenarios 117
Table 5-7: Suitability parameter rankings and weights according to the resident's agents . 120
Table 5-8: Summary output from linear regression with zero set at origin........................ 122
Table 5-9: Simulation parameters 123
Table 6-1: Survey target 146
Table 6-2: Survey questions for residents 148
Table 6-3: Differences and similarities between Kuwaitis and non-Kuwaitis 151
Table 6-4: Scenarios characteristics 154
Table 6-5: Model's agents 154
Table 6-6: Model main assumptions 157
Table 6-7: Locational suitability parameter rankings and weights 158
Table 6-8: Collected input variables 159
Table 6-9: Scenarios predictions of demographics and distributions 162
Table 6-10: Establishing new cities order based on scenarios 165

Abbreviations

ABM	Agent Based Modelling
CA	Cellular Automata
CBD	Central Business District
GCC	Cooperation Council for the Arab States of the Gulf
GIS	Geographical Information System
KCSB	Kuwait Central Statistical Bureau
KISR	Kuwait Institute for Scientific Research
KWD	Kuwait Dinar
LUT	Land Use and Transportation
LUTM	Land Use and Transportation Modelling
PAHW	Public Authority for Housing Welfare
PACI	Public Authority for Civil Information
VKT	Vehicle Kilometres Travelled

Chapter 1 : Introduction

1.1 Background

It is speculated that more new urban areas are going to be created between 2018 and 2070 compared to the past two centuries, as a result of persisting trends of urbanisation around the world (United Nations 2015). With more than 50% of the global population now living in urban areas and predictions that this ratio will be higher in the near and mid-term future (The World Bank 2015), the prospect of creating new cities is an attractive alternative to continued burgeoning of existing cities. Urban expansion or intensification of existing cities often leads to a number of adverse impacts, such as congestion, deterioration of the environment or unaffordable land and property values (Brueckner 1997; Brueckner 2000). Modelling and developing new urban areas is an approach that may provide adequate solutions to such issues (Batty 2007). However, the development process of new cities is not without risks, as these projects may cause significant financial or environmental damage if they are not planned with thorough consideration of all underlying factors. Regardless, the notion of creating new cities appears to be especially suitable for counties in the Arabian Gulf, like Kuwait, Dubai in the UAE or Doha in Qatar, as they are rapidly growing and aspiring to become multicultural societies with a global character (Khalaf 2006; Rizzo 2014).

Solving the impacts of urbanisation and urban growth constitutes a core topic in the field of urban systems. Research on urban systems first needs to recognise how cities have been modelled in the past (Batty 2013). However, applying older urban models is undoubtedly insufficient to simulate the increasingly complex dynamics of modern cities and market forces, and hence new urban modelling practices, such as automata, have been gaining ground in research related to urban systems (Batty 2012). This PhD thesis attempts to investigate whether new cities are able to solve urban problems if they are developed by models based on automata theory.

In order to contextualise the research, the remainder of this section will present a brief historical introduction to the theoretical development of urban models and describe how land use has been related to location. Through this introduction, it will be possible to illustrate that while many existing urban models have advanced significantly in sophistication, a different modelling approach is required in order to clearly understand new city formation processes. The approach is based on automata, which puts greater emphasis on non-deterministic transitions and modelling parts of urban systems at a disaggregate level. The research is applied to urban growth in Arabian Gulf countries, and Kuwait in particular. Kuwait faces unique urbanisation issues in relation to population growth, urbanisation impacts and governance. This provides a background to the thesis research questions in the next section.

The first cities were formed close to rivers and fertile fields with ample access to agricultural land. Apart from ensuring a steady food supply, cities formed as a result of social reasons as well, in places where trade routes were easy to access and in places where it was easy to defend against potential invaders (Knox & McCarthy 2012). The economies of these first cities were simple and the cities themselves were relatively small in size and population, so land use could be explained with basic economic principles at the local level, mainly revolving around agriculture, trade and religious activities. One of the first urban models was developed in the 19th century by von Thunen (Fujita & Krugman 1995). The von Thunen model claimed that the inherent value of a piece of land could be determined in relation to the distance from the town centre, as well as the commodity associated with this piece of land. Logistics of the time were inefficient compared to modern standards, so land further away from the town centre was typically less valuable. Furthermore, land use was determined by the necessity and value of goods grown/harvested in any piece of land. This resulted in the emergence of clearly distinguishable concentric zones around the town centre, representing different agricultural activities (Verburg et al. 2006). As long as the economies of cities were based on agriculture, the von Thunen model was sufficient in explaining land use. This model made sense in a world that centralised systems concentrated in small areas around towns were the rule.

During the industrial revolution era, urbanisation picked up momentum and millions of new residents moved to cities to find jobs in factories, and drastically changed the dynamics of cities (Birch 1971). Urbanisation and the associated city growth have had profound impacts on the lives of city dwellers around the world (Black & Henderson 1999; Seto et al. 2010). However, as the urban population grew, urban systems became increasingly difficult to understand (Batty 2007). During that time, city dwellers witnessed the emergence of more complex systems and urban networks in relation to infrastructure, economic activities and logistics. The prosperity of residents and cities depended on a functional and well-designed transportation system, as this was the key for linking goods, services and people (Antrop 2004).

The Von Thunen model was not able to adequately explain these changes around urban networks in modern cities, and new Land Use and Transportation Modelling (LUTM) were eventually developed (Sivakumar 2007). These top-down models reflect the land use primarily as a function of transportation and other networks in a city. In LUTM, urban systems are modelled in terms of demand and supply of jobs, goods and services along existing networks. For instance, these models helped with understanding traffic congestion by analysing the routes of commuters from their homes in residential zones (supply) to their workplaces in industrial zones (demand) (Small &

Verhoef 2007; Batty 2009). Urban transportation involves different modes, such as cars, trains, bicycles and pedestrians moving via different routes, at different speeds, times and frequencies. Over time, these transportation patterns shaped urban development within larger or smaller scales. For example, urban demographic composition may change over the course of decades after a new highway is completed that would allow adult residents to live away from the city centre (large scale change), or suburban development rates may vary over the course of several years after the construction of a local train station (small scale change) (Putman 1975). LUTM are effective in modelling how cities expand along the main transportation routes, as they are based on common commuting patterns of residents and the flow of trade goods (which typically coincides with the flow of people), especially if the networks are planned from a top-down perspective (such as the State authorities). LUTM have also assisted with explaining and addressing the roots of traffic congestion, as well as modelling the links between different groups within a city (Ran & Boyce 2012).

Nowadays, with the advent of computers and communications, logistics are much more efficient and networks are often evolving as a result of bottom-up interactions (Batty 2008; Batty 2012). For instance, residents can do their shopping online and financial service branches are able to carry out any activity without the need to process information at a central location. Modelling all these interactions in modern urban systems individually is nearly impossible even with powerful computers, and in fact it is also unnecessary. Instead, modern urban models simulate specific aspects of systems based on a set of parameters and representative samples, and by making a range of simplifications and assumptions they are able to produce accurate predictions about the system's future state (Batty 2007; Crooks et al. 2008; Miller 2009; Miller & Page 2009).

The primary hurdle in understanding and improving modern urban systems is their ever increasing complexity. Urban systems form and evolve as a result of countless human interactions, decisions and random events that occur over different spatial and temporal scales (Batty 2007). Perhaps counter intuitively, it may be argued that even at the individual resident level these interactions matter and have an impact on the urban systems (Pumain et al 2006). For instance, where and how does one choose to build their house, the respect they have for public city areas or the choices they make in local city council elections may appear to be negligible events when looking at the big picture. However, the impacts of these micro-scale events accumulate if integrated over the whole population and may manifest in unpredictable ways over longer periods of time. In that sense, urban systems are similar to body systems - each cell in the body carries out its own functions as programmed by its DNA, and interacts with other local cells in its tissue and its immediate environment. Any changes in these small-scale cellular operations may eventually and over time affect the health of the tissue, the body system and finally the organism; similarly macroscopic urban systems emerge from a combination of microscopic scale events and interactions for the worse or the better (Heckbert and Smajgl 2005; Pumain 2012).

Both the Von Thunen and LUTM modelling approaches are top-down, which means systems are modelled at a macroscopic level and any micro-scale interactions are represented based on aggregate trends from socio-demographic data. On the contrary, bottom-up modelling starts with micro-scale level interactions that occur within system and builds upon their aggregate impacts. This type of modelling is becoming more well received in the research field of urban systems (Batty 2013). Automata is such a form of bottom-up modelling, which attempts to model the low level decisions and interactions in order to understand the emerging systems (Torrens 2002; Benenson & Torrens 2004). In automata models, individual decisions, behaviours and desires can be accounted for, given attributes, and collectively be simulated in order to provide a prediction about the future state of urban systems and any associated impacts (Crooks 2015). The advantage of automata in urban modelling is that they can capture the heterogeneous character of socio-demographic groups in cities and the dynamic feedback between urban planning and individual actions and responses (Batty 2009). Hence, they can model cities in a way that the resident needs and expectations are easier to simulate and address.

This PhD thesis is mainly relying on automata models and makes predictions about the future state of urban systems and their impacts on the residents' lives in the case study region of Kuwait. The decision to apply automata modelling in Kuwait is a novel research contribution, due to the country's unique context. Kuwait is among the cities that grew through the wealth of oil trade in the Arabian Gulf. Conversion from a port town to a modern urban area occurred in a very short time compared to Western cities (Abu-Ayyash 1980; Rizzo 2014). Another trait of Arabian Gulf cities and Kuwait in particular is that population growth was not driven by internal migration from rural areas, but from overseas immigration of labourers (Malecki & Ewers 2007). The main impacts of these phenomena are visible in a variety of urban systems in Kuwait and similar cities: there is increased and costly traffic congestion, reduced housing availability, high nationality segregation ratio between citizens and non-citizens and inefficient land use.

The responsibilities and actions of groups that influence urban systems vary greatly around the world. Many cities in the United States and Europe have adopted policies to alleviate any negative consequences of urban development with involvement of local communities (Krueger & Gibbs 2007). In addition, most of Western cities adopted urban modelling in their planning system as a planning decision tool (Waddell 2002). On the other hand, countries in the Arabian Gulf are most often reactively responding to problems and place emphasis on improving the welfare of society (healthcare, housing, education, income and social-welfare) (Kroft 2007). There are in fact two distinct differences related to urban planning in Gulf countries compared to other Western states:

1- There is no utilisation of urban modelling of any kind as a tool to facilitate and guide urban planning strategies. Instead, planning is carried out based on empirical studies from past and present social, statistical and spatial data.
2- Urban planning is exclusively controlled by the central authorities via top-down master plans without any resident participatory planning or community consultations (Madbouly 2009; Al-Nakib 2014b).

The lack of urban modelling practices means negative impacts of urban growth in Arabian Gulf countries cannot be properly assessed. This has mainly been attributed to the fact that the unique characteristics of the Arabian Gulf cities and other regional political and social traditions make it difficult to model long term, effective and coherent urban development plans (Al-Hathloul 2004). Urban planning and systems in Kuwait and most other Arabian Gulf cities are exclusively controlled by the government without any public participation or private sector involvement (Madbouly 2009; Rizzo 2014). Over the last decades, urban development in the region has been dominated by a series of master plans, which were largely based on conceptual designs and have been inadequate in predicting urban growth related impacts (Al-Damkhi et al. 2008; Ramadan et al. 2010). Furthermore, these plans were based on assumptions that have not been modeled; a notable example is the failure to address the reality of the significantly high ratio of non-citizens to citizens in most cities (3:1 in Kuwait and 7:1 in Qatar) (Snoj, 2014; PACI 2017).

This research investigates whether automata modelling can be successfully applied in Kuwait and other similar Arabian Gulf cities in order to model the existing and future states of specific urban systems. In doing so, it will be possible to better understand any negative aspects of urban systems and assess the capability of automata to provide the foundations for developing appropriate solutions. The proposed model follows a bottom-up approach, which accounts for the resident choices and actions; such models have never been applied in Kuwait or any other Arabian Gulf country before. The project methodology takes into account the unique characteristics of the case study area of Kuwait, and models the impacts of future development on urban systems related to housing shortage, traffic congestion and nationality segregation.

1.2 Research questions

The aim of this research thesis is to integrate urban modelling in the planning process of Arabian Gulf countries. The conceptual issue that the thesis attempts to solve is that in these states, nationality segregation and centralised urban planning result in urban growth patterns that have detrimental effects on several issues, like traffic congestion, housing availability and social cohesion. Hence, by attempting to address the conceptual issue, the research thesis aspires to assist in alleviating the aforementioned practical urban issues. In order to solve both the conceptual and practical issues, new simulation models with resident inputs and top-down parameters are developed. The model outputs are used to simulate the effects of alternative urban growth plans, such as establishing new cities with a more integrated social order.

The overarching issue of this thesis then is that nationality segregation and planning approaches based upon extending existing urban forms lead to undesirable growth impacts in Arabian Gulf countries. This issue clearly applies to Kuwait, demonstrates all the unique characteristics of a typical city in the region. In an attempt to address the overarching issue summarised above, the research hypothesis of this thesis is:

“Simulating the urban dynamics based on the preferences and behaviours of population groups and integrating the findings into future planning, can alleviate the negative impacts of urban growth in Kuwait and similar Arabian Gulf countries.”

Testing this hypothesis is not simple, as it entails several urban growth, and population dynamics dimensions. In this thesis, the testing of the main hypothesis is comprised of four statements linked to different dimensions of the overarching issue. The research questions that must be answered to test the main hypothesis are:

1. Has the history of urban planning and land use decision making in Kuwait, which is driven by the government and very centralised planning processes, contributed to undesirable urban growth impacts?

   In order to test the main hypothesis, the past and current planning approaches must be understood and analysed. This must be done in order to identify the relation between urban growth impacts and centralised planning.
2. How do different urban expansion approaches affect the impacts of growth in Kuwait and other Arabian Gulf countries?

As the main hypothesis suggests, modelling may reveal alternative urban expansion plans that will be capable of reducing the negative impacts of growth. Hence, the future effects of different expansion approaches need to be simulated in order to test the research hypothesis.

3. How well can automata modelling simulate existing and future urban systems?
   The hypothesis claims that integration of the simulation results in planning can provide a practical solution to the overarching issue in Kuwait or other Arabian Gulf countries. Automata modelling (which is used for the simulations in this thesis) must be tested in regards to how effectively it may be integrated in planning approaches and how easy it is to extract useful conclusions by using it.
4. How would the consideration of public opinion and resident preferences influence future urban development land use patterns and any negative impacts of growth on urban systems of Arabian Gulf countries?
   Finally, the hypothesis claims that the preferences and behaviours of residents will be useful in improving the future expansion planning and alleviating urban growth impacts. This statement needs to be tested, especially because public participation is a particularly novel concept in Arabian Gulf societies.

1.3 Research objectives

In order to answer the research questions, a range of research objectives have been formulated. These objectives aim to:

1. *Assess urban growth's negative impacts on the urban systems of Arabian Gulf countries using Kuwait as a case study.* The specific issues of traffic congestion, housing shortages and nationality segregation are closely investigated in respect to whether they are of the greatest concern to residents of these countries. This objective aims to evaluate the severity of said impacts and understand their underlying factors. This objective is linked to question 1.
2. *Investigate whether the key negative impacts identified in objective 1 will get aggravated in the near future (30 to 40 years).* Automata modelling is used to predict the impacts according to different future scenarios and assess the states of the systems in question. Automata modelling's ability to simulate how decisions are made by local agents and how interactions between stakeholders may affect urban systems is also assessed. This objective will partially assist in answering research questions 1 and 2.
3. *Correlate and interpret historical urban growth patterns and development trends according to socio-economic and land use data for Kuwait from 1995 to 2015*. This serves as a

foundation for developing the urban model and forecast growth and future impacts. This objective will mainly assist in answering a part of research question 2 and 3.

4. *Investigate the differences in outcomes between two alternative urban expansion options by modelling: expanding the existing urban areas or developing new cities.* This will provide further data in validating the automata modelling and understanding local urban systems. Simulations are carried out with multiple different inputs in order to obtain a range of results for all potential outcomes. This objective will mainly assist in answering research questions 2 and 3.
5. *Incorporate the opinions and preferences of Kuwait resident groups as rules into an urban automata model and investigate if this leads to different outcomes for urban growth patterns and the respective negative impacts.* Information from residents is gathered via a public participatory survey to: i) discover the groups' opinions and preferences for future urban development, whilst also considering trade-offs between current and future systems, ii) ascertain if there is any significant difference between citizen and non-citizen responses, iii) understand decision making processes on whether residents desire to stay or relocate to new cities, and iv) evaluate if this may be an effective way to engage the public with urban planning issues in Kuwait. This objective will assist in answering research question 4.

These five objectives are addressed in the thesis chapters, but three key chapters 4, 5 and 6 describe spatial models for future growth scenarios with different stakeholder involvement based on Agent Based Modelling (ABM) and GIS. The overall relationship between research questions, objectives and the key chapters 4-6 is shown in Figures 1-1, 1-2 and 1-3. Further details that solidify and justify the research questions and objectives can be found in the literature review (Chapter 2).

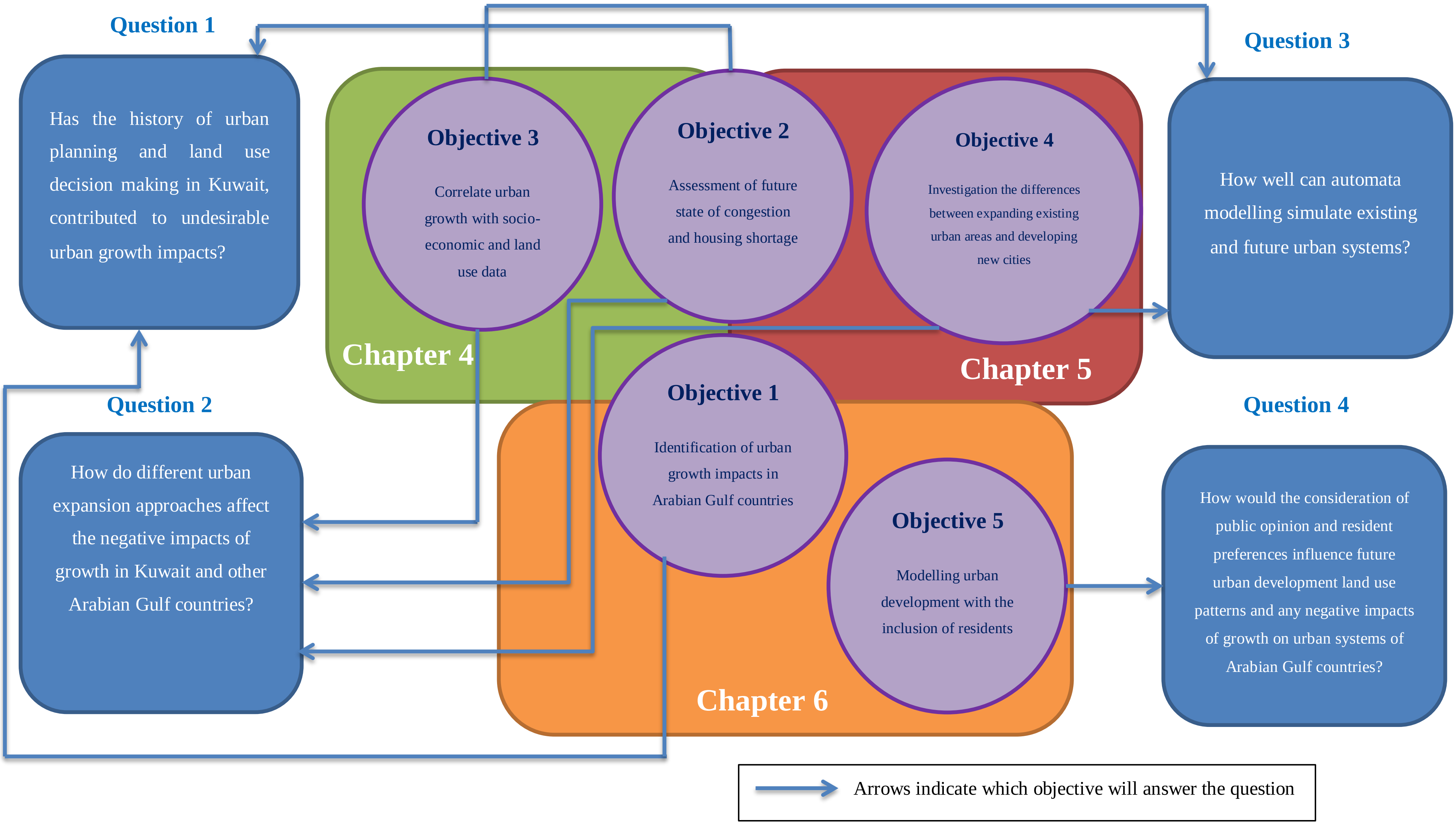


Figure 1-1: Research plan overview

Chapter 4 — Modelling the business as usual scenario of existing city expansion

- Assess current trends of urban growth in Kuwait based on historical data.
- Identify the availability and format of data that could be spatially collated and integrated in GIS.
- Develop a foundation of the urban model for other streams.
- Assess the contribution of past urban growth patterns on impacts such as housing shortage and traffic congestion in the present and future.
- Identify the main urban growth impacts in Kuwait based on the literature.
- Simulations are based on a simple land use model by using (ABM).

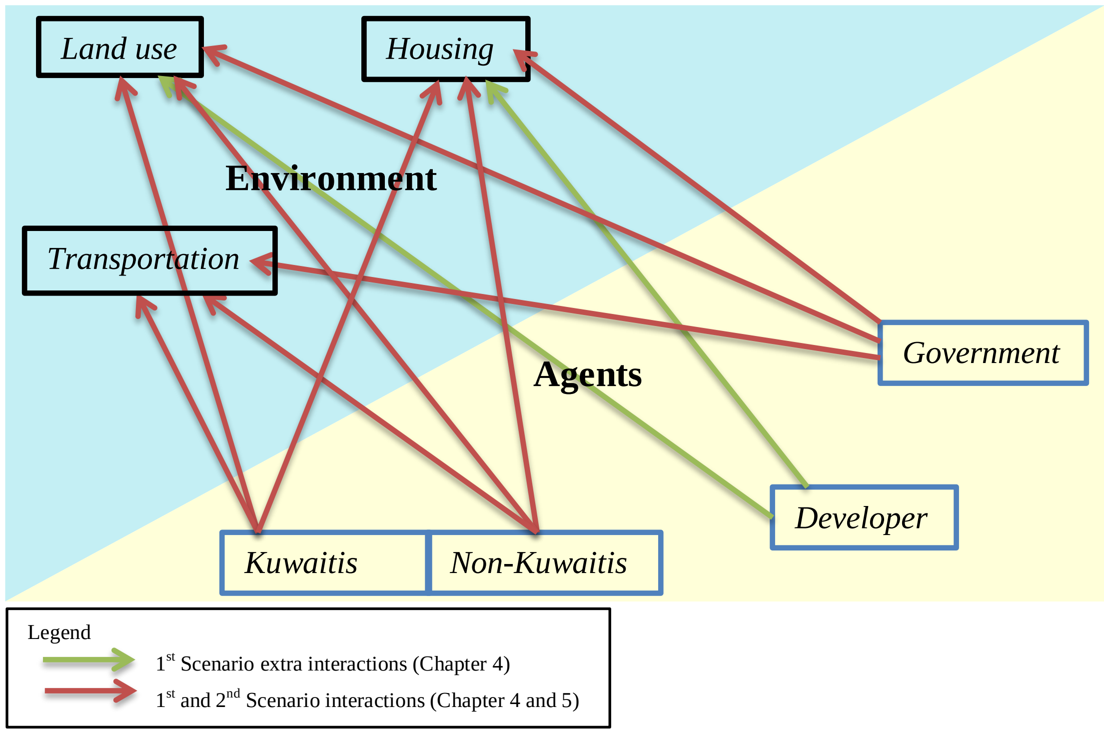
Chapter 5 — Modelling the master plan 2030 scenario (new multi-cities creation)

- Identify the main urban growth impacts that concern the government and the residents based on the decision makers interviews and public surveys.
- Assess government's urban planning approaches based on interviews with government representatives and developers and surveying the residents.
- Assess the effectiveness of the master plan in addressing the key impacts.
- Examine the impacts of delays in construction projects on future urban growth.
- Simulations are based on a transport model combined with certain automata elements (ABM).

Chapter 6 — Modelling the scenario implementing resident preferences and needs

- Assess the potential influence of public participation in urban planning on the nationality segregation.
- Identify the differences in needs, preferences and expectations between citizen and non-citizen groups.
- Develop a survey for data collection that may be presented as a proof of the importance of inclusion of public in planning processes to the authorities.
- Evaluate the new master plan from the residents perspectives and the desirability of new cities.
- Understand the factors that affect the residents internal migration to the new cities.
- Investigate the differences between residents expectations and government plans.
- Simulations are exclusively carried out by an automaton model (ABM).

Figure 1-2: Outline of the three key chapters, their scenarios and research activities



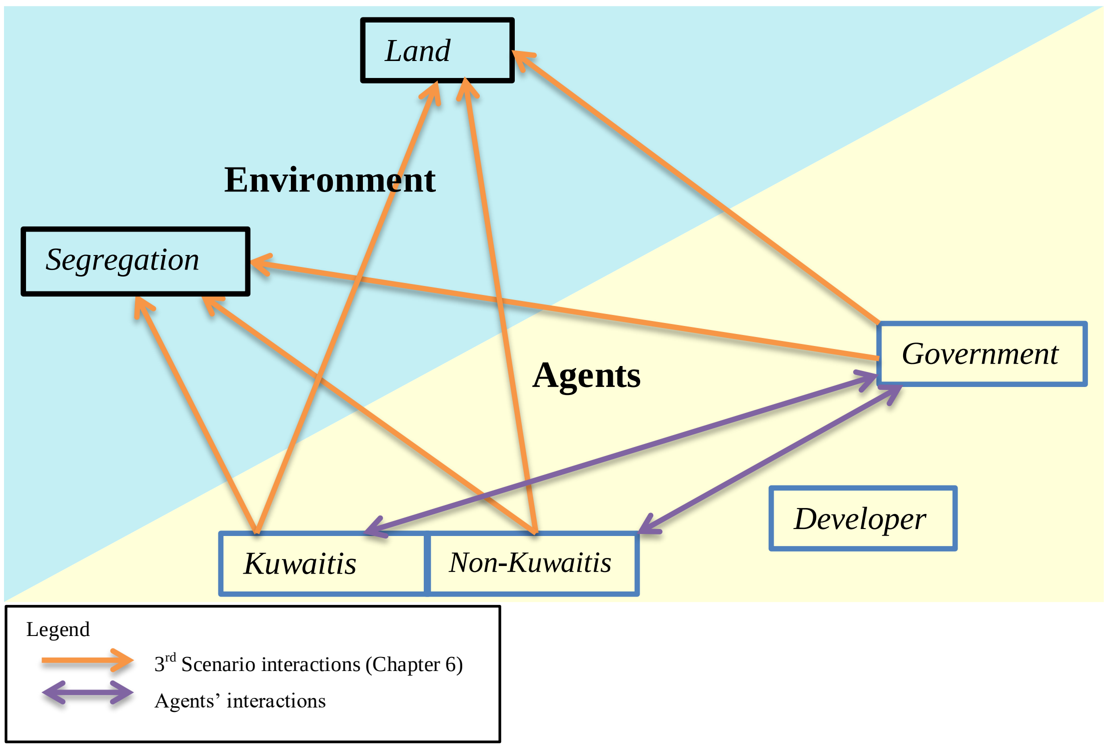


Figure 1-3: Schematic of the interactions between agents and their environment in the simulations

1.4 Summary of research and its significance

The main theme of this research thesis stems from the concepts and theories related to urban dynamics, which models urban patterns in terms of preferences and behaviours of population groups making up society. Specifically, the thesis describes and models the patterns of urban growth that have resulted from nationality segregation within Kuwait's society and its historical centralised planning approach. Urban simulation is used to demonstrate that establishing new cities with a more integrated social order may address future urban growth pressures. The models in this research simulate urban development in Kuwait as the case study from 2015 to 2050 in 5-yearly intervals, through the interactions of different agent groups. The different simulation scenarios are conceptualised as a combination of Top-Down and Bottom-Up modelling scenarios, with the government planners and developers as agent groups on one hand and residents (citizens and non-citizens) on the other. Under these scenarios for urban development in Kuwait, the impacts of growth on traffic congestion, housing shortage and nationality segregation is evaluated and assessed. Each scenario has its own design parameters, inputs and outputs. However, all scenarios are simulated on the same platforms (ArcGIS and ABM) and share the same agent groups, time frames and basic rules.

The work presented in this thesis contributes to the field of urban systems in two ways:

1. Prince of Kuwait Sabah Al-Ahmad during his speech in his first year of leadership in 2006 said; "*Development and planning have the first national priority that must be agreed upon, and work to achieve, for planning and development are life necessity and the bases for building and securing the future of our sons and our future generations. What we aspire to in planning and developments must revolve around the Kuwaiti citizen, their objectives are his welfare and happiness, ...*" (Al-Diwan Al-Amiri 2017). In order to achieve the objectives and development envisioned by Prince, this research models and analyses different scenarios of urban growth in Kuwait. The research on new cities in particular is especially useful for the local authorities, since no automata modelling has ever been conducted and there have been no instances of participatory planning. In addition, the research thesis investigates the aspects of urban system evolution as experienced by Arabian Gulf countries. The unique conditions that drive growth in this region include an oil-based export economy, rapid urbanisation resulting from immigration of foreign labour and lack of private sector or public involvement in urban planning processes. The project identifies and attempts to understand the historical and future trends of the impacts of growth on certain

urban systems (traffic congestion, housing availability, nationality segregation), under these unique conditions.

2. According to Timmermans (2012), " .... *Automata models have also been developed as planning models, simulating the evolution of an urban system.*" (p.182). In addition and according to Benenson and Torrens (2004), " *Automata-based modeling tools hold many advantages for simulation of urban phenomena in space. ..... their ability to directly handle individual spatial and nonspatial elements, simplicity of formulation- all of these features offer many benefits to model-builders*." (p. 8-9). The applicability of automata in urban system modelling has been already recognised in the literature. In this thesis, automata modelling is combined with participatory surveys, which is a novel contribution to the field. Specifically, the actions of different resident and decision maker groups involved with urban systems in Kuwait are simulated based on survey responses. Interviews and public participatory surveys helped to discover the desires and behaviours of these groups and the results are analysed to show the effectiveness of automata in general (and ABM in specific), as a tool for modelling systems and future impacts in Arabian Gulf countries. To the author's best knowledge, these novel approaches in modelling have never been attempted before.

Through addressing the research questions, this research thesis contributes towards alleviating the impacts of urban growth on traffic congestion, housing shortage and nationality segregation in Kuwait. Moreover, a model for the new master plan of Kuwait provides a validation of Kuwait's future urban systems with feedback and recommendations for the local planning. The outcomes from the survey for public engagement and the questionnaire may be used by the planning authorities as a basis for incorporating the residents' opinions and suggestions in future decisions. In addition, a potential outcome is to recommend the adoption of robust modelling based on automata in urban planning processes to the Kuwaiti government. The suggestions may be used either as adjustments to the existing master plan, or as a basis to form alternative urban development strategies (for instance comprehensive planning) if the government decides to go down that path in the future. The research is also significant for other Arabian Gulf countries with similar circumstances as Kuwait.

1.5 Thesis outline

Chapter 1 outlined the research objectives, questions and rationale.

Chapter 2 begins with an outline of the principles of urbanisation, urban development and associated modelling techniques. The main purpose of the chapter is to justify the research gaps based on the relevant literature. Throughout the chapter, there will be critical assessment of other studies, and the findings or methods that are related to the research thesis.

Following the literature review, Chapter 3 describes in detail the historical and current conditions in relation to the case study of Kuwait. This includes a thorough explanation of existing urban systems, the most critical issues and the respective reasons, as well as local data sources that were used in the development of the model.

Chapter 4 examines the future impacts of current urban development trends in Kuwait as derived from automata simulations. A top-down development approach models the urban area expansion, population and land use according to historical trends. This scenario uses global parameters for the agent interactions and will serve as the foundation for the urban models in following chapters. In addition, it allows examining the impacts of future urban development on traffic congestion and housing problems if it follows the historical trends.

Chapter 5 models and analyses the outcomes of the Kuwait master plan under the assumption that the population distribution and land use are going to evolve according to the projections of the Kuwait Municipality. The main theme of this Chapter is modelling the future development of new cities according to the Kuwait Municipality Master Plan. The simulation parameters are varied in order to investigate the possible effects of the new proposed train network and construction delays and validate the new master plan. Additionally, the population movements from existing urban areas to the new cities are modelled according to resident responses for the first time in Kuwait.

Chapter 6 examines the impacts of involving the resident preferences in the process of planning and establishing new cities. In this chapter, future urban growth patterns are evaluated by Kuwait's residents based on their needs and preferences. The analysis of the resident behaviours and migration patterns to new cities as extracted from the responses, help to further evaluate the new master plan and develop recommendations for the government, as well as assess the possibility of formal integration of public opinion in the development of urban systems and policies.

Chapter 7 includes a preview of the main findings, results and outputs from the three main scenarios and post processing that allows the extraction of useful conclusions. There is also a concise discussion of the significance of the research thesis.

At the end of the thesis, there is an Appendix section. Appendix A contains Human Ethical clearance approval for this research provided from the school of Earth and Environmental Sciences ethics officer at the University of Queensland. Appendix B contains the survey that has been distributed to the planning decision makers in Kuwait (government and private sector representatives). Appendix C contains the survey that has been distributed to the residents. Appendix D includes supplementary material for the 1st scenario- Chapter 4. Appendix E includes supplementary materials for the 3rd scenario- Chapter 6.

Chapter 2 : Literature Review

This chapter discusses the concepts and issues related to urban development, urban systems and urban models. It expands on the gaps that form the theoretical foundations for this research and were identified in Chapter 1. Besides reviewing the relevant literature, this chapter partially answers aspects of the research questions related to the availability of modelling data and the key impacts of urban growth in Arabian Gulf countries (Kuwait as a case study) as well as identifying the key decision maker groups that shaped the urban development process.

The literature review begins by outlining important principles in the field of urbanisation and urban growth (Section 2.1). This section attempts to make the reasons and historical progress of urbanisation and urban growth clear and introduce how urban systems are affected by them. Section 2.2 attempts to highlight the links between urban development and urban systems in order to understand how the city as a physical dynamic entity is affected by several factors. Section 2.3 compares and contrasts urban growth patterns and certain systems in both Western (European/American) and Arabian Gulf cities, and attempts to provide a foundation for developing an appropriate methodology to simulate the unique conditions of the case study region. Finally, section 2.4 presents different urban system models, and the main findings and shortcomings of these models are discussed and where necessary linked to the research objectives. Emphasis will be placed on automata modelling as a framework for urban modelling. This section also describes the integration of Geographical Information Systems (GIS) in automata models, in order to simulate urban development and urban systems, as well as the importance of receiving empirical data from surveys.

2.1 Urbanisation and urban growth

This research thesis investigates and models urban systems and how they evolve as cities grow. Hence, in order to contextualise the models, it is first deemed necessary to review the traits and impacts outcomes of urban growth. The purpose of this section is to highlight and expand on the key elements of urbanisation and urban growth. Through the following discussion, it will be possible to comprehend the main drivers of urbanisation and the ways it can influence urban systems in current and future cities as they expand.

Urbanisation may be regarded as the increase of the proportion of the population living in urban areas (cities) compared to nonurban areas (rural areas) (Birch 1971). Population growth is the primary driver initiating and accelerating the process of urbanisation (Bhatta 2010; Marcotullio &

Solecki 2013). After the 1940's, an unprecedented rise of urban population in the world led to a new milestone in human history, as the percentage of city dwellers reached 50% of the total global population in 2007 (The World Bank 2015). Therefore, it is not surprising that urbanisation is considered as one of the most important phenomena that has shaped the world in the 20th and 21st centuries (United Nations 2015). Most countries have experienced and gone through the process of urbanisation, which has affected and altered the traditional lifestyles that people were once accustomed to. The percentage of urban population is different between continents as seen in Figure 2-1.

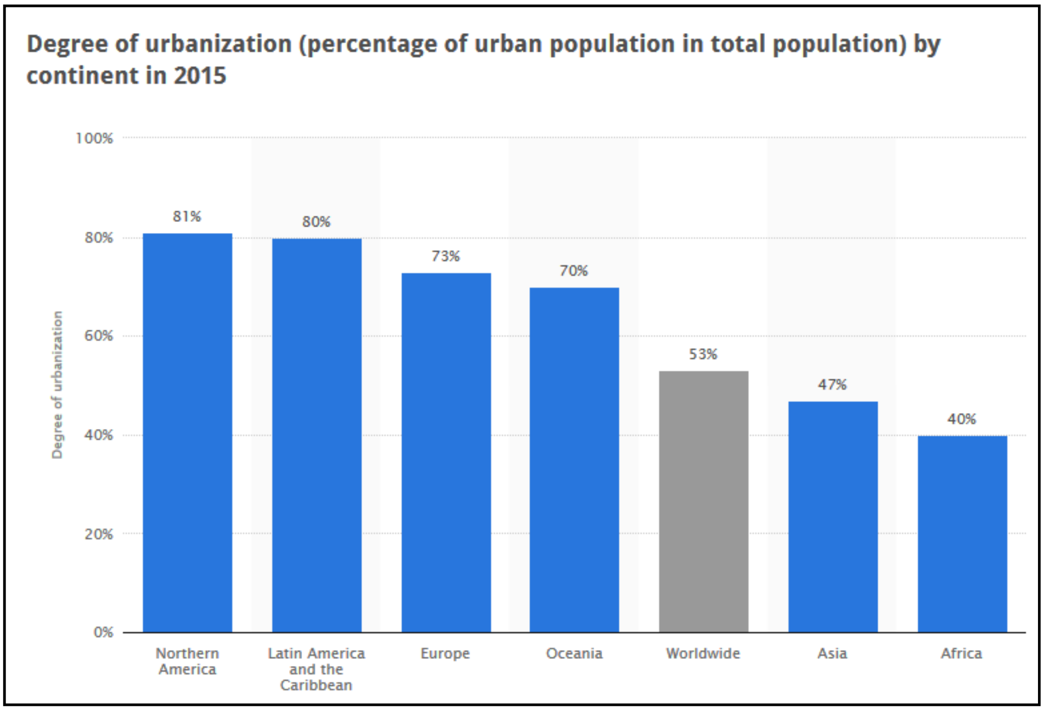


Figure 2-1: Urbanisation ratios around the world (Statista 2015)

2.1.1 Urbanisation causes and consequences

Urbanisation can be regarded as a process linked to a variety of human social changes. The process of urbanisation is rather complex and varies regionally, but Figure 2-2 highlights the key components of urbanisation that are common in the majority of cases.

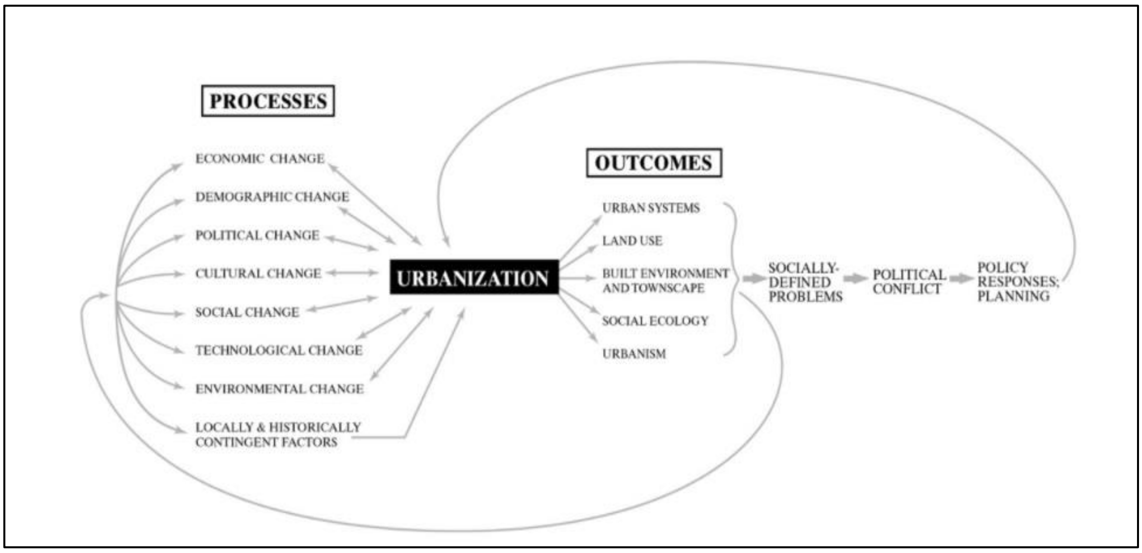


Figure 2-2: The different dimensions of urbanisation (Knox & McCarthy 2012)

According to Knox and McCarthy (2012) urbanisation is not just the increase of the urban population, but rather multiple interconnected and integrated processes of change such as:

- **Economic Change:** Cities are the engines of national economic growth (Marcotullio & Solecki 2013), and as a result, they attract people to move within their geographical boundaries to seek new opportunities and a better lifestyle (Black & Henderson 1999). Economic conditions that shape urban systems have evolved over time; for instance, during the Industrial Revolution the city economy shifted from agricultural to manufacturing, and more recently there is a clear shift from manufacturing to service sector (Kenessey 1987).
- **Demographic Change:** Demographic change refers to the population size and its composition. It has three dimensions: i) natural change in population via births or deaths, ii) internal migration (movement of people nationally within borders) and iii) immigration and emigration (movement of people internationally across political borders) (McGranahan & Satterthwaite 2014). Factors that could attract residents to a city include better education, healthcare and employment. Factors that may cause them to abandon their current location include war risk, inequality, unemployment or housing affordability (Lee 1966).
- **Political Change:** The changes in policies initiated and carried out by governmental authorities may incentivise urbanisation directly or indirectly, by offering tangible benefits (access to large hospitals, universities, airports) or intangible benefits (community events, security) to urban dwellers. These urban policies have traditionally had profound capacity to shape cities and the systems within (Sager 2011).
- **Cultural and Social Change:** Cultural and social changes are components associated with the heritage and values of people within the borders of cities. Drivers of change may be

related to the diversity in race, gender, nationality, religious background, ethnicity, status in social hierarchy, educational background and marital status.

- **Other forms and drivers of change:** Additional changes may be driven by technological innovation, environmental change and historically contingent factors specific to a city or region (Knox & McCarthy 2012).

The main result of urbanisation has been the expansion of cities, which is known as urban growth. Urban growth can be characterised as both a spatial and demographic process that increases the prominence of the city role in human society (Glaeser & Kahn 2004). According to Bhatta (2010) urban growth can be described as the expansion of urban systems mainly in terms of physical, social and economic components. Other components of urban growth may also include environmental, infrastructural and institutional systems (Bhatta 2010).

Physically, cities and their associated systems expand in the three dimensional space and affect the surrounding landscape. Urbanised zones can no longer be utilised for other activities (e.g. agriculture and grazing). Increased demand for developed zones alters the physical landscape around the city. The social component of urban growth is associated with the movement of groups of people often resulting into major changes in their lifestyle. The movement can be from rural to urban areas or between urban areas of the same region or internationally. Finally, the economic component of urban growth is linked to the transition of economic systems between different sectors: primary sector based economies to (resources and raw materials), secondary sector based economies (manufacturing), tertiary sector based economies (services for consumers and businesses) and quaternary sector based economies (finance and insurance) (Kenessey 1987).

2.1.2 Urban growth impacts

Urban growth is an ongoing process, due to the continuous increase in global population (Clark 1982; Cohen 2004). Living in a city offers benefits, such as employment opportunities, better access to services, modern infrastructure and participation in a socially diverse community. However, there are also several adverse impacts. These generally differ around the world; however there are certain similarities in many cities, which are necessary to understand for any kind of urban system and modelling study. These common impacts resulting from urban growth are traffic congestion, property overvaluation, deterioration of infrastructure, social and environmental issues.

Traffic congestion is an important issue resulting from urban growth (Glaeser & Kahn 2004; Duranton & Turner 2012). Traffic congestion is *"a condition where vehicle speeds are below free-flow speed and the travel time is increased*" (Behan et al. 2008, p.293). The main reasons for traffic congestion according to the literature include the poor design or operation of urban systems related to transport networks (Ligmann-Zielinska & Jankowski 2010; Klarl 2015), inadequate or poor planning policies (Harvey & Clark 1965), failure to enforce planning strategies, physical constraints (hills, rivers), disparities in per capita income, living and property costs and housing affordability (Glaeser & Kahn 2004; Bhatta 2010). Urban expansion also tends to increase car dependency and traffic congestions (Seliske et al. 2012; Yeo et al. 2015). Ideally, urban growth should be accompanied by a proportional expansion of the major transportation axes (Yang & Lo 2003; Kim et al. 2014). However, this requires very thorough and costly urban modelling, upgrades and management of transportation systems. Naturally, this is not common in many modern cities, and as a result major congestion issues appear.

Another negative impact of urban growth is housing affordability (Isma'il et al. 2015). To an extent, this pattern makes sense, as there is increased demand for housing in an area with limited supply. Hence, property prices in already developed city areas are driven up. New land developed as a result of urban expansion puts further pressure on property prices (Chen et al. 2011) as expanding the existing urban systems is often expensive (Bhatta 2010) and this cost passes on to the prospective buyer. To aggravate the problem, housing welfare policies (PAHW 2015), discrepancy of incomes (International Monetary Fund 2013), mistakes in the planning systems and processes (Al-Hathloul 2004) all contribute to higher property prices.

Deterioration of living standards may be another consequence of urban growth; most often the underlying reasons are inefficient institutional frameworks, poor governmental management or financial shortcomings. Controlling urban growth requires the creation and management of urban systems, such as infrastructure (roads, electricity, telecommunications grids) and public services (fire stations, police stations, health care centres, and schools) (Bhatta 2010). Typically, institutional changes to urban systems are slow to manifest and can lag behind population growth resulting in inadequate access to housing and limited infrastructure for a long period. In addition to the deterioration of living standards, poor infrastructure is costly for the economy. While managing and funding well-planned urban systems as cities grow appears to be more expensive, the negative impacts of uncontrolled patterns of urban growth far outweigh the increased capital investment fostered by appropriate urban planning. The costs associated with inadequate infrastructure that is not synchronised with urban growth is estimated to be around $1 trillion annually in the United States alone (Litman 2015).

Urban growth may also negatively affect social coherence. Under certain conditions, the introversion of families may rise and the sense of community may deteriorate. Social segregation has roots in the exclusion caused by indirect conflicts between groups with different lifestyles and concerns, such as between low-income and high-income residents or between locals and migrants. An example of social segregation according to nationality and originating from urban growth is present in many Arabian Gulf cities between citizens and non-citizens (Farber & Li 2013; Zhao 2013; Pereira et al. 2014).

Finally, uncontrolled urbanisation and land development may often lead to various environmental issues, such as the loss of natural habitats, loss of open space, increased air pollution and higher energy consumption (Irwin & Johnson 2001; Bockstael 2004; Sypharda et al. 2011; Arouri et al. 2012; Seto et al. 2012; Vaz et al. 2012; United Nations 2015).

It can be concluded that urbanisation and urban growth are associated with a variety of issues. Local authorities and communities have to continuously adapt existing urban systems or implement new ones to counter any such negative issues. As modern cities become more complex, it is increasingly difficult to correctly predict and prepare urban systems for any future changes in the city. The result is that urban development to accommodate growth is often poorly planned and administered; as such, certain impacts may be aggravated. Regardless, the following section analyses in depth a selection of dimensions and challenges linked to urban development and how systems are planned and implemented.

2.2 Urban development process

This section describes the specifics of the process of urban development. In doing so, it will be possible to identify key decision makers for development in most modern cities, understand their roles in proposing and modifying new systems (both of which are among the main research questions of this thesis), as well as highlight any trends that will be useful later on in the modelling stages.

Urban development can be understood as the process that occurs in cities as a result of urban growth. During this process, various urban systems are generated, linked and form a cohesive physical entity known as the city (Clark 1982). Developing modern cities entails the planning and management of numerous and increasingly complex urban systems, such as the road networks, public transportation routes, population and resource flows between suburbs, as well as different types of infrastructure (telecommunications, electricity, sewage, water and so on).

Urban development is not only related to the contemporary process of city growth, but also designing, planning and managing urban systems with future population forecasts into consideration

(Hopkins 2001). The complexity of urban development augmented, as several groups participate in decision making and very often each group has different motivations, behaviours and objectives; hence conflicts may frequently arise (Knox & McCarthy 2012). Examples of groups involved in urban development directly or indirectly are urban designers and planners, architects, land owners, holders, private investors, companies, residents and government authorities (Knox & McCarthy 2012). All these groups interact with each other through a multitude of channels and means during the planning and development of systems.

For example, demand for land arises from desirability of specific locations from residents, investors and companies. The government authorities and urban planners typically want to regulate land demand and may decide the conversion of land use or new urban development to keep the property market and land values in check. If the demand cannot be met within the existing urban form, then urban expansion and outward sprawl may occur. The private sector (investors, developers and builders) may capitalise on such opportunities to develop sites and build necessary infrastructure services. From its side, the private sector group may exert pressure on the government and planners to facilitate available land for urban development in order to maximise value and returns. On the other hand, residents desire good quality of living and infrastructure services. Governmental entities, architects and urban planners are not completely free in negotiating and managing new urban development as they are constrained by policy frameworks and legislation (Knox & McCarthy 2012). In short, urban development and the associated systems is a rather complex and multidimensional process.

It should be noted that the above example and other development processes are not universal around the world, as different regions have different laws and policies in effect. However, physical city form expansion occurs commonly via specific development types.

2.2.1 Urban Development Types

Urban development involves the physical expansion of cities. Regardless of the underlying decisions and systems, urban development types can typically be classified as:

1- Intensification, which occurs as a result of increasing dwelling density within the existing built-up areas (Melia et al. 2011). Intensification may be further classified into:
   a. Brownfield Developments – This refers to the development of abandoned and undesirable commercial and manufacturing facilities that are concentrated in low value inner city localities. The process of Brownfield development transforms such suburbs into high density residential zones. These sites may present limitations in the conversion

process, as previous activities such as chemical or petro-chemical manufacturing may have increased local pollution levels.

b. Infill Developments – This type of development concentrates on intensifying and consolidating urban development from low into medium or high density development commonly via the construction of high rise apartment blocks.

2- City expansion or Greenfield Developments: Greenfield entails the expansion of existing city fringes onto natural or agricultural lands. Prominent features of this type of expansion are large housing lots, dispersed or sprawling development, low population density, limited infrastructure provision (public transport, footpaths, public space, third spaces) and relying on regional economic centres in the form of suburban shopping malls and activity districts (Biddle et al. 2006). Problems that may occur with this type of development include limited access to employment centres and public services, higher car dependency, degradation of the local environment and increasing social segregation. Greenfield development often as a more costly option compared to intensification, due to the high capital required to integrate the new areas in the existing infrastructure systems (Newton 2010).

3- Developing new cities independent from the existing ones: This type of development is considered to be the most expensive, as it requires building in previously undeveloped areas and generally requires the construction of new infrastructure from scratch (Wang et al. 2011). In addition to the high cost of this type of urban development there is the inherent risk of the new city not attracting enough residents, resulting in what is known as a "Ghost City", a city with all or almost all services and infrastructure ready to function, but without any residents (Moreno & Blanco 2014).

All urban development types involve a number of preliminary steps: site selection, project conceptualisation and the feasibility study with long term vision. The implementation stage typically comprises financing and actual construction. Finally, the post-completion stages are related to the operational management of the urban systems in place (Knox & McCarthy 2012). These stages are carried out collectively through specific urban planning approaches suited to the specific economic, demographic, socio-cultural and geo-political factors of each city.

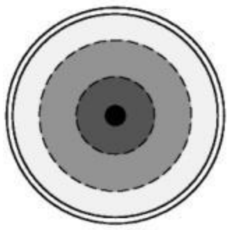
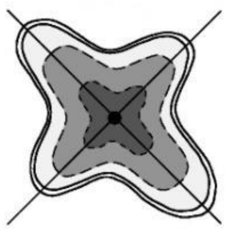
2.2.2 Urban planning

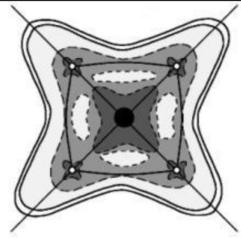
Urban planning can be considered as the way of shaping cities and the urban systems within cities. Among the main objectives of planning is to improve citizen welfare by creating more convenient, equitable, healthy, efficient, and attractive cities (Wang & Hofe 2008). However, city systems are complex systems, and often have evolved from interdependent interactions between many aspects of the society, economy and politics. Traditional urban theories examine urban planning in the context of the aforementioned interactions of systems, populations and economic activities within the urban form.

2.2.2.1 Urban form

No uniform definition exists for urban form due to its complexity and broad range of principles that are encompassed within. One of the most widespread definitions has been given by Anderson and stated that urban form is "*the spatial configuration of fixed elements within metropolitan region. This includes the spatial pattern of land uses and their densities as well as the spatial design of transport and communication infrastructure*" (Anderson et al. 1996, p.9). Urban planning shapes the physical space and shape of existence of the city and characterises the physical distribution of land use, accessibility to services and transportation systems for cities (Besussi et al. 2010). In fact, planning of transportation systems over time is among the primary drivers that shape the urban form. There are three basic urban forms types, resulting from planning around three types of transportation systems respectively, which can be seen in Table 2-1.

Table 2-1: Urban form types through history (Anderson et al. 1996)

Types	Characteristics	Graphs
Concentric form	• The first kind of urban form established. • Occurs via developing new cities and intensification. • The Central Business District (CBD) is the focal point (Centralised city). • The highest population and employment density, as well as land value appear in the CBD.	
Radial form	• The second type that evolved from the concentric city. • Occurs via expansion or Greenfield. • Land uses spread out from the CBD along major routes. • Population growth expanded further away from the CBD.	

Multi-nucleated form	• The third and last shape evolved from the previous types. • Occurs via developing new cities and/or expansion or Greenfield for existing cities. • Decentralised city. • Spatial interactions flow in all directions. • Not all routes are toward the CBD. • Higher level of connections between various locations in the city.	

In practice, cities grow with more complicated patterns and in different ways, so classification is sometimes challenging.

Another way of studying planning in terms of the urban form is according to population density. There are two common spatial trends in urban form development: compact urban form and sprawl (Maoh et al. 2010). Compact urban form has been defined in many ways, such as *"high-density or monocentric development"*, *"some concentration of employment and housing, as well as some mixture of land uses"*, *"both monocentric and polycentric forms are compact urban form"* and *"compactness is the degree to which development is clustered and minimises land developed"* (Tsai 2005, p 142). Urban sprawl may be described as *"low density, leapfrog development occurring at the edge of a city*" or *"low-density development beyond the edge of service and employment, which separates where people live from where they shop, work, recreate and educate thus requiring cars to move between zones"* (Kashem et al. 2014, p 2234).

2.2.2.2 Strategies for urban planning

As discussed earlier, different kinds of urban systems have to be planned and operated in an attempt to alleviate issues resulting from urban growth (Judd & Swanstrom 2014; Fischel 2015). In most countries, planning strategies have to be carefully developed ahead of time to make sure important urban systems are regulated properly and negative factors related to living standards of citizens are minimised (Vos 2002; Nechyba & Walsh 2004; Couch et al. 2008; Patacchini & Zenou 2009). These planning strategies often originate as parts of the local or state government's political agendas.

Examples of such planning strategies include strategic spatial planning, comprehensive planning and sustainable planning. Generally speaking, strategic planning involves both rural and urban development through a bundle of policies on integrated transportation systems, land use management, environmental conservation, economic growth and community participation. Strategic planning can assist in implementing better transportation policies, such as increasing taxes on using private cars and promoting public transportation (Todes 2012; Vos & Witlox 2013). Comprehensive planning is another common approach that includes the community goals and aspirations in the planning process. Greater public involvement is influential in public policies for urban transportation, land use distribution and future housing needs (Bengston et al. 2004); particularly in cities with high population growth rates. Finally, sustainable planning is an approach based on developing environmentally friendly smart cities and has gained momentum lately (Lord et al. 2015). Smart, green cities are characterised as cities that utilise modern infrastructure and information technology to efficiently manage urban systems in terms of resources while reducing environmental impacts at the same time (Bronstein 2009; Caragliu et al. 2011). Sustainable planning typically invests in efficient and widespread public transportation options, as well as infrastructure for non-motorised commuting, such as walking and cycling, which contributes towards the easing of congestion and pollution (Sag and Karaman 2014; Litman 2015).

Commonly, the development of urban planning policies that affect urban systems is centrally regulated by authorities. The central authorities use data about demographics, spatial and financial indices to make decisions about present and future policies and urban plans. Politics are also involved in the process, as regulators have to satisfy their voters' expectations or align with their political agendas. In some cases, and especially in Western cities there are plenty of bottom-up elements present, as systems are adjusted based on community participation, rather than solely depending on the plans set by the central authority (Bengston et al. 2004; Ergler et al., 2015). However, this is not evident in countries with less democratic cultures; in fact this constitutes a main research pillar, as the case study region of Arabian Gulf does not adopt any community participation channel in urban planning.

In section 2.2, it was shown that interactions between urban development decision makers may be motivated by aligned goals, conflicting interests or be simply a result of independent actions by each party. It can be concluded that successful planning for urban expansion and the associated urban systems should take into consideration these dynamic group interactions and accommodate the needs of as many of these groups as possible, as cities are complex systems and there are multiple perspectives to approach each issue.

2.3 Differences between Urban systems in Western and Arabian Gulf Countries

In section 2.3, urban development is going to be studied and compared under specific conditions in different regions. The findings from the relevant literature will enable the reader to understand how urban systems and modelling in Arabian Gulf countries offer different research challenges to Western countries and justify the necessity for this research thesis.

2.3.1 Urban systems in Western countries

The powers and composition of decision making groups that influence urban development vary greatly around the world. However, culturally close societies demonstrate similar patterns in urban development. For example, several cities in the United States and Europe have proactively adopted principles of sustainability in their urban systems, as a measure to alleviate the negative impacts of growth (Krueger & Gibbs 2007).

The roots of this pattern are originating in the urbanisation movement in Western counties that has occurred steadily since the time of the industrial revolution. Most Western nations have reached urbanisation levels between 75 and 90% in 2015 (The World Bank 2015). Differences in percentages of urban population may still exist between states or districts, due to their resources, location, economic development and their national or regional political power. The District of Columbia in the US for example, which is the political centre of the federal governance systems is 100% urbanised, while the state Iowa being an agricultural based economy has an urban population of only 64% (Iowa State University 2015).

Economic development in most modern Western cities is facilitated by specialised manufacturing operations and services (banking, finance, real estate, information technology and insurance) (Kenessey 1987). Diversification of opportunities continuously attracts people of different skills to move in these cities. In turn, this increases not only the urban population percentage, but development rates as well.

The Western political system has been built upon democratic foundations and based on a regulatory framework which encourages active involvement and participation of the public in various political decisions and policy implementation exercises (Helbig et al. 2015). Such political systems are oriented towards promoting accountability and transparency when public money collected by taxation is spent. Figure 2-3 illustrates the principles of good governance that are applied in the majority of Western countries.

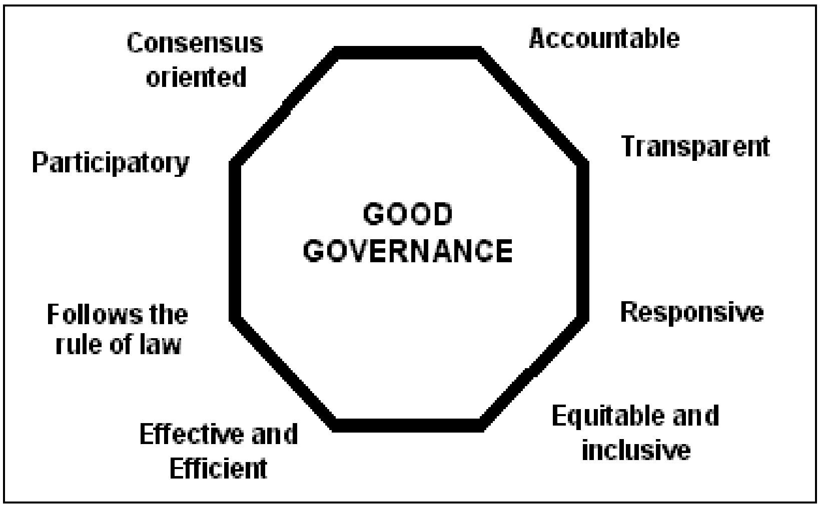


Figure 2-3: The principles of good governance (UNESCAP 2009)

The active involvement and collaboration of multiple stakeholders within urban system planning is directed via a combination of top-down and bottom-up strategies, which involve consultations and exchange of opinions, in an effort to minimise conflict between participating groups (Helbig et al. 2015). The role of state authorities is regulating the design and enforcement of policies related to urban development and systems. The private sector on the other hand, is responsible for providing the necessary infrastructure and construction services. Furthermore, the significance of its role is enhanced through the acquisition of funds and investment management holdings that aim to stimulate development and returns. The residents are considered as the third important pillar of system planning and urban development processes, being both dwellers and prospective future investors (Knox & McCarthy 2012).

A noteworthy trait of Western cities is that the majority of the population comprises of citizens or permanent residents, and non-citizens that live or work in the city for an extended period are only a minority. For example, the total percentage of working non-citizens in the UK is to around 6.6%, while in France and Germany it is 5.8% and 8.8% respectively (Rogers, 2010). In most cases, non-citizen residents are overseas workers that were granted temporary visas for jobs that are in high demand, but do not otherwise enjoy any benefits given to regular citizens. The largest part of the population is also actively involved in one or more stages of urban planning and protects their interests as residents. However, social segregation is often visible, especially in respect to wealth. Land value within the same city varies significantly and wealthy citizens tend to prefer dwellings in expensive and highly sought after suburbs. This in turn increases demand and prices in these suburbs even further, making it impossible for middle class and low income residents to afford any property there; hence social segregation is perpetuated (White 1983; Musterd & Ostendorf 2013).

Most development policies in Western cities aim to maintain the natural environment as close to its original state as possible, for instance preserving existing ecosystems within urban areas or regulating pollution and access to certain sensitive waterways (Jonas & While 2007).

Studies related to urban development in various Western cities confirm these common traits of high citizenship ratios, active participation in urban planning, segregation due to financial inequalities and environmental consideration (Pettit & Pullar 2004; Koomen et al., 2011). The reasons behind these common characteristics identified in most such studies were: the presence of diverse free market capitalist economies based on services and manufacturing, a long history and tradition of democratic practices, and social values such as respect for the environment and the legal systems. The combination of these traits forms a baseline to which urban systems in Arabian Gulf countries may be compared and contrasted.

2.3.2 Urban systems in Arabian Gulf Countries

Among the most notable background traits shared by most Arabian Gulf countries is their economic foundation. Arabian Gulf countries control and export 50% of global oil reserves worldwide, and this has had a profound effect on their economic and urban development (OPEC 2015). For the most part of the 20th century, the region was mostly uninhabited apart from some minor trading and fishing settlements and roaming nomadic tribes. Coastal towns, such as Kuwait, Doha and Dubai engaged in trade and were mostly traditional seaport economies. The discovery of oil in the 1950's dramatically altered the economy and initiated intense urbanisation and tumultuous growth especially in the 1970's (Fuccaro 2001; Malecki & Ewers 2007). For instance, urbanisation in Kuwait is 99% (Al-Nakib 2014a), in Qatar 98% and in the United Arab Emirates (UAE) 85% (The World Bank 2015). Since the 70's, the oil based economy dominates the national GDP. The increasing demand for energy worldwide has been and remains the back-bone of the economy and drives urban development.

Another notable difference to the West lies in the timing and pace for urbanisation. While in Western countries this occurred over long periods of time in the 18th and early 19th centuries, in Arabian Gulf countries it occurred over a few decades in the late 20th century. This rapid urbanisation was of course facilitated by the discovery of oil, which generated massive wealth and gave rise to new opportunities for employment (El-Arifi 1986). Most Arabian Gulf countries lacked the technology, knowledge and necessary manpower to expand their oil-driven development and hence relied on mass immigration of skilled and unskilled workers (Malecki & Ewers 2007).

These foreign workers occupied positions across all levels and sectors, including professionals in the fields of built environment and urban and policy planning (Stanek 2015). The comparatively higher salaries, better healthcare and improved living standards in Arabian Gulf countries have led to high international migration rates, mainly from other countries in the Middle East and South Asia (Malecki & Ewers 2007). Hence, the demographic composition of Arabian Gulf countries is characterised by a high ratio of foreign labourers, more than 70% in many cases. For example, in Dubai over 80% of the population consists of foreign workers, and similar patterns exist in Doha and Kuwait (85% and 70% respectively) (Dubai Statistics Center 2014; Snoj, 2014; Snoj, 2015). The gender and age ratios are also unbalanced, as the majority of the immigrants are young adults or middle aged males. This imbalance has been further aggravated by national policies that limit the options to obtain citizenship, which is only possible under extremely stringent criteria and selection processes (Nagy 2006; Sater 2014).

Malecki and Ewers (2007) argued that a new form of segmentation and polarisation had originated in the Arab Gulf countries caused by the unique demographic composition of citizens and expatriates. Typically, there are three demographic groups with largely different lifestyles and needs:

a. the local citizens and Arabs,
b. skilled westerners with shortterm contracts (working in IT, engineering and science-based oil service operations), and
c. low-skilled - overseas (mostly south Asian) workers- with shortterm contracts (working in construction workers and domestic servants).

The coexistence of these groups resulst in a “kaleidoscopic society” or in other words a ‘three tiered society’, which is often more complicated than other types of social segregation, such as between blacks/whites or rich/poor (Malecki & Ewers 2007). The reason for the additional complexity is that there is little cohesion between these groups – for example the overseas workers form many sub-groups of different nationalities, genders or occupations with similar cultures and needs that often are different or even at conflict with other sub-groups.

The division of residents based on citizenship or nationality is also the most notable reason for differences in residential distribution in the built environment, as landownership is limited to citizens only in most Arabian Gulf countries (Nagy 2006). Citizens typically reside in their own houses, while most non-citizen residents reside in employer-provided housing, rented homes, work camps located in the industrial areas or in separate migrant housing (Malecki & Ewers 2007). Additionally, the implementation of the land grant policy offered by many Arabian Gulf governments supports this spatial segregation between citizens and non-citizens and exacerbates differences in the dwelling type preferred by each group. As only few of the foreign migrants speak and understand Arabic, their social circle mostly consists of peers from their home countries. As a result, they prefer to maintain close national or ethnic groups and look for housing at the same suburbs. These urban systems are notably different from the Western cities, where social segergation is mostly based on income and ethnic (Massey 2001; Gardner et al., 2014).

The governance system in Arabian Gulf countries is hereditary monarchy with limited democratic elements in parliaments and municipalities (Madbouly 2009). This method of governance excludes active citizen participation the planning and development of urban systems (Al-Nakib 2014b, BinTouq 2015). This also translates into very limited involvement of the private sector, as the most of the capital used for development is allocated directly by the government from the oil export revenue (Al-Shamiry 2011). Public driven investments naturally limit the free market competition and the necessity for Arabian Gulf countries to adhere and implement the principles of good governance that were discussed in the previous section 2.3.1. The Crown Prince of Dubai, Prime Minister and the Vice President of the UAE, Sheik Mohammed bin Rashid Al Maktoum defended this approach and indicated that top-down centralised management allows for the provision of the highest quality services, facilities and welfare for all citizens at present and in the future (Kroft 2007). Indeed, the citizens in Arabian Gulf countries, while exempt from any form of personal income taxation (Uddin & Raj 2012) enjoy high levels of welfare, such as free education at all levels, free healthcare, government employment and free housing (Nagy 2006; Al-Obid 2009; Alshalfan 2013). On the other hand, environmental and social sustainability has been traditionally a low priority in the development of urban systems (Kroft 2007; Rizzo 2014).

This centralised urban development process faced many challenges in the early years while the state was trying to modernise urban systems and manage the integration of large number of foreign immigrants. Partly this was due to projections for total population being inaccurate and did not accounting for growing reliance on cars, growing demands for public housing and drops in affordability and environmental sustainability (Abu-Ayyash 1980; Abu-Ayyash 1981; Madbouly 2009). Furthermore, the master plans and the major projects linked to them depended substantially on foreign consultants, who were not aware of the specific regional characteristics and dynamics of local systems (Rizzo 2014).

In conclusion, urban growth drivers in Arabian Gulf countries are different than in Western countries. The main difference is that the economy and most socio-political aspects of Arabian Gulf countries are related to oil exports. Combined with a traditionally strong monarchic regime, this enables a centralised master plan approach in urban development and planning of urban systems. Typically, planning in Arabian Gulf countries is implemented through this top-down strategy with the exclusion of public participation (Al-Nakib 2014b). While many social welfare advantages are present as a result of this strategy, there are notable shortcomings too: lack of public participation in planning, limited private sector involvement, lack of sustainable development and risk of major downturns during oil price collapses. Arabian Gulf are more reactive to responding to problems and place emphasis on improving welfare systems (healthcare, housing, education, income and social-welfare) compared to the proactive approaches in most Western cities (Kroft 2007).

Additionally, urban systems function in an environment that the majority of the population is considered non-citizen. In the literature, there is a clear lack of studies on modelling these systems and any urban growth impacts in the Arabian Gulf region under these conditions. Finally, the research case study in this project is carried out in an area with the distinct characteristic of social segregation according to nationality.

2.4 Urban modelling

The previous section highlighted shortcomings in the urban development process in Arabian Gulf countries due to its unique history and growth. To address these shortcomings, this research thesis proposes a novel framework of urban modelling. Models of urban systems have been used before, however not in the unique niche context of Gulf countries; hence newly developed and tailored models are proposed to analyse the urban systems in the regions. In this final section of the literature review, urban modelling studies and principles are reviewed to justify the current research's methodology and contextualise the research questions related to automata modelling applicability.

Modelling is an important component of urban planning as it helps represent and understand how cities develop and change (Epstein 2008). According to Batty (2013), cities contain complex systems with spatiotemporal dynamics. Obviously testing new measures for research purposes in a real city is both costly time-consuming and impractical. For instance, constructing an actual new train system in hope that congestion is reduced, only to find that the population does not use it is extremely wasteful. Naturally, urban simulations are needed to model these system changes both in space and time and extract useful outcomes to be used in planning and policy making. Crooks and Heppenstall (2012) confirm this and state that simulations are required to make experimental observations on urban systems, as cities develop over decades and it is not possible to generate new ones or modify them easily as part of an experiment. Hence, these simulations are invaluable in decision making processes.

An urban model is a mathematical representation of the state and processes occurring in a set of urban systems at any point of time (Liu 2009). In a model, predictions of future system states are forecasted from previous states according to trends and rules based on urban growth theories. Urban modelling may deal with data related to the spatial distribution of population, land use, transportation and the environment. Both historical and present data are typically necessary to generate predictions for the future (Bhatta 2010).

Throughout the last 50 years, the technological advancements in computing facilitated the evolution of urban models from static macroscopic models to dynamic micro-scale models; which better represent the processes of development and population group behaviours at the individual or the household level (Liu 2009; Crooks & Heppenstall 2012). This transition coincided with the transformation of urban planning from top-down and centralized approaches towards bottom-up data driven approaches in many Western cities. In many ways, it can be claimed that urban modelling and planning started focusing on individuals' behaviours, attributes and interactions (Brunsdon & Singleton 2015).

Urban models can be categorised in two groups: top-down models and bottom-up models. The following sections will outline the advantages and disadvantages, as well as the applications of both groups, with emphasis on automata models, which will be used for the simulations proposed in this research thesis.

2.4.1 Top-down modelling

Top-down urban models are aimed at explaining aspects of urban systems by purely theoretical equations. They can predict the state of these systems based on a set of global rules and coefficients for each set of equations. As the control of most variables are predefined globally, these models are better suited to explaining general – as opposed to locally specific - patterns and trends. Furthermore, these top-down models increase the role and power of technical expertise over practical explanation (Pissourios 2014).

Early top-down models were developed from classical spatial theories explaining land use interactions. Some classical theory examples are Von Thunen's agricultural land use model in 1826 (Verburg et al. 2006), Weber's (1909) Industrial Location model (Liu 2009), urban- social ecology (Burgess 2008), central place theory model by Christaller in 1933 and refined by Losch in 1945

(Smith & Floyd 2013), radial sector model by Hoyt in 1939 (Clarke 2014) and multiple nuclei model by Harris and Ullman in 1945 (Lichtenberger 1997). The main advantage of these models is that they can be applied in a large number of situations and are well-founded on tested theories.

These models however, have certain shortcomings, which may make them inappropriate for some modern practical applications. Researchers have pointed out that these models are based on assumptions that do not account for the dynamic dimensions of urban growth variables and system interactions. They assume urban growth is mostly linear and attains a state of equilibrium. Thus, they were proven to be unrealistic in terms of their operational feasibility (Cheng & Masser 2003; Batty 2007; Liu 2009). For instance, most such models focus on the central district areas of urban zones, as these are the nuclei of economic activities. Zones away from the centre are considered to be of secondary importance to urban growth and development. However, this is an oversimplified assumption of real cities, as most modern urban systems are heterogeneous and extend to the fringes of the urban form. The most prominent reason for this shortcoming was the unexpected rise in car ownership in the middle of the 20th century, which in turn produced new trends of dynamic urban systems and polycentric urban forms. This type of expansion based on motorised personal mobility was not accounted for by classical urban theories in the first half of the 20th century (Batty 1998). Later, in the second half of the 20th century, advancements in information technology enabled the implementation of complex mathematical models that allowed to partially overcome this limitation and improve the modelling of transportation patterns with top-down models (Liu 2009).

Dynamics systems in modern cities are sensitive to time-dependent changes in their components, which may be within larger or smaller scales. For example, changes in population and demographic composition may change over the course of decades (large scale change), and suburban transportation infrastructure may change over the course of a few years (small scale change). These dynamics were considered first in Land Use Transport (LUT) Modelling. In the 1950's and 1960's LUT models were used to predict transportation patterns and land use changes as a response to changing demographic and economic drivers. According to Batty (2009), LUT models emulate the dynamic interactions of state variables in urban systems representing population growth and movements. Common platforms using this type of LUT top-down modelling are LILT, DRAM/EMPAL, IMREL, MUSSA (Sivakumar 2007) and more recently UrbanSim (Waddell 2002).

LUT models have been criticised for not encompassing all aspects of urban spatial processes. As with the earlier theoretical top-down models, LUT models often fail in validating the outcomes, observing the underlying processes and more importantly capturing the underlying complexity of urban systems (Bhatta 2010). This means that specific local interactions between actors involved in transportation and development, such as changes in car ownership ratios or decisions of households to move in different suburbs cannot be easily modelled. While individually these interactions may not appear impactful, collectively they may significantly alter the state of many urban systems and impact future development. Nevertheless, many of these models are still used in transportation modelling and integrated in modern day planning approaches (Sivakumar 2007).

Despite the broad use of LUT models in the past and present, the inability to represent and analyse urban dynamics systems encouraged model builders and researchers to work on developing new bottom up platforms (Batty 2007; Crooks & Castle 2012; Crooks & Heppenstall 2012). The main motivation for that was that despite the general applicability of theoretical models in explaining urban development problems, they are not able to provide answers within the context of the specific local factors of particular case studies especially when applying micro-scale interactions and emergent behaviours of individuals or groups.

2.4.2 Bottom-up modelling

Cities contain complex systems involving multiple socio-economic activities and stakeholder interactions at various levels, which occur within the physical urban form. As discussed in 2.2.2, urban planning must deal with this complexity in an effective manner. Batty (2007) puts forward the notion that urban planning is now transitioning from top-down approaches into bottom-up and decentralized ones, as cities are constantly evolving systems and urban dynamics are better modelled from the bottom-up perspective. Bottom-up dynamic or Automata models, such as Cellular Automata (CA), and Agent Based Models (ABM) have assisted in comprehensively decoding and analysing the complexity of interactions between agents in urban systems (Batty 2012).

Bottom up models are primarily controlled by local rules of the interactions of individual agents that affect urban systems directly or indirectly. Individual agents have behaviours and constraints according to their goals, expectations and current status. These local interactions depending on the issue that the model is trying to address and the time frame, may be dynamic or static– for instance intra-city migration patterns may be considered static in short horizons, or dynamic in longer horizons.

CA is characterised as a ‘discrete spatiotemporal dynamic system based on local rules’ by (Miller 2009), and has the capacity to simulate complex urban and social frameworks with relative simplicity compared to other models. It has five main elements: grid cells that represent a phenomenon, neighbourhood cells, initial cell conditions (states), transition rules and time (Liu 2009). CA modelling has been used in many applications to generate a better understanding of spatial diffusion, such as the patterns of migrant settlements, pedestrian behaviours and the spread of epidemics over time (White et al. 2007).

Although CA modelling has overcome some shortcomings of the previous models, it has its own limitations. Cell geometry is often based on a uniform fixed grid where interactions across many cells are difficult to model and they do not readily handle multiple attributes per cell. Moreover, a common issue with CA models is their ‘physical approach’ to urban dynamics. In CA models, other processes that are not associated with land development are not considered in the designs (Batty 2012).

These limitations can be overcome in ABM as state spatial objects are not limited to a uniform fixed grid do not assume a specific spatial data distribution (Crooks & Heppenstall 2012).In addition, ABM can use more complicated rules for each agent (Batty 2012). This advantage of ABM is contextualised in specific problem-solving situation in the field of urban modelling in later sections.

ABMs have been considered as a powerful tool in urban modelling research for over two decades (Ligmann-Zielinska & Jankowski 2007). Research using ABMs as an automata modelling are based on simulating interactions between agents in order to understand issues such as traffic congestion and resident segregation from a bottom-up perspective (Crooks & Heppenstall 2012). ABMs have the capacity to simulate individual actions and measure the macroscopic outcomes over time. It is sometimes considered as an extension of the Cellular Automata (CA) framework, as ABM overcomes CA’s limitations in terms of capturing the interactions of urban dynamics and including several socioeconomic factors, such as human decisions and social behaviours. An example would be modelling decision making processes for purchasing property or relocating to a suburb that better matches the constraints and goals of a household. The most important difference between CA and ABM is that in ABM, each individual object in the model may have its own behaviour and rules, as opposed to CA, where the object behaviour is part of an aggregate set of shared rules. In addition, ABM have the capacity to carry out simulations between the domains of space, time and objects (Batty 2012).

The main element of ABM as automata models is the presence of agents. Agents represent groups that are parts of the system and are autonomous units that can take decisions independently after interacting with one another, as well as their environment (Aliaga 2012; Crooks & Heppenstall 2012). The agents could be individuals or groups such as land parcels, residents, developers and government officers or urban planners (Brunsdon & Singleton 2015). In each ABM, there are certain conditions that determine agent behaviour and their interactions with other agents and/or their environment. These conditions or rules are typically based on ‘if-else’ statements for agents’ actions once a specified condition has been met. The actions can be standardised and “learned” by the simulation framework, and eventually make the agents autonomous. Agent relationships may be modelled in multiple ways, from reactive to seeking a particular goal (Crooks & Heppenstall 2012).

Small scale interactions of agents collectively result in macroscopic outcomes within the context of urban systems. For instance, the choices made by commuters for different types of trips according to their individual condition, contribute towards traffic congestion. Scheduling agent behaviours can take place synchronously or asynchronously over a period of time that could be from seconds to decades (Brunsdon & Singleton 2015). The environment is another element of ABM, it can be analysed at various scales as well as over different time frames. Several types of data can be used to develop the rules and behaviours of agents, such as demographic, spatial and land use data.

The key benefits of ABM as automata model over traditional models are its ability to capture local interactions within dynamic urban systems from a bottom-up perspective and its flexibility, particularly in terms of geospatial model development (Crooks & Heppenstall 2012). Furthermore, interactions between autonomous units in ABM are examined at a disaggregate level, which evolves in the simulations to reveal emergent macroscopic land use patterns. Another notable advantage is the capacity to model relations between agent decisions and actions, effects of heterogeneous values, and to downscale feedback from macro to micro-scale levels with the ability of adaptation in decision making (Verburg et al. 2006).

Because of the aforementioned advantages, ABM has been widely advocated in research for urban modelling, and other spatial applications such as simulating cancer cell growth (Wang et al. 2015), archaeology (Rubio Campillo et al. 2012), environmental studies (Brown et al. 2004), Engineering Team Work (Crowder et al. 2012), evacuation plans (Zhang et al. 2014), spatial firm relocations (Tsekeris & Vogiatzoglou 2011) and others. In urban geography and urban planning, many applications using ABM has been developed for modelling land use dynamics (Murray-Rust et al. 2013), urban residential dynamics and mobility (Benenson 2004, Jordan et al. 2014), the impact of planning policies of residents choices (Gaube & Remesch 2013) and modelling traffic movement (Beuck et al. 2007).

The use of ABMs in cities and urban systems research can be beneficial as it both enhances our understanding of urban dynamics and helps predict future system (Bonabeau 2002). Gupta (2005) confirmed that ABM's ability to simulate agent behaviours at the micro level makes it a powerful tool for analysis and prediction studies. Furthermore and unlike top-down models, ABM can easily incorporate local interactions and rules for the agents involved in issues of urban development. This is significant, as often goals of a certain group are constraints of another. However, Batty (2005) argued that ABM is mostly an analytic rather than a predictive tool. In any case, ABM's ability to generate future predictions and analyse trends with a bottom up approach can help in analysing the complexity of city systems and the dynamics therein.

Urban modelling has evolved from earlier theoretical models and land-use transport models (LUT). They employed a top-down system approach, which later gave way to bottom-up system approach to better capture the urban system dynamics that are inherent local interactions between model components. Hence, they can be used to solve problems that involve interactions of heterogeneous groups. In addition, automata or bottom-up modelling approaches, such as CA and ABM have overcome these limitations. ABM in particular excels in its abilities as both an analytic and predictive tool for urban development. In this thesis, and in order to address the objectives, ABM is selected as the base automaton model for simulations due to the advantages described in this section. Automata models are often combined with GIS layers, an approach that is adopted in the present study as well. The following section will review the relevant literature for GIS applications in urban modelling and the benefits of combining it with automata modelling.

2.4.3 GIS in urban modelling

Geographical Information System (GIS) is an invaluable platform for transportation and land use modelling in urban simulations (Tao 2013). Revolutionary changes in the last 50 years allowed GIS to become a major tool for studying urban issues and solving related problems. It is a more powerful tool compared to static maps, as it may segregate geospatial data from graphic representations, integrate with the navigational needs of residents, visualise any type of spatial data and assist with the in-depth application of spatial analytics.

In the 1990s, the development of GIS and its integration in urban modelling revolutionised the field by providing a large amount of new data sources and techniques (Sui 1998). These developments pushed urban modelling into a new era (Liu 2009) as GIS helped in representing and visualising the real world in new ways. GIS has been integrated with many types of urban models, including automata to prepare, manage, store and transform data, as well as to analyse changes in datasets over space and time (Goodchild 2005). This integration aims to offer a platform for potential modelling and visualising urban phenomena and agent interactions within time and space (Brunsdon & Singleton 2015) and the simulation outputs of such hybrid models can be easily compared and evaluated.

Automata have been combined with GIS in a variety of applications but is not generally available in commercial GIS (Brown et al. 2005; Heppenstall et al. 2012). One exception is Agent Analyst, which is available as a free open source software extension to ArcGIS (Johnston 2012). This tool is well integrated within an ArcGIS environment by functions that access and operate on GIS data sources. This extension has been used and recommended by various studies (Robinson et al. 2013; Dahal & Chow 2014; Haslauer et al. 2015). This extension tool will be used in this research thesis for modelling the future of urban system and urban development in Kuwait.

To illustrate the advantages of combining automata and GIS for urban modelling, the following sections will outline recent studies that are relevant to this research and concluded in findings that can help in answering the research questions and objectives.

2.4.3.1 Urban modelling applications

When combined with automata models of urban systems, GIS makes it easier to simulate different hypotheses and theories with even higher accuracy. A common trait of such studies is the existence of dynamic interactions. One such study has been carried out in Mid-Atlantic, United States. ABM was used to simulate property markets and investigate dispersed development patterns (Magliocca et al. 2015). This simulation focused on the temporal scales and characteristics of land conversion from agricultural to residential as a dynamic process in order to investigate and solve urban sprawl impacts. Another example was an environmental impact assessment in Tehran, Iran (Jokar Arsanjani et al. 2013), where it was concluded that GIS/ABM as a technique can be applied to regions that have similar characteristics, and government constraints about land use exist. GIS with ABM models were also used to model spatiotemporal dynamics of urban development (Zhang et al. 2015). It was found that by combining the macroscopic and microscopic decision making behaviours of agents to simulate dynamic urban systems produced better results in understanding development compared to a traditional simulation approach. The main aspect of macroscopic and microscopic modelling in the studies above was land use – different agent groups have different preferences for distribution of land use according to their goals (for example households would prefer their workplace to be as close as possible to their residence).

Simulations in GIS urban models can be modified in terms of the spatial variables to represent different policies for urban development. These policies may be either speculative (under consideration) or in effect already. In the former case, the outputs enable the authorities to adjust the proposed policies for optimal results and in the latter case; changes may be made to alleviate certain issues once understood. Either way, comparisons of policies may assist with planning processes. Such an example model in Overijssel, Netherlands simulated and compared two land use policies in terms of sustainability impacts (Koomen et al. 2011). The findings suggested that the proposed strategy outperformed the business as usual approach for planning. Similarly, in Hervey Bay, Australia, urban growth scenarios have been designed to evaluate the different land use planning from 2003 to 2021 and used in the decision making process (Pettit & Pullar 2004). Another interesting study using demographic and spatial land use data designed four urban planning policy alternatives of land change from 2010 to 2030 for Dublin, Ireland (Voorde et al. 2016). After comparison of the simulated policy effects, the authors suggested a calibration step to produce realistic outputs, which was taken in consideration from the planning authorities.

Such GIS/automata models have been also developed to explore residential market dynamics and address two important issues of Australian urban systems, namely population growth and interest rates (Heckbert and Smajgl 2005). The inclusion of automata was found to be beneficial in representing the outcomes of policy impacts, as the impacts could be distributed within the society, addressing the issue of ‘social gap’. Another similar study in Sydney, Australia (Huynh et al. 2015) simulated urban system dynamics and associated the demographics, transportation and housing market efficiency to the average satisfaction of the local residents.

On the topic of enhancing realism, a GIS study used automata models for comparing urban growth scenarios with interesting results (Barreira-González et al. 2015), One of the most interesting findings was that using vectors (points, lines, and polygons) data rather than raster (pixels or grid) data resulted into a more realistic representation of the urban area. Another study in Shanghai, China, simulated urban growth in different scenarios (Zhang et al. 2011). The authors emphasised the importance of a validation stage after running the models as a way to augment realism. Traditional land use models were not applicable in modelling interactions throughout the landscape of Shanghai and hence local rules were used in the ABM context for groups residing in different areas (industrialised, rural, high/low density).

Finally, GIS and automata can also be used for comparing the impacts of different urban forms. A study by Katoshevski-Cavari et al. (2014) compared different city forms and plans. The plans were based on three city forms (basic city, corridor city and connected city) and used mainly data related to land use and development status. According to Katoshevski-Cavari et al. (2014), a compact city form with mixed land-use districts scored the highest in terms of environmental-sustainability indicators.

In light of the findings above, it can be concluded that a scenario approach in urban modelling has many advantages. This is a notable trait of GIS as models with different data inputs are easy to design as scenarios. Most often, use of demographic, transport and land use spatial data is necessary to design and compare different scenarios. The comparison of outputs provides valuable information in decision making for urban planners and policy decision makers. The inclusion of automata is beneficial, as dynamic interactions of systems may be simulated. To differentiate from the existing approaches and to add novelty value to the field of urban modelling, this research thesis emphasises on evaluation of the scenario performance based on transportation quality, housing availability and nationality segregation level.

2.4.3.2 Transportation quality modelling

Transportation is considered as a critical system in urban development as it allows mobility of population and goods, it influences the urban form and the economic activity through land accessibility (Aljoufie et al. 2012). Transportation is regarded as one of the main forces driving urban growth (Yang & Lo 2003; Bhatta 2010; Kim et al. 2014). Transportation, both personal and mass, within a city is inherently dynamic. Hence any patterns can be modelled with an agent based approach in the spatiotemporal domain laid out by GIS. According to Manley et al. (2014) the majority of transportation simulation tools –microscopic, macroscopic or agent-based– replicate the principle of equilibrium in traffic distribution. Urban traffic dynamics are a result of individual drivers' behaviours and interactions, and hence an agent approach is appropriate. In such automata models can for example predict short term congestion through data related to real-time traffic flow, road occupancy, and average speed (Stathopoulos & Karlaftis 2002). Data from transport registries are often used to model transportation patterns (Potoglou & Kanaroglou 2008). The data are related to transportation itself (for example average commute time, vehicle kilometres travelled) and land use (for example distribution of commercial zones) in the areas under investigation.

The effects of diversifying land use and mixing zones on transportation systems is an idea that has not been investigated or modelled in the context of Kuwait or any Arabian Gulf city so far. Interestingly, due to cheap oil prices, a very large part of the population owns and depends on cars – hence we believe, research in this subject will be valuable for policy makers. Interactions of agents involved in transportation systems in different time-scales are governed by different kinds of rules.

In the present research thesis, a global set of rules as dictated by the master plan will be used for the first scenario, while local parameterisation with direct inputs from the residents will be mainly utilised in the second and third scenarios. Further details about the history and development of past and the present master plan can be found in section 3.2.

2.4.3.3 Housing availability modelling

Unlike transportation, which is inherently dynamic even in timeframes of a few minutes, housing availability can be considered as a more static aspect of urban systems, especially in short time frames. However, as this section will discuss, there are several interactions between the decision makers in urban development that affect and change housing availability.

Movement of population within a city is influenced by housing availability and property prices in different urban areas. Households consider moving for various reasons, such as proximity to their workplace, changes in family status and size, affordability and cultural background of a neighbourhood among others. Automata models are able to model movement and household choice behaviours for different groups of agents (citizens with different needs) (Jordan et al. 2014).

Besides urban movement, agent behaviours regarding housing availability may depend on various other factors. A project using automata models in Leipzig, Germany (Haase et al. 2010) used population growth and household size data for the agent design in a housing availability modelling problem. The model used agents to replicate the patterns of intra-city household movements and assist in developing appropriate policies, such as demolitions in low demand suburbs. Another study simulated housing prices in Lyon, France using spatial data, such as the distribution of households, jobs and real estate prices (Kryvobokov et al. 2012). All these cases include static changes in short term horizons of less than a few years but nevertheless represent interactions of household agents with their environment and other agent groups. Housing shortage, which is among the main research objectives of this research thesis, is linked to housing availability. This linkage can be expressed as an equation, the coefficients of which can be globally or locally controlled in long horizon timeframes (years-decades) in terms of agent interactions.

In addition to the studies described above that examined availability, research has been done on the property market pricing and the factors that affect it. While the links of affordability with availability are not always straightforward, in most cases the laws of supply and demand apply low availability of housing will generally increase prices (Din and Moise, 2012). Furthermore, the type of housing development may affect prices (Voyer 2004). Many other factors are related to pricing of undeveloped districts, such as distance from the CBD and the coast, access to sub-centres, house and lot size, distance to railway stations and population density (Abelson et al. 2013).

The data used by most studies reviewed in this section, whether related to housing availability or affordability are related to internal factors, such as household size and composition or external factors, such as the type of urban form and construction. Housing availability (and shortage) is a multidimensional issue, with a variety of underlying factors. In this research thesis, in addition to demographic and household data, information about future housing and migration plans and future settlement location preferences of residents are obtained and used to design the agent group behaviours in the context of Arabian Gulf countries.

2.4.3.4 Residential segregation modelling

As discussed earlier, residential segregation may be the result of deliberate planning policies or the result of residents' own choices (Schelling 1971). According to Charles (2003), residential segregation causes a variety of social and economic issues to particular residents groups, such as poverty, unemployment, poor public services, low school achievement, low healthcare, and isolation.

One of the earliest urban models for segregation was proposed by Schelling (1971). Although it was not based on computer modelling, it includes concepts familiar to automata, such as autonomous agents, environment, interactions and outcomes. The model operation was based on the movement and settlement choices of residents and calculated their impacts on future racial segregation (between white and black residents). Schelling's model was further developed in following studies and implemented in many different segregation models in automata simulations. Each of these simulations investigated segregation based on different criteria.

Racial segregation patterns between white and black residents in the United States have been attributed to resident choices. Specifically, a strong correlation of neighbourhood racial composition and resident opinions was observed using survey data (Bruch 2006) Segregation can also be studied based on ethnic and religious groups (Jews, Muslims and Christians) (Hatna & Benenson 2012) or financial criteria via Multi-agent simulator for urban segregation (MASUS) (Feitosa et al. 2010). Typically, such simulations about residential segregation rely on resident survey data for drawing conclusions.

According to the best knowledge of the researcher, there is no similar research done on the nationality segregation in the Arabian Gulf cities and using primary response data from surveys.

The next and final section of this chapter will discuss the ways that different types of surveys may be used in modelling as tools for data collection.

2.4.3.5 Surveys for data collection

Surveys and questionnaires may be used for data collection in this project. This section will outline the usefulness of surveys in modelling and certain considerations pertaining to the survey design.

Firstly, surveys may be used to identify resident groups and understand their preferences and behaviours in relation to specific urban systems. An example of this practice is described in the work of Brown and Robinson (2006). In this article, surveys were targeted to residents to identify their preferred dwelling locations based on a number of factors: landscape aesthetics, proximity to infrastructure, availability of services and job closeness. Another similar survey has formed the basis of modelling of residents commuting behaviour (Buchmann et al. 2016).

To avoid statistical bias from these resident surveys, appropriate post-processing is required (Brown & Robinson 2006). The need to carefully select the participant sample is also stressed by Buchmann et al. (2016). A broad and stratified sample of participants in surveys must be taken to capture the heterogeneity of preferences and behaviours of agents. In addition to resident groups, surveys may be used to obtain modelling data from urban planning stakeholders, such as government agencies and developers. Like with residents, post-processed data from authority surveys can reveal the groups' behaviours and preferences in interactions with other groups in the context of urban system planning (Jokar Arsanjani et al. 2013).

While such surveying is not uncommon in communities in the US or other European countries, it is a rather new concept for residents of an Arabian Gulf city. As this research thesis extensively models the urban systems in the case study city of Kuwait, any surveys used in data collection were carefully designed in the context of the local cultural and social norms.

Urban system modelling and their relationships to urban growth have been reviewed in the previews sections in Chapter 2. It can be concluded that different urban growth patterns do affect the future state of systems and modelling can help with planning proper responses. While this partially answers the second and third research questions based on existing studies, first hand data from modelling is needed to generate robust conclusions for cities and systems in the unique context of the Arabian Gulf countries. Since Kuwait is used as the case study city, the following chapter will introduce the local urban development history and existing systems to the reader.

Chapter 3 : Kuwait case study

The simulations in this study were carried out in order to answer the research questions with the help of a case study, the state of Kuwait. To the author's best knowledge, there are no other studies modelling the urban development and its impacts in Kuwait. The latest relevant studies in Kuwait are out-dated as they were conducted in the 80s (Abu-Ayyash 1980; Abu-Ayyash 1981). Because of its small size and its single urban area, Kuwait is ideal for the easy collection and management of data by a single researcher in the context of a PhD project.

The aim of this chapter is to provide an outline of the case study area with its characteristics, history of urban development and growth impacts. Additionally, the required data for setting up and running the simulations are identified and the behaviours of stakeholder groups in Kuwait are analysed.

3.1 Study area characteristics

The State of Kuwait is a prime candidate for a case study in the Arabian Gulf region. It demonstrates all factors identified earlier that affect the urban development; specifically, it is a city-state that experienced rapid urban growth in relatively short time and transformed from a small town to a regional metropolis due to financial prosperity after the discovery of oil (El-Arifi 1986; Fuccaro 2001; Mahgoub 2004). This transformation was associated with a change in demographics, as non-citizens make up for 70% of the total population in Kuwait (PACI 2017). Furthermore, its location imposes political complexities, due to its importance to the global oil supply, as Kuwait is the world's sixth-largest exporter of oil (Al-Nakib 2013). These complexities are aggravated due to the country's proximity to regions of war or high war risk (Soliman 2012). Kuwait's oil exports account for around 95% of state revenue (Keay 2012).

Figure 3-1: Kuwait location map

As shown in Figure 3-1, Kuwait is a sovereign Arab emirate that borders Saudi Arabia in the south and Iraq in the north and west. Kuwait has a population of 4.1 million living in an area of 17,818 km^2 – hence the population density is roughly 230 people/km^2 (PACI 2017). According to Al-Nakib (2014a) 99% of the population lives in urban areas accounting for 7% of the total area of Kuwait and resulting in an urban density of 2800 people/km^2, which is considered high compared to other parts of the world (Al-Obid 2009; UNDP 2009). Most of the urban areas are located by the coastal regions in the eastern part of the country, as shown in Figure 3-2.

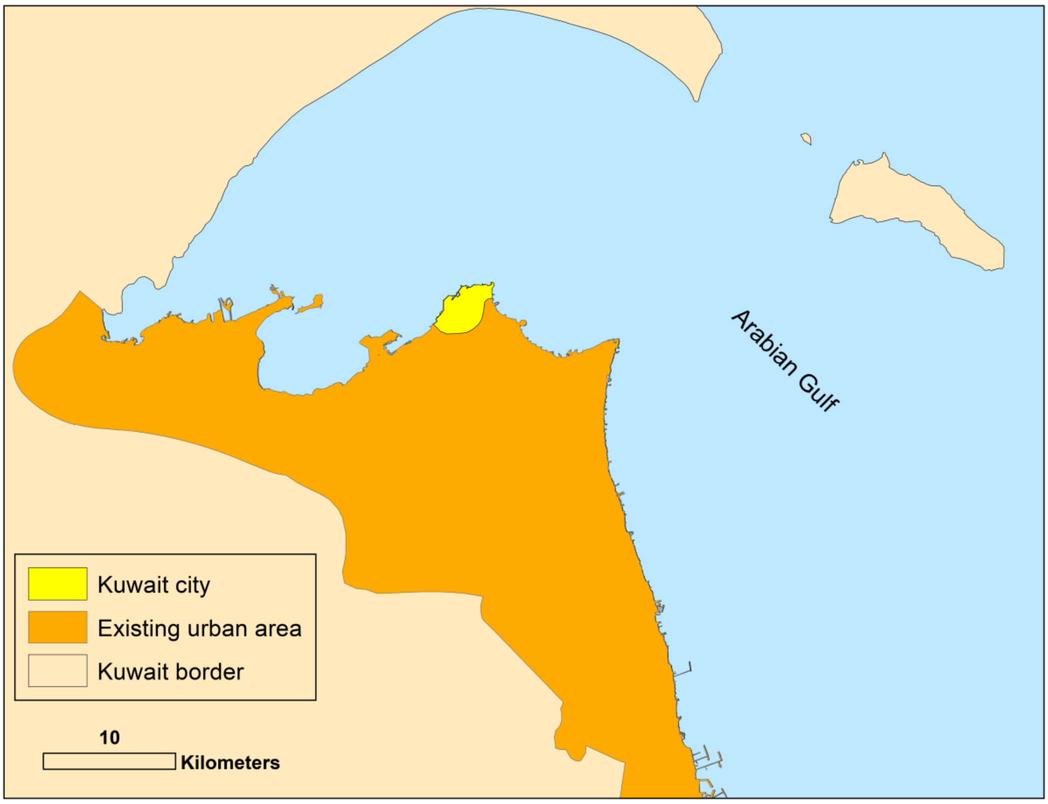


Figure 3-2: Land distribution in Kuwait

Prior to the discovery of oil in 1938, Kuwait was a small city with the characteristics of a seaport economy. Kuwaitis at that time were mostly relying on pearl diving, trading and grazing for income (Al-Nakib 2014a). After 1946, the financial growth from the blossoming oil industry was the primary reason for the rapid urbanisation (Stanek 2015), as well as the architectural and social changes, collectively known as the “Alnahda” Age in Kuwait (Al-Nakib 2013). During this period the quality of life improved dramatically and the country’s administration and society modernised in several aspects. This shift also changed the urban systems of Kuwait and resulted into unprecedented population growth. The rapid growth was attributed to the immigration of a large number of new workers seeking employment in new oil and infrastructure related jobs. The growth from migration was significantly higher than the natural birth rate of Kuwaiti nationals. The average annual population compounded growth between 1955 and 2015 was 7.2% as calculated from Figure 3-3.

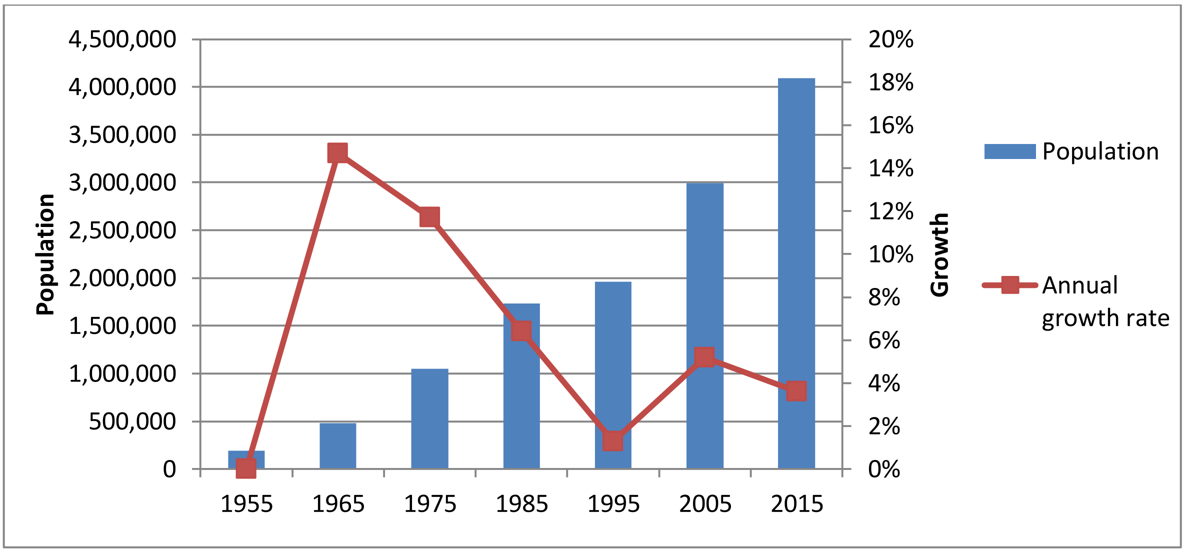


Figure 3-3: Kuwait population growth 1955-2015 (United Nations 2015)

3.2 Urban history of Kuwait

The first plan that shaped Kuwait dates back to 1760, when residents erected defensive walls against intruders from other tribes. That wall was expanded twice in 1811 and 1921, to protect additional areas as population grew (Al-Damkhi et al. 2008). Prior to the discovery of oil, the population was roughly 150,000, with the highest part of it residing in Kuwait Town, while the rest was living in the desert as nomads (Al-Nakib 2014a). At that time, the urban form was concentric.

After exporting the first oil shipment in 1946 (Abu-Ayyash 1980), Kuwait started implementing official urban development policies, known as the Master Plans. The company that was chosen to create the first master plan in 1952 was the British consulting company Minoporio, Spencely and Macfarlane. The first master plan is now considered as Kuwait's turning point in regards to urbanisation (Al-Damkhi et al. 2008). The main features of this plan were demolitions of older buildings and their replacement with new constructions. The goal was to change Kuwait from a port town to a modern city and redesign the architecture and infrastructure in the capital (Al-Nakib 2013). This was done via the construction of an efficient road network that linked the new city with the proposed suburbs, the centralised allocation of government buildings, and commercial centres in the new capital, the identification of new housing areas for the greenfield development process, as well as the redevelopment of the old city to a radial form as shown in Figure 3-4 (Al-Damkhi et al. 2008).

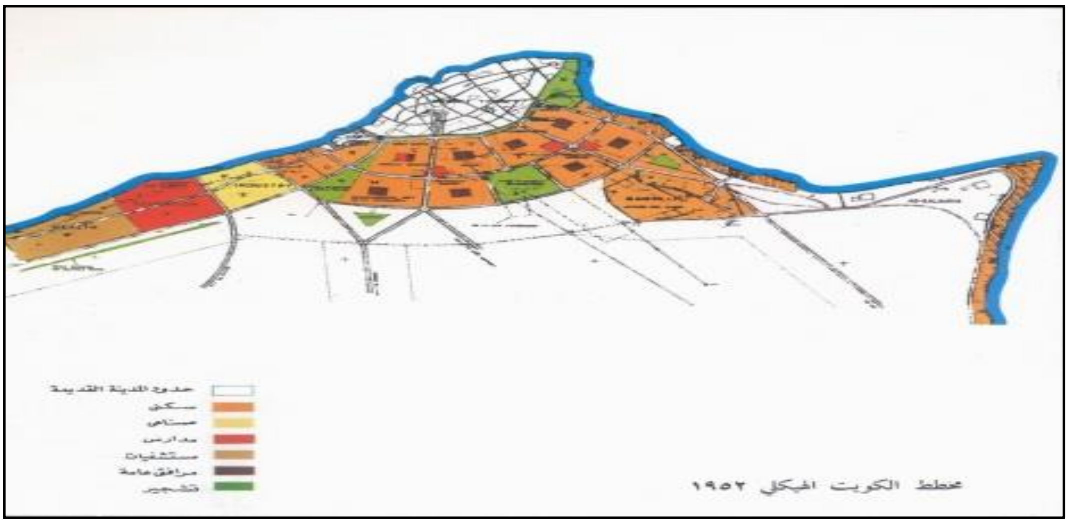


Figure 3-4: Kuwait first master plan 1952 (Kuwait Municipality 2009)

According to Al-Nakib (2013) this master plan was relatively successfully applied in the first ten years; however, it did not achieve its targets for several reasons. Firstly, the master plan was designed hastily and used wrong assumptions and expectations in terms of population growth. While it predicted that the population would be 250,000 in 1970, in reality the population at that time exceeded 700,000, which in turn led to a lot of intensification in the existing districts through an infilling development process. Secondly, the plan was restricted to a small area and excluded lots of new districts that developed independently. Finally, the lack of cooperation between government offices limited the success of the plan (Abu-Ayyash 1980).

According to Abu-Ayyash (1980), as a result of these shortcomings of the first plan and its failure to predict and control the urban growth, a modification was applied from 1960 to 1967. This modification designed by the Kuwait municipality had some strong points compared to the first master plan, as it changed the focus from local to regional development. However, even this could not solve the urban growth problems, leading to the need of another new master plan.

In 1967 the Kuwait municipality assigned the design of the second master plan to the British consulting company Colin Buchanan & Partners (CBP). A planning group included Kuwait municipality staff and a advisors from the United Nations was established. The primary aims of this group were to develop a long-term strategic plan for Kuwait and to generate a prestigious capital city in the CBD (Al-Damkhi et al. 2008). Certain constraints have been taken into account to limit potential uncontrolled urban growth, mainly related to the exclusion of various zones from development (oil fields, belts of agriculture, recreational areas, military sites, historical and touristic sites and potential industrial areas) (Abu-Ayyash 1980).

CBP suggested two urban growth strategies: a regional and a local strategy. Kuwait municipality selected the regional strategy that proposed the development of a conurbation that would span from Jahra – a historical town - in the west located at a distance of 20 km from the capital, to Shuaiba - an industrial district - in the south located at a distance of 20 km from the capital, as can be seen in Figure 3-5.

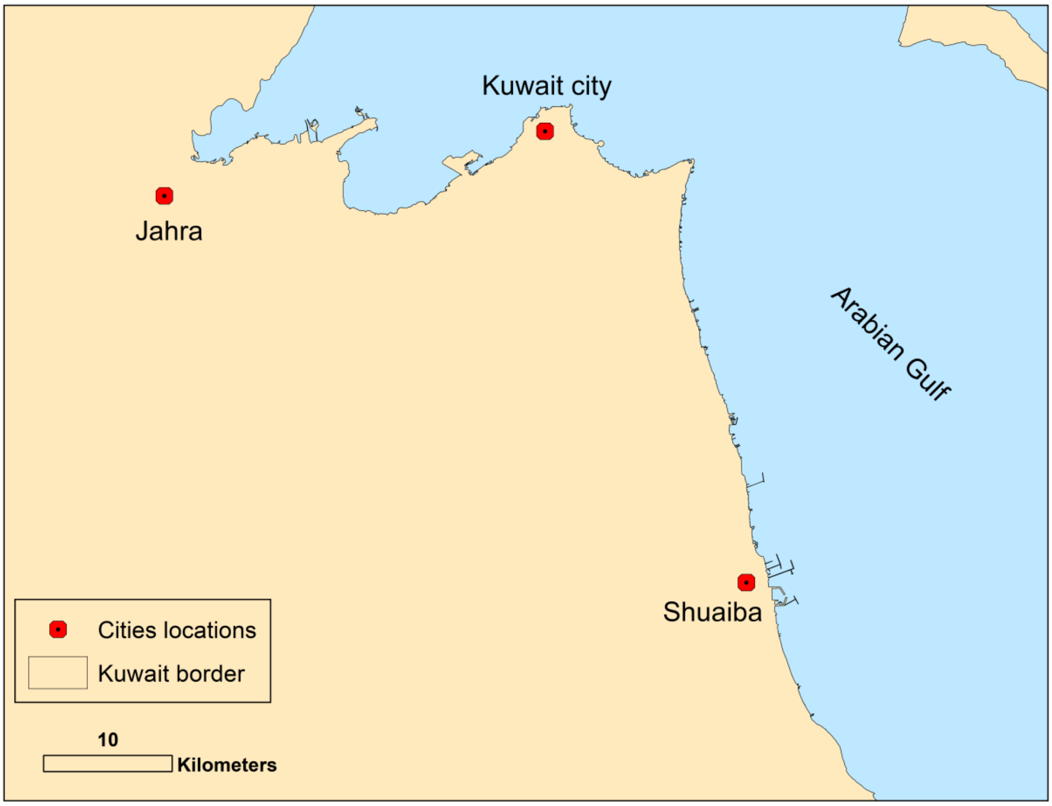


Figure 3-5: Kuwait city, Jahra and Shuaiba locations

This zone spanned over a distance of about 70 km and covered an area of about 850 km^2 (Abu-Ayyash 1980). This master plan was a continuation of the first master plan, and facilitated expansion in a radial urban form. Among the strategies that Kuwait municipality did not implement was the development of six major urban centres at equal distances from each other, which later on transformed the urban form to a multi-nucleated form; ironically this strategy was implemented in the latest master plan 2030.

The second master plan was applied in 1970 and had two revisions in 1977 and in 1983, which addressed the high immigration rate after the rise of oil revenues in the 70s. In 1975, Kuwait's population was 1 million and in 1980 the population was 1.3 million, which was higher than the original forecasts (Abu-Ayyash 1980). According to Al-Damkhi et al. (2008) in the first review of 1977, Kuwait municipality requested the assistance of the United Nations to revise several existing urban systems. These included the provision of more residential areas to accommodate the new residents, the redevelopment of the transportation system of ring and radial roads for higher traffic capacity, and improving the urban environment with the principles of conservation of natural resources, land integrity, oil wealth and natural vegetation.

After the invasion by Iraq and the first Gulf War or Operation Desert Storm in 1991 various problems appeared in Kuwait such as vandalism, destruction, and environmental degradation (Westing 2013). After the liberation of Kuwait, the government and society focus was on rebuilding and redeveloping the country. For the first time in over half a century, rapid urbanisation and population growth in Kuwait ceased and in fact the population started to decrease; in 1990 the total population was 2.1 million, while after the Gulf War in 1993 it became 1.6 million, as many non-citizens left Kuwait for safety reasons. However, this trend was reversed quickly and in 1998 the total population again exceeded 2.2 million due to the return of non-citizens after political stability and safety were reinstated (PACI 2017). This is a unique urban dynamic pattern to Kuwait, as no other major modern city in the world has experienced a large invasion and war damage.

In 1997, the third Master Plan was established and focused on accommodating the population that was projected to be 3.8 million by 2015. Its focus was on improving land use, generating land subdivisions, and strengthening legislation (Al-Damkhi et al. 2008). The trend of low density development by greenfield expansion process was promoted. This was achieved via establishing new residential districts in empty lands, and at the same time promoting the high concentration of commercial and state buildings in the capital. The intensification was dominant during that period as shown in Figure 3-6.

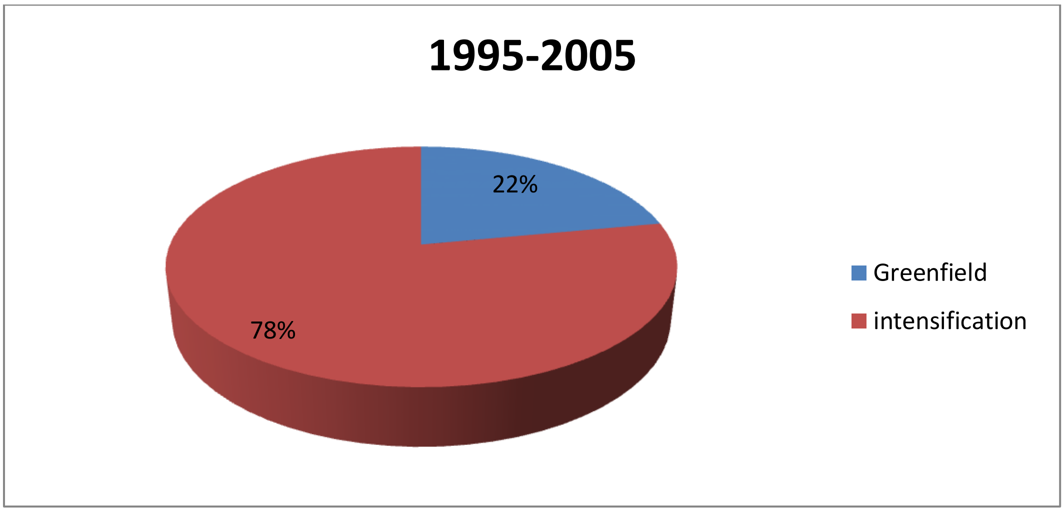


Figure 3-6: Ratio of greenfield and intensification development in Kuwait (1995-2005) [1]

In 2008, a new Master Plan was approved by the Prince of Kuwait as a revision of the third master plan with a development horizon spanning to 2045. The new master plan contains a range of projects to redefine the urban form of Kuwait, as a multi-nucleated form for the first time. However, not many construction projects have started as of 2015, except the new south -Sabah Al-Ahmed city, as the development costs are higher than initially projected (Stanek 2015). The new master plan assumes that the total population will reach 5.368 million by 2030 (MEED 2014). However, it is clear by extrapolating the current rate of growth that the population estimate will likely be exceeded several years earlier (United Nations 2015).

In all master plans, the resident (citizens and non-citizens) perspectives and opinions were not taken into consideration (Al-Nakib 2014b). The top-down nature of the master plans did not include any smart growth, sustainability concepts or modelling and simulation for future urban growth. Furthermore, no systematic study for transforming from a radial to a multi-nucleated urban form had been carried out (Kaganova et al. 2005; Al-Shamiry 2011). All these are significant issues that influence the local urban systems even today, and that the current research project attempts to address.

3.3 Urban growth impacts in Kuwait

The rapid urban growth in the 20th century in Kuwait resulted in several problems such as the creation of slum areas after the first master plan, the rise in traffic congestion and accidents,

[1] Source: Calculations based on statistics of population distribution on districts.
PACI 2017, *Population statistics*, The Public Authority For Civil Information, Kuwait, viewed 21 October 2017, <http://publicstat.paci.gov.kw/stat/en/.>

pressure on public services and high cost of infrastructure construction (Abu-Ayyash 1980; Abu-Ayyash 1981; Abu-Ayyash 1986). Another issue realised in the 80s was the land shortage, and costly housing government program (Al-Khaiat 1989). Additionally, increasing high nationality segregation between citizens and non-citizens occurred, due to the certain policies. This section analyses the causes and effects of urban growth in Kuwait, emphasising on traffic, housing shortage and nationality segregation.

3.3.1 Traffic congestion

An evident issue resulting from the radial urban form and urban growth as shaped by six decades of master plans is the high car dependency in Kuwait. Residential districts are separated by a radial ring motor network that extend beyond the capital as shown in Figure 3-7.

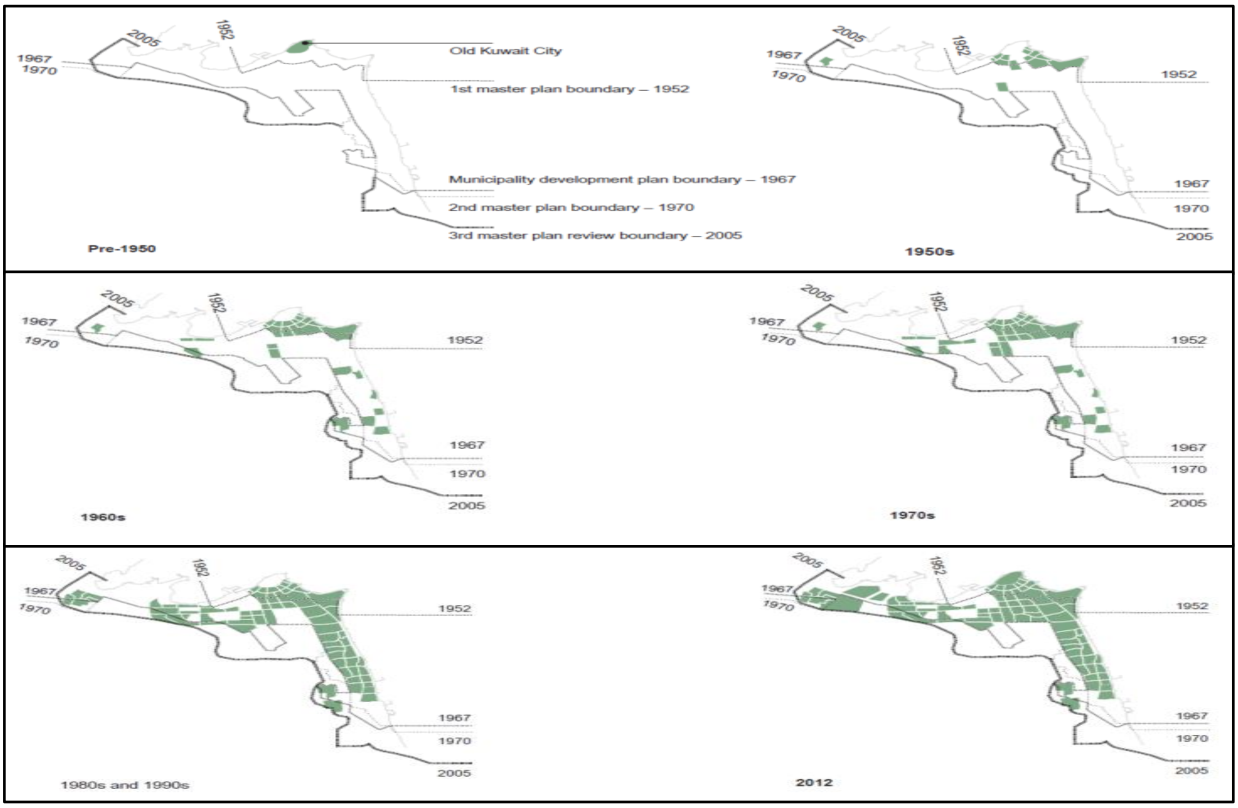


Figure 3-7: Distribution of residential areas in Kuwait 1950–2012 (Alshalfan 2013)

The total number of vehicles registered in Kuwait was 1.9 million registered vehicles in 2015 according to the KCSB (2015). Most commuters use private vehicles (around 85% of the total population). Bus is the only mode of public transportation available in Kuwait as of 2017, further aggravating the issue. The policy makers have the intention to construct around 700 km of new high standard motor network by 2020 and a new rail network that includes a city metro (UNDP 2009).

Kuwait is the 4th country with the highest number of registered vehicles per kilometre of motor network and congestion has been estimated to cost around 3% of the annual Kuwait GDP (UNDP 2009). Besides delays with severe economic impacts, traffic congestion in Kuwait has other direct and indirect consequences, such as wasting fuel, increasing harmful emissions, hampering emergency vehicle access to congested areas, deteriorating driver behaviour, higher rates of accidents, inflating real estate prices and inability of reliably predict commute time (UNDP 2009).

The rate of accidents is an important indicator for congestion (Chang & Xiang 2003). Historical accident data correlated to the number of vehicles and population can be seen in Figure 3-8. Additionally, accidents, injuries and fatalities from 1975 to 2013 can be seen in Figure 3-9. Besides the direct issues for people engaged in traffic accidents, there are indirect detrimental effects as well, as very often accidents impose financial pressure on the victims and their family, as well as potential limitations to work, leisure and social activities (Al-Ramzy 2009).

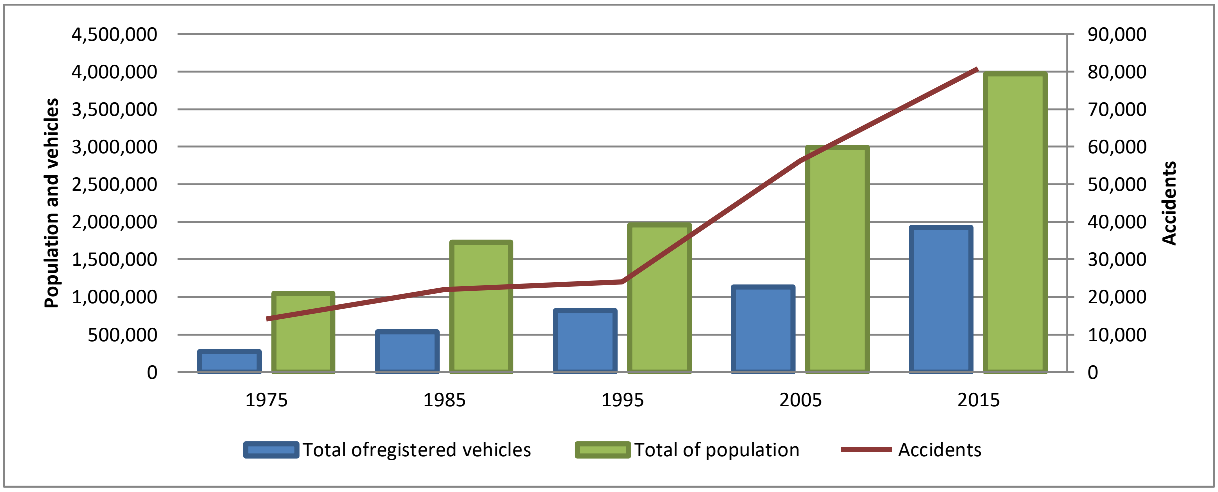


Figure 3-8: Comparison of registered vehicles, population and accidents for the period 1975-2013 in Kuwait (Koushki et al. 2003; KCSB 2015)

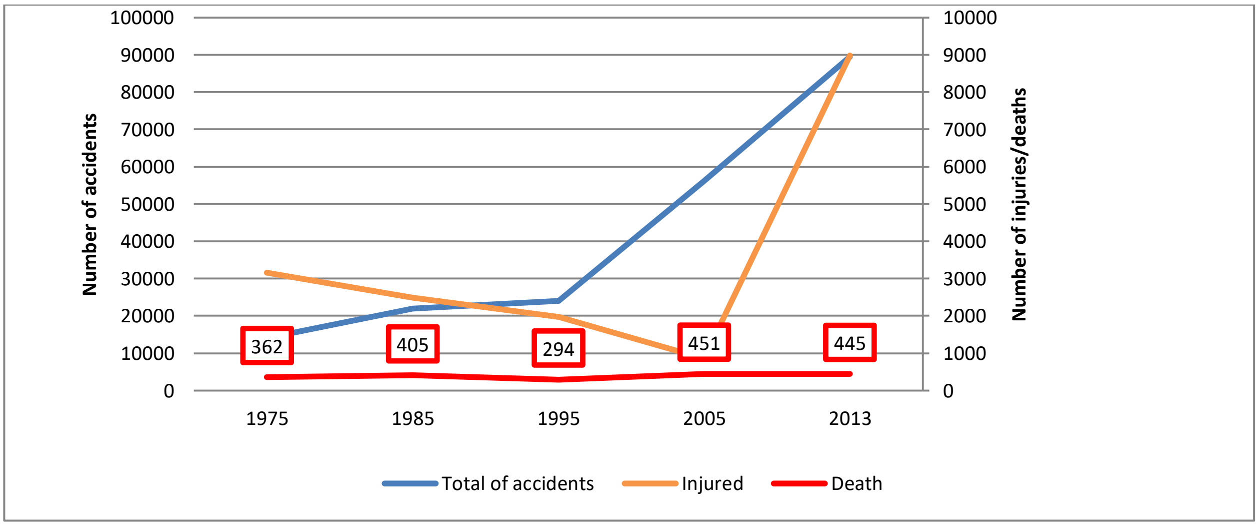


Figure 3-9: Comparison of accidents, injuries and fatalities for the period 1975-2013 in Kuwait (Jadaan 1990; Koushki et al. 2003; KCSB 2015)

According to (Al-Ramzy 2009) traffic problems in Kuwait are aggravated by:

- The lack of regulatory mechanisms for limiting the maximum number of owned vehicles per person (there are no related taxes on vehicles beyond the first).
- The increased population growth rate, which results to a rise in the total number of registered vehicles.
- The limited capacity of the existing road network to accommodate the increased number of vehicles.
- Increased reliance of residents on cars for even short trips, mainly due to lack of mass transport options.
- No major highway expansions since the mid-80’s.
- The high concentration of government services and administrative and commercial centres within the capital.
- Absence of non-overlapping schedules for government departments and public and private schools that are located in residential and mixed districts.
- Lack of traffic awareness among non-citizens that are not familiar with Kuwait’s motorised transportation status.

3.3.2 Housing problem

Besides transportation, a major impact of growth and development policies in Kuwait is limited housing availability (Alshalfan 2013). The main reasons behind this issue is land development constraints; developed land accounts for only 7% of the area of Kuwait (Al-Obid 2009). The state imposes constraints that exclude certain zones from urban development, such as oil fields, natural parks and military sites.

Furthermore, the system of housing welfare follows a top-down strategy (Alshalfan 2013). Kuwaiti nationality is associated with several benefits, such as free education and healthcare, public employment opportunities and most importantly eligibility for housing welfare. The National Housing Authority (NHA) - now the Public Authority for Housing Welfare (PAHW) - was founded in 1974 to regulate housing welfare (PAHW 2015). NHA applies specific laws, regarding the welfare housing size and location. Nowadays, the government offers three options of welfare housing for any married Kuwaiti couples:

- A townhouse sized no less than 400 m^2 or a 400 m^2 unit provided by the PAHW, in addition to a monthly rent bonus of KWD 150 for the duration of the processing of the welfare application.
- An at least 400 m^2 plot of land offered by the PAHW and a long-term, interest-free loan of KWD 70,000 for building a house in that land, in addition to a monthly rent bonus of KWD 150 for the duration of the processing of the welfare application.
- A long-term, interest-free loan of KWD 70,000 to purchase or construct a house with a floor plan area greater than 360 m^2, or to purchase a unit with a floor plan area greater than 360 m^2.

NHA was unable to meet the demand for welfare housing since its first years of operation (Al-Khaiat 1989). In 1980, approximately 19,000 applications were lodged and the government was incapable of providing houses at the required rate since then. This issue continued to aggravate, as the number of housing applications in 2012 exceeded 100,000, which is more than the total number of houses and land claims the government has been able to provide in the last sixty years as shown in Figure 3-10 (Alshalfan 2013).

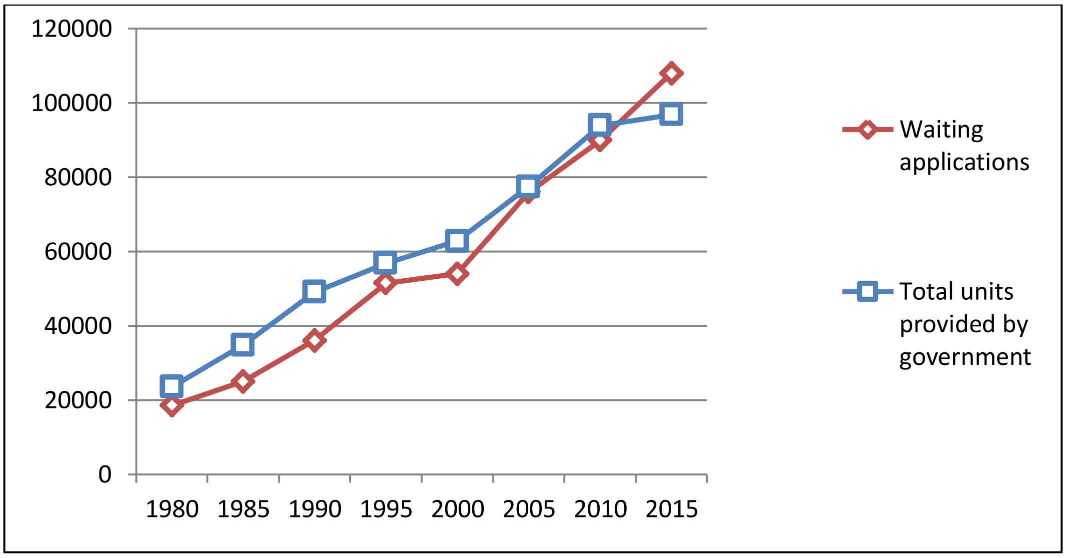


Figure 3-10: Housing demand and supply in Kuwait between 1975-2015 (Alshalfan 2013)

Non-citizens have fewer options for accommodation. Typically, many expatriates rent a unit with the help of their private employer in mixed use districts close to the CBD. Overseas workers that are employed as servants on the other hand may only stay at the same residence as their Kuwaiti employers.

According to Al-Obid (2009) the housing crisis in Kuwait is complicated and there are many reasons behind it, besides the land constraints and welfare system that can be summarised as following:

1. Policy reasons:
    a. Sole design and implementation of policies from government entities, without external independent consultation.
    b. The absence of long-term planning for the provision of citizen housing.
    c. Contradicting government policies; for example, the government encouraged marriage by grants, loans and social allowances for each child. However, the emergence of a newly-wed families increased demand for housing and resulted in higher number of PHAW applications.
    d. The lack of coordination between the bodies and institutions responsible for housing in Kuwait with bureaucratic overlapping of responsibilities. This results in delays in the implementation of the housing plans and projects.
2. Demographic reasons: high population growth rates due to natural population growth (2.7%) and external immigration (3.8%) annually (PACI 2017).

3. Limited private sector contribution in developing new residential and mixed zones, mainly for non-citizens. Typically, private developers construct high-rise buildings, where most non-citizens rent units in. The Government of Kuwait is committed to solving housing problems without any involvement of the private sector (Al-Khaiat 1989; Alshalfan 2013).

All these reasons are associated with many negative impacts, such as the rise of waiting times to receive housing welfare from eleven to eighteen years and rising prices in both sales and rental property markets to a level that makes it challenging for young adults to buy their own property. Therefore, citizens are forced to find alternatives; for instance new families are living in their parents' houses during the waiting time. The result of this practice is a rise in the average size of Kuwaiti households to 7.5, which is notably high comparing to other countries (TekCarta 2015). Citizen protesting is another consequence, such as the one in 2011 where around 150,000 of Kuwaiti nationals attended and demanded their citizenship rights including their housing rights (Keay 2012).

The government responded to the housing problem by providing a monthly allowance as a social subsidy during the waiting period for Kuwaiti citizens, but this amount typically covers less than half of the actual rental costs. Although the Government offers citizens a housing loan as an alternative to waiting, it is not sufficient to cover the cost for buying a house within a reasonable timeframe and interest payments (as many buyers need to apply for a private bank loan on top of the government one). PAHW assistance is considered as the only reliable way of securing housing ownership for Kuwaitis today.

Additionally, the difference in housing rights between Kuwaitis and non-Kuwaitis has led to a distinct differentiation of the two groups. While tensions have not been severe, the group segregation results into weak integration of the migrants in the local society (Harvey & Groutsis 2012).

3.3.3 Nationality segregation

The reason behind high nationality segregation in Kuwait stems from the series of master plans of the past that facilitated the separate development of purely residential districts and mixed districts with residential high rise and commercial/industrial sites. This separation was required in order to make the provision of free dwellings to Kuwaitis in the residential districts easily regulated. The latest master plan policies continue to support this type of land use classification. Arguably, this policy fuels segregation based on nationality as most Kuwaitis are directed to stay in purely residential districts, whereas non-Kuwaitis can mainly afford dwellings in mixed districts. This trend is shown in Figure 3-11. In addition, Figure 3-12 shows a map of the distribution of population according to the ratio of citizens to non-citizens.

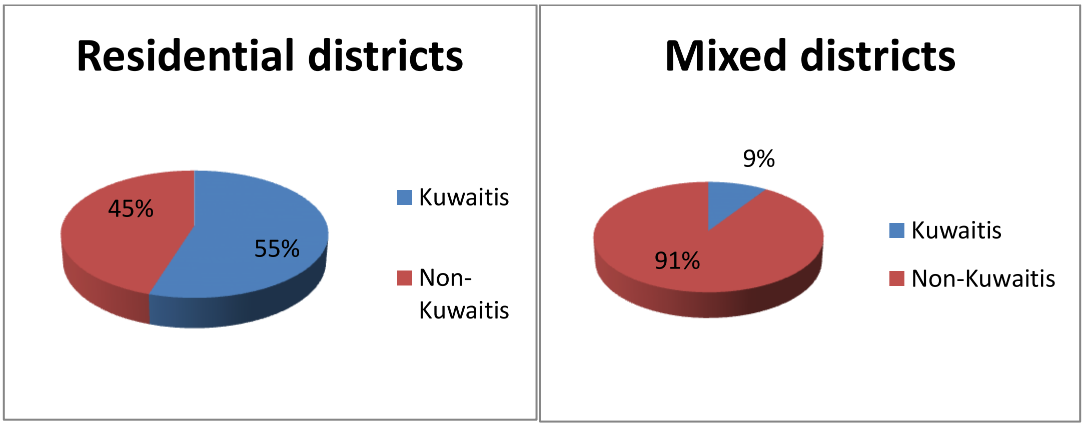


Figure 3-11: District Population composition according to nationality in Kuwait

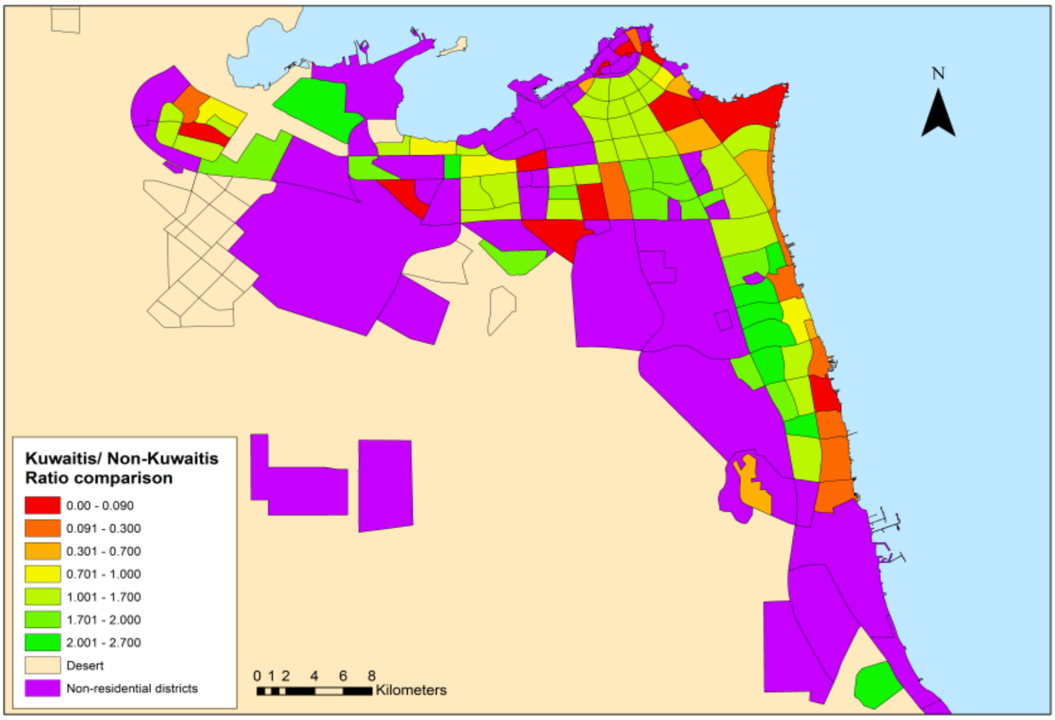


Figure 3-12: Population distribution by nationality in 2015

3.4 Future urban development

In light of the issues described in section 3.3, Prince of Kuwait Sabah Al-Ahmad during his speech for the first anniversary of his leadership in 2007 said; " *The diversification of Kuwait's resources of income looms high on the state's agenda to secure the future of the next generation because oil is naturally a depleted source, therefore transforming Kuwait into a distinguished regional financial centre has become an un-substituted solution ....*" (Al-Diwan Al-Amiri 2016). Around the same time, the government established a program titled "Kuwait Vision 2035" after consulting with the former British Prime Minister Tony Blair, in order to transform Kuwait as the major financial and trade centre of the region by 2035. The program includes a new urban development plan (master plan) proposing the construction of new cities (Keay 2012). In this master plan, for the first time in Kuwait, new measures were proposed to assist the transition from existing developed urban areas to new interdepended multi-cities. A major component of these measures is the development of new transportation modes, including a train network. The proposed 500 km train network will have more than 100 stations and link the existing urban area with the new cities, as well as be part of the new of Gulf Railway connecting Arabian Gulf countries (Lowe & Altrairi 2013).

Furthermore, the new master plan is focused on relieving the high concentration of buildings in the capital by 2030 through the establishment of 12 new regional cities around the country. Figure 3-13 shows the location of these new areas in red circles. It is expected that they will change the urban form of Kuwait and status as a city-state forever (Al-Nakib 2014b).

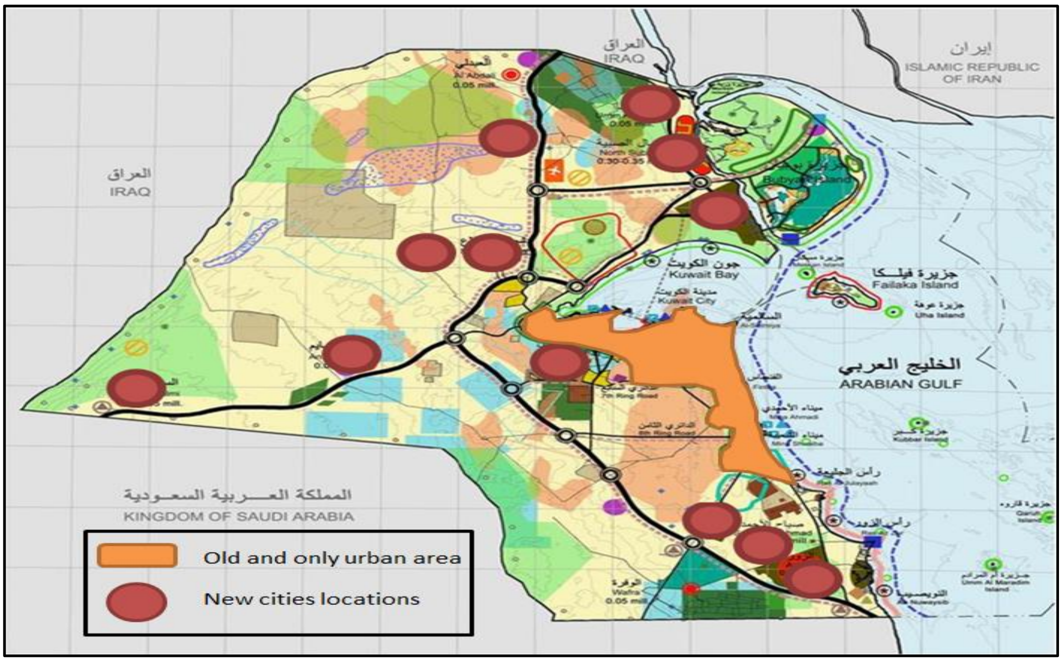


Figure 3-13: Kuwait new master plan 2030 (Kuwait Municipality 2009)

One of the largest, and perhaps the most notable project in the new master plan, is the Silk City or "Madinat al-Hareer", located on the north side of Kuwait Bay. Once complete it is expected to house a large number of work and leisure facilities, and will be linked to the city by one of the tallest water bridges in the world (Jaber Al-Ahmad Bridge). An illustration of the bridge can be seen in Figure 3-14. Silk City is expected to have 700,000 residents, and 175,000 new dwellings will be provided by the government to Kuwaiti families. These will be in addition to 12,000 new dwellings per year for Kuwaitis over the coming 10 years constructed in other new cities (Kuwait Times 2014). Finally, the Silk City will feature the highest tower in the world (Burj Mubarak Al-

Kabir 1001m) in the city centre. The development cost for Silk City is estimated to cost more than 100 billion USD (Goldschein, 2011).

Figure 3-14: Silk city location and Jaber Al-Ahmad Bridge (Kuwait Municipality 2009)

Kuwait's government had adjusted its budget since 2008 for these new ambitious development projects, including the construction of new cities with facilities and services. However, at the time it was assumed that oil prices will be trending upward, and as of 2017 this has not been the case (KUNA 2016). Reduced state revenues and other factors may impede the implementation of the new master plan. Such delays may be due to:

1. Bureaucracy in monitoring bodies (Al-Fuzai, 2016).
2. Slow decision making processes.
3. Reduced state funding.
4. Lack of coordination between stakeholders.
5. Difficulty of working in summer, due to high temperatures.
6. Lack of planning in the municipality.
7. Poor scheduling and time management (Al-Tabtabai 2002).
8. Design changes.
9. Shortage of labour and equipment (Soliman 2010).

On top of these potential delay reasons, Kuwait is still not particularly open to foreign investments, as any such investments are under the strict control and scrutiny of the Parliament (Keay 2012). Even if the projects are complete without delays, there is a concern about how successful the new cities will be in attracting residents. Examples of similarly ambitious, but unsuccessful construction projects are known as ghost cities in China (Moreno & Blanco 2014).

The new master plan and projected urban systems resulting from it, to the author's best knowledge, have never been modelled in the past. The lack of modelling extends to the issue of segregation between citizens and non-citizens, which must be better understood in order to relieve the impacts of traffic congestion and housing shortage in Kuwait.

3.5 Urban modelling in Kuwait

In Arabian Gulf cities like Kuwait, urban systems have developed over the last decades very rapidly and according to policies and plans conceptualised by the governments without any public or private sector involvement. Furthermore, the development in Kuwait was driven by oil-related investments and exports and resulted into the majority of residents being non-citizens (typically foreign labourers).The implementation of the master plans in Kuwait over the last 70 years has given rise to several key issues:

- The residents (citizens and non-citizens) perspectives have not been taken into consideration, leading to poor decision making, redundant projects and failure to fix urban issues affecting everyday life.
- Suboptimal land use and sparse spatial distribution of developed areas that aggravate congestion.
- Exclusion of many zones from urban form that adds pressure to property prices and increases house shortage.
- New infrastructure, such as the train transportation system and the establishment of regional cities were modelled independently of congestion and housing problems, which entails the risk of failing to address these issues properly.
- No alternative scenarios for population growth were examined, which has happened in the past and resulted in the aggravation of urban issues.
- There were errors in population projections.
- Population is segregated according to nationality due to housing welfare policies and restrictions on who can actually own land in Kuwait (only citizens), which makes traffic congestion, land value and social stability issues worse.
- Several project delays have been experienced and attributed to the lack of preliminary modelling.

In most Arabian Gulf cities, urban modelling and simulations are not common practices for analysing and solving such issues. This presents a research opportunity, as Kuwait's urban systems can be modelled and better understood if an appropriate model was designed. Understanding and predicting the evolution of urban systems is imperative in an effort to alleviate the issues outlined above.

The proposed model must be able to include the dynamic underlying factors and interactions between different agent groups in the city, as well as the agents and the environment. ABM has been recognised and is used often as an appropriate modelling approach, typically supplemented by a GIS platform. These hybrid systems have the ability to simulate the evolution of urban development in future horizons, based on pre-programmed rules under which, the agents interact and behave. Traffic Congestion, housing availability and nationality segregation are such issues, with several complex and dynamic dimensions and stakeholders with often conflicting interests in Kuwait and hence form three excellent opportunities for simulations with ABM/GIS.

3.6 Data sources

The primary data for this study was obtained via surveys and interviews with stakeholders in Kuwait, which constitute the agent groups in the proposed ABM. The secondary data was collected directly from government organisations via formal requests and informally from government official government websites.

3.6.1 Primary data sources

The primary data was obtained via a series of surveys and interviews. The information about the participants, the questions and the responses can be found in chapters 5 and 6, as well as in appendices B and C. According to Din and Moise (2012), interviews have to be carried out with key players that represent different groups to help finding any important factors affecting urban systems. The interviews in this project were with different groups in order to study the urban growth impacts on traffic congestion, housing shortage and segregation from different perspectives: the government agencies and private sector representatives. The interview primary data made it possible to understand the participant behaviours and interactions between themselves and their environment in order to model them in ABM.

In addition to the interviews, a survey was developed. The survey assisted in capturing the residents' expectations, needs and preferences for the state of their future urban environment. The data collected from the survey allowed understanding the agents' behaviours and setting the rules for the simulations in ABM. The survey was targeted to both non-citizens as well as citizens of Kuwait and the results associated with each group were analysed separately. Resident opinions have not been previously considered in any such survey.

The results from both the interviews and resident surveys are displayed and analysed in detail in chapters 5 and 6, which discuss the actual design architecture and implementation of the model.

3.6.2 Secondary data sources

In addition to primary data sources, plenty of information was acquired from various secondary sources in Kuwait. According to Stevens et al. (2007), current and future land use data is required in order to comprehend and model the urban growth in any city. Land use data used in this research was acquired from Kuwait Institute for Scientific Research (KISR), Kuwait Central Statistical Bureau (KCSB), Public Authority for Civil Information (PACI), Kuwait Municipality, the Traffic Management Department of the Ministry of Interior and Public Authority of Housing Welfare (PAHW).

Kuwait Institute for Scientific Research (KISR) is the agency responsible for providing various GIS shapefiles, which were the backbone for creating the base map, the Governorates and district boundaries. The shapefiles were used in analysing the land use in Kuwait and identify developed urban areas, future development areas and areas excluded from development plans.

Other important types of secondary data that were obtained from Kuwaiti agencies include socio-economic and demographic variables. These variables were among others, the current and future estimates of population, density, nationality, number of people per household, population distribution and population projection in the future (Boarnet & Crane 2001; Camagni et al. 2002; Kashem et al. 2014). The data was obtained from the Kuwait Central Statistical Bureau (KCSB) and the Public Authority for Civil Information (PACI), the official agencies responsible for producing various socio-economic and demographic statistics via censuses. Kuwait Municipality and the Municipality Council were the main sources for data related to the master plans, including future land use design characteristics and urban expansion and planning policies.

To simulate future population trends, a locally developed population projection was also used. This projection was developed in the Kuwait Institute for Scientific Research (KISR) and what distinguishes it from other forecasts is that:

a. it is based on the Cohort Component Population Projection Method used separately for citizens and non-citizens,
b. it projects higher population in Kuwait compared to the UN forecasts, and
c. it used the natural factors of population change (fertility, mortality and migration) as well as an citizenship acquisition rates (Alramadan & Almusallam 2013).

For the simulation of the current and future transportation status, the Traffic Management Department in the Ministry of Interior was contacted, as it is the authority responsible for providing GIS transportation data in Kuwait. The data acquired included current and historical street networks for the past 20 years, vehicle statistics, traffic accident statistics and congestion statistics. While metrics such as the Vehicle Kilometres Travelled (VKT) are used broadly in traffic related researches, this information was not readily available in Kuwait. Hence, alternative methods had to be developed for the urban system simulations. The proposed methods were instead based on:

a. Collecting accident data and using them to derive metrics for traffic congestion. The projection is based on the fact that congestion and accident occurrence appear to be correlated. Specifically, accident frequency is positively correlated to congestion levels, which can be explained by the fact that more vehicles share the motor network (Chang & Xiang 2003).
b. Using the Google Traffic tool, which not only displays real time traffic but also it is able to forecast future traffic conditions for one week ahead with data from users' mobile GPS devices. This tool can classify the congestion in three distinct levels: no congestion, medium and high and has been used in different traffic modelling studies (Marfia et al. 2013; Solé-Ribalta et al. 2016). In the current research project, traffic data were recorded in Kuwait at certain days and times (8 am, 2pm on Sundays and 8pm on Thursdays). Data for 8 months from January to August 2016 were recorded in order to analyse congestion patterns and levels in all districts.

Further information and the analysis of the traffic data can be found in Chapters 4 and 5.

Certain authorities, such as Kuwait Municipality and Kuwait Central Statistical Bureau (KCSB), provided readily available data on their websites or published material. Other entities, like Kuwait Institute for Scientific Research (KISR), Public Authority for Civil Information (PACI), the Traffic Management Department, and Ministry of Interior required formally submitted applications in their physical offices in Kuwait. The Public Authority of Housing Welfare (PAHW) was also contacted, since it is responsible for providing data related to developing new residential districts and providing new housing options for citizens (PAHW 2015).

3.7 Conclusion

Chapter 3 has explained and discussed the unique and set of conditions and urban development history in Kuwait that make it an interesting candidate for a case study for the proposed urban model. It should be stressed out that the research work presented in the following Chapters 4-6 is unprecedented for Kuwait or any other Arabian Gulf country. Hence, we believe that the questions raised and answered via modelling in Chapters 4-6 are especially valuable for current and future urban development in the case study region.

Chapter 4 : Modelling future impacts of current patterns of urban development in Kuwait with the use of ABM and GIS

Chapter outline

The content of Chapter 4 is based on an article published in Transaction in GIS Journal. The work described within this Chapter is related to modelling the business as usual scenario of urban expansion in Kuwait. This is necessary for addressing the conceptual part of the research aim, specifically understanding the effects of nationality segregation, centralised planning and the other unique traits of Arabian Gulf societies on urban growth. Furthermore, the modelling will enable quantifying some practical issues like traffic congestion and housing shortages and show how integration of such tools may be valuable in urban planning. These are novel contributions aligned to the overriding theme of the thesis that has never been investigated before in existing literature.

The findings contribute towards addressing the following research questions:

1. Who are the key decision makers affecting past urban growth in Kuwait and other Arabian Gulf countries?
2. What impacts will urban growth with expansion around the CBD according to past trends have?
3. How well can automata (ABM) simulate existing and future urban systems?

The research highlights of Chapter 4 include:

i) Spatially collating historical socio-economic and land use data in Kuwait from 1995 to 2015 using GIS.
ii) Developing a predictive land use model of future urban growth patterns and evaluating potential negative impacts, namely, traffic congestion and housing shortages.
iii) Identifying the key decision makers for urban development and most important urban growth impacts in Kuwait based on the literature.
iv) Identifying the future outcomes of development based on historical trends of expansion of the existing urban area without considering any modelling.

Modelling future impacts of urban development in Kuwait with the use of ABM and GIS

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Abstract

During the last six decades Kuwait has experienced a rapid and unprecedented population growth with only a small increase in the urban areas. The alarming rise in urban density in Kuwait has caused issues for the residents' lifestyles, the economy and the environment. These issues have been aggravated by urban planning that perpetuated a city-centric urban form without modelling the impacts of current patterns of urban growth. A spatial model using Agent Based Modelling (ABM) and Geographical Information Systems (GIS) is proposed to model disaggregate future changes in land use patterns given forecast population estimates and planning policies. The two main impacts considered are housing shortage and traffic congestion as these are the two most significant social impacts for Kuwaitis. This paper discusses the design methodology and parameterization of the ABM and the agent groups. It characterizes urban growth by rules for different citizen groups, historical growth patterns and the influence of decision makers. The model is validated against data for the period 1995-2015 and simulations run to 2050; the results predict that continued city-centric growth will aggravate the problems with greater than 50% increase in housing shortage and congestion unless the government intervenes to rectify the situation.

1. Introduction

Urbanization affects modern societies in several ways, such as the economy, the environment and culture and is a central principle in the research fields of demographic, economic and regional geography (Birch 1971; Knox & McCarthy 2012). Urbanization and related city growth have adverse impacts on the lives of millions around the world, such as overcrowded transportation (Duranton & Turner 2012; Kim et al. 2014) housing affordability issues (Isma'il et al. 2015) and environmental degradation (Sypharda et al. 2011; Arouri et al. 2012; Seto et al. 2012).To mitigate any negative impacts of urban growth, and to improve livability, a variety of measures have been proposed and enacted globally. This set of measures includes better planning approaches, such as strategic spatial planning (Todes 2012; Vos & Witlox 2013), comprehensive planning (Bengston et al. 2004) and sustainable planning (Lord et al. 2015). Additionally, urban modelling integration in planning helps to understand growth processes (Epstein 2008), model urban systems from disaggregate spatial data (Batty 2012) and predict future changes that, in turn, allows us to act early for the mitigation of any negative impacts (Miller & Page 2009; Crooks & Heppenstall 2012). However, a fundamental issue in developing such measures is that not all cities experience the same history of urban growth and urbanization.

One region of increasing interest is the Arabian Gulf, in which cities have transformed from small ports to metropolitan areas within a very short time (Abu-Ayyash 1980; Rizzo 2014). Another characteristic of the growth in the Gulf region is that it was not primarily driven by internal migration from rural areas, but from overseas immigration of laborers (Malecki & Ewers 2007). Major effects of these phenomena include increased and costly traffic congestion and accidents, reduced housing availability and inefficient land use.

Urban planning in Gulf cities is exclusively controlled by the government, without any public involvement (Al-Shamiry 2011, Al-Nakib 2014a). The planning process is focused on redistributing some of the wealth from oil exports through housing welfare and infrastructure. Over the last decades, urban development in the region has been dominated by a series of master plans which were driven by a conceptual design approach to planning. These plans have been inadequate in dealing with urban growth related impacts (Madbouly 2009; Rizzo 2014). Furthermore, there were several assumptions that have not been tested in the preliminary analyses; a notable example is the failure to address the reality of the significantly high ratio of non-citizens in the demographics of most cities (Abu-Ayyash 1980; Abu-Ayyash 1981), higher car dependency, inefficient transportation (Al-Ramzy 2009; UNDP 2009), and the affordability of housing (Alshalfan 2013). All of these are key concerns for both governments and residents of the Arabian Gulf.

Although several studies have highlighted the need for robust urban planning in Arabian Gulf cities in order to tackle the negative impacts of urban growth, no clear process for modelling urban development and its impacts in the area has been proposed (Madbouly 2009; Aljoufie et al. 2012; Rizzo 2014). Therefore, this study aims to model urban development in Gulf cities and, in doing so, to identify any negative impacts and identify potential solutions. The two primary objectives in this study involve:

i) disaggregating existing sources of land use and census data to a form suitable for modelling future urban growth and its impacts, and
ii) developing a predictive model of future urban growth patterns and evaluating potential negative impacts, namely, traffic congestion and housing shortages.

The predictive model will be explored by two scenarios to envision urban growth Kuwait within a horizon of 35 years and assessing future impacts. Two scenarios are explored:

1. A business as usual scenario following the historical trends.
2. An adaptive growth scenario where government is more reactive to solve the housing shortage.

With these scenarios in mind, a research question is whether an adaptive planning approach evaluated on a medium term basis, i.e. 5 years that triggers changes in public housing releases may significantly reduce housing shortages and other impacts in the long term in Kuwait?

The paper mainly focuses on housing shortage as an impact, and with a lesser emphasis on traffic congestion as there was limited available transport data adequately assess it. The work presented in this study is an extension of a published conference paper (Alghais and Pullar 2015).

The motivation for the work in this paper was that current planning processes have been limited by the use of aggregated data (such as the national census) and a conceptual planning approach that does not anticipate future growth and potential impacts. Using aggregated data often fails to correctly identify and solve local issues. Disaggregated spatial data on the other hand, gathered from local communities offer insight on the residents' concerns and expectations from urban planning in their immediate area.

2. Background

2.1 Case study site

Kuwait will be used as a case study site. Kuwait has a population of 4.1 million living in an area of 17,818 km2 (PACI 2015) and demonstrates all the unique traits of Gulf cities discussed earlier. Most of the developed land is located along a coastal region in the eastern part of the country, as shown in Figure 4-1.

Figure 4-1: Kuwait land use distribution

After the discovery of oil in the 1960s, Kuwait has seen a rapid growth in population, primarily because of incoming immigration. Specifically the country's population grew from less than 200,000 in 1955 to more than 4 million in 2015 (United Nations 2015).

Since the 1950s, the government of Kuwait has developed master plans for urban planning, which focused on concentrated development in the central business district (CBD) and low density residential areas around it. The long-term implementation of the master plan is overseen and managed by the Kuwait government. State and local authorities decide on the most suitable use of land in order to promote general welfare and livability, and appropriate locations for future development and transport, while protecting the environment and cultural resources at the same time (Abu-Ayyash 1980). Districts have been used in land use planning in Kuwait since the 1960's.

They follow a distinct socio-spatial composition designed to accommodate Kuwaiti citizens and non-Kuwaitis in separate areas. The majority of non-Kuwaitis live in districts with a mix of high density unit development, shopping and commercial zones. They tend to reside closer to their workplaces compared to the Kuwaiti citizens. Only a few non-Kuwaitis live in designated residential districts, as they are not allowed by law to own property and they may only rent or reside in Kuwaiti households as service staff (Al-Nakib 2014a).

This planning approach and population growth has resulted in issues such as housing shortages, overpriced property, congested traffic networks and pressure on public facilities and infrastructure (Abu-Ayyash 1980; Abu-Ayyash 1986; Al-Hathloul 2004). Alshalfan (2013) identifies high car dependency as another problem arising due to the master plan. The more alarming concern from the increase in total number of vehicles is the higher rates of accidents, which can be seen in Figure 4-2.

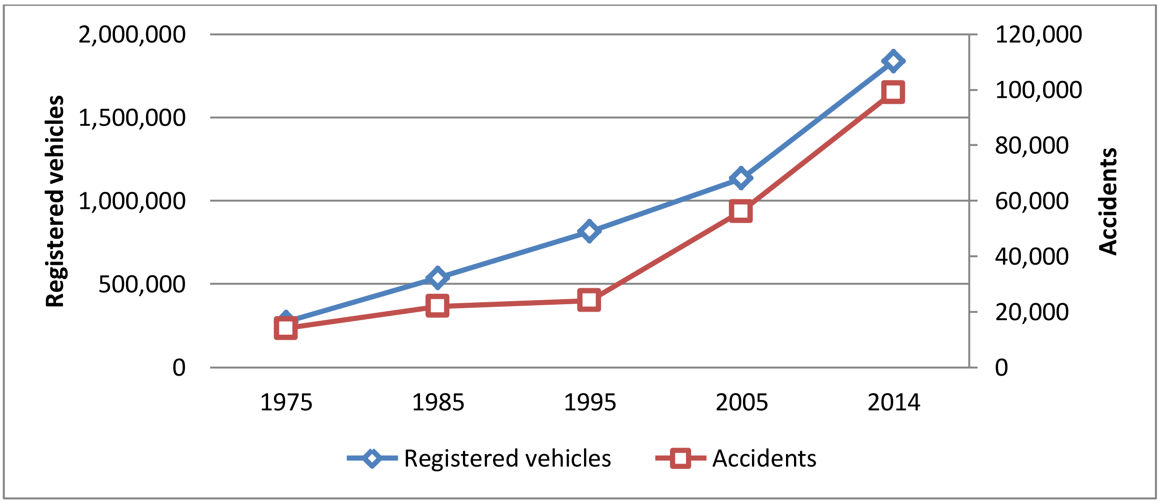

Figure 4-2: Annual numbers of accidents and registered vehicles in the period 1975-2014 in Kuwait (Jadaan 1990; Koushki et al. 2003; KCSB 2014)

There is a scarcity of traffic surveys and data on traffic congestion in Kuwait, so we decided to use data on traffic accident reports as a surrogate for traffic congestion. Traffic accidents and congestion are related (Chang & Xiang 2003) and have a common factor for vehicle usage. Vehicle ownership in Kuwait is 1 car per 2 persons (2014 data), and may be related to demographics for the drivable age of population in districts. Traffic accident data reported for police regions (typically several districts makeup a police region) shows a relationship between vehicle ownership and accidents (see Figure 4-2). Kuwait has high traffic congestion and traffic accidents, for instance data for 2014 indicate an average of 400 accidents per district. A more detailed analysis of the correlation of accident data and congestion is presented in section 3.3.

2.2 Agent based modelling

This study uses an urban modelling approach, based on Geographical Information Systems (GIS) and Agent Based Modelling (ABM), to model changes and interactions between land use and agents and understand future patterns of urban development. A business as usual scenario simulation mimics historical growth for the case study where current patterns of urban growth persist from 2015-2050. The results of the simulation are expected to help in assessing current trends of urban growth, to show it spatially in GIS, and to better comprehend the impacts of existing urban growth patterns on housing availability. A second more adaptive scenario was also run with the government being more reactive to housing shortages and releasing more residential districts and distributing more dwellings for the citizens.

GIS has been hybridized with many types of spatial models for managing and analyzing datasets (Goodchild 2005) and, likewise, computational tools for the spatial modelling of cities and transportation over space and time have been coupled to GIS (Batty 2012). ABM is such a tool, and has been integrated with GIS for modelling predictions and assessing plans (Clark 1982; Brueckner 1997; Waddell 2002; Liu 2009; Jokar Arsanjani et al. 2013). The combination is regarded as a powerful way to model spatiotemporal dynamics of urban development (Zhang et al. 2015) or the dynamics between demographics, transportation, housing and the average satisfaction of the residents (Huynh et al. 2015).

Spatial models that use ABM simulate the actions and interactions of autonomous units within a system. These interactions are based on simple rules, but may result in the emergence of complex system behaviors (Torrens 2002; Batty 2008). ABM in the context of GIS integration is operated by having agents influence land uses or explicitly representing agents as land facets that exhibit land use changes (Ligmann-Zielinska & Jankowski 2007). The advantage of this type of model is that interactions between autonomous units are examined at a disaggregate level, which evolves via a simulation to reveal emergent macroscopic land use patterns. This is termed a bottom-up modelling approach (Crooks & Heppenstall 2012). The selection of ABM for this project is then justified as a means to evaluate decisions by different groups, as agents, based on their settlement patterns and interactions with future plans.

While there is no universally accepted definition of agents in ABM, they can be regarded as a collection of autonomous decision-making entities within a system. Agents are able to individually assess their situation and make decisions based on a set of predefined rules (Bonabeau 2002). Urban models incorporate two components—a spatial component for land uses and a human decision making component—and urban ABM has been developed based on both components. Land use may be treated as the spatial environment by focusing on dynamic patterns of land use change, and the decision making on the collective behavior of decision makers, such as risk behavior by groups of individuals (Ligmann-Zielinska & Jankowski 2010). Typically, groups of stakeholders represent different agents, as their interests and behaviors in terms of land uses vary and may be captured via population and economic data and census statistics. Agents represented as individuals, such as people or households, may have more active behavior than groups, as they are able to roam freely around the environment permitting more complicated and heterogeneous interactions (Crooks & Heppenstall 2012). However, these behaviors need to be regulated by rules obtained from social survey data (Brown & Robinson 2006) which may be challenging to obtain.

In this study, the ABM includes multiple agents that are constrained by their environment. The spatial environment is the developable and urban areas segmented as land use districts. Given the lack of individual social survey data available in Kuwait, it was decided to focus on agents as collective groups or decision makers. Interacting agent groups include Kuwaiti and non-Kuwaitis citizens, land developers and government as the key organization affecting land use decisions. Further information on behaviors is described in the model design in the following section.

3. Data and Methodology

3.1 Data types and sources

Base mapping layers used in this study include GIS data such as road networks, districts and urban activity destinations in Kuwait (hospitals, shopping malls, factories, government offices, companies and universities) from 1995-2015. Population data with aggregate projections from 2015-2050 (Alramadan & Almusallam 2013) were obtained from Kuwait Institute for Scientific Research (KISR). Other significant data include socio-economic, transportation and demographic variables (density, nationality, household sizes and population distribution) were obtained from the Kuwait Central Statistical Bureau (KCSB) and the Public Authority for Civil Information (PACI). Finally, housing related data, such as the number of applicants and the supply of dwellings from the government, were obtained from the Public Authority of Housing Welfare (PAHW). The only available data related to traffic congestion in Kuwait are accidents data collected from the Interior ministry. This set of data needed to be disaggregated and classified into a uniform spatial form, in order to create a profile of urban expansion of Kuwait for modelling.

3.2 Disaggregation of district data

As mentioned earlier, urban models require disaggregate spatial data to simulate future urban growth, and the district scale was used for this purpose in this study. Data on district characteristics were collected to understand the historical development trends, as Kuwait's districts provide relatively uniform characteristics for land use type and population composition. This section describes the acquisition and preparation processes of this dataset.

The first step was to identify and classify districts according to their land use type as residential, mixed and others. In terms of population composition, residential districts consist mainly of Kuwaiti households and overseas support staff, while mixed districts host the majority of the non-Kuwaiti population. Figures 4-3 and 4-4 show the difference between typical mixed use and residential districts for Sharq and Qurtuba respectively.

Figure 4-3: Sharq one of the mixed use districts in Kuwait

Figure 4-4: Qurtuba, one of the residential districts in Kuwait

No land use mapping was readily available for Kuwait. Maps for populated districts were available, but these still required updating and compilation into a land use layer in GIS for modelling purposes. Kuwait's districts were classified according to land use into residential, mixed use and other non-urban areas (industrial, agricultural, ports, desert). Historical population data from 1995-2015 are reported by district and contains basic information on nationality (Kuwaitis and non-Kuwaitis); this was used to map population composition and density for districts in the GIS. For established areas there were four different denominations of densities according to the type of district and residents: average Kuwaiti density in residential districts (40 persons/ha), average Kuwaiti density in mixed districts (20 persons/ha), average non-Kuwaiti density in residential districts (30 persons/ha) and average non-Kuwaiti density in mixed districts (2,000 persons/ha). Since the model attempts to emulate the continuation of existing urban patterns, the expected population capacity was calculated for each new simulation district based on the aforementioned variables and has similar average population densities.

Future urban developable sites also needed to be identified. This task involved classifying the development status for areas as developed, developable in the future (including vacant land inside developed areas) and land excluded from development or prohibited to development such as military areas, oil fields, culturally significant areas or highly environmentally sensitive areas. The excluded areas were defined using photos, maps and satellite images collected from the Kuwait municipality and Google Earth. This process was carried out by utilizing the master plan's maps and visually interpreting settlement patterns from Google Earth satellite images. The outputs were compiled into a uniform representation in ArcGIS, and model parameters for growth were derived from analyzing historical growth patterns. This classification was necessary for overlaying the data on the ABM model. The resulting map can be seen in Figure 4-5.

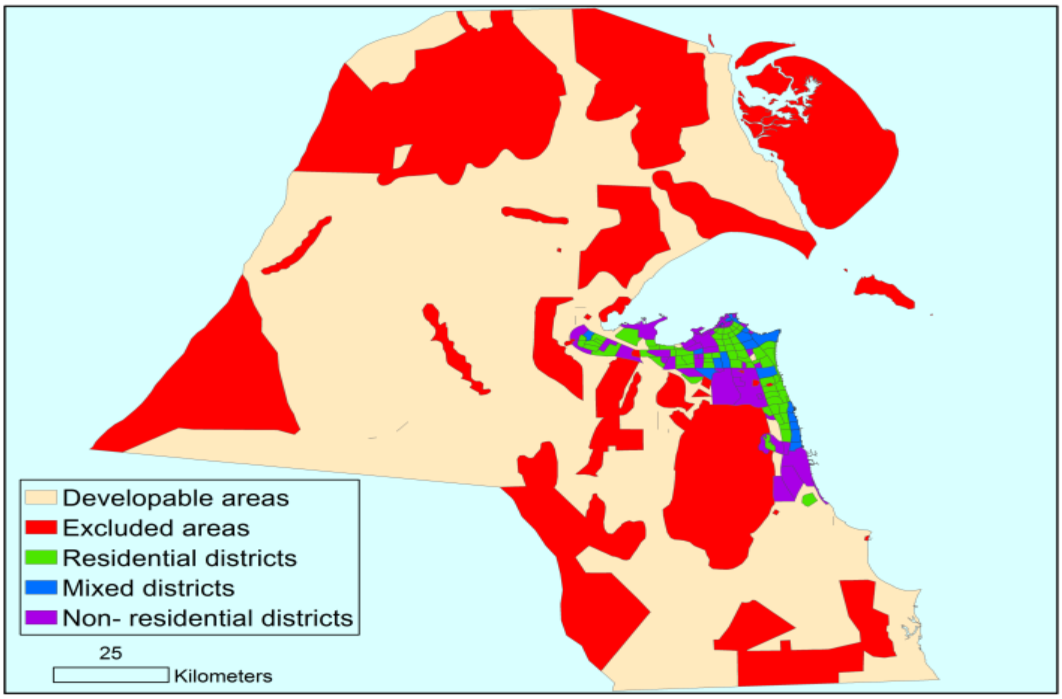

Figure 4-5: Classification of Kuwait's districts according to land use and development status

3.3 Analysis of historical data

Analysis of historical data was necessary to set the historical urban growth model parameters used to simulate urban expansion in Kuwait. In this section, the most important findings from the historical data will be discussed and the development of ABM rules will be justified.

Urban development, in general, can occur via greenfield policies (developing new districts in previously undeveloped areas, such as desert) or intensification (increasing population within existing developed areas, such as infill or high-rise expansion) (Biddle et al. 2006; Melia et al. 2011). Figure 4-6 shows the ratio of greenfield and intensification developments in Kuwait between 1995 and 2015. It can be seen that intensification is dominant. It was found that annual growth rates for new dwellings for Kuwaitis in residential and mixed districts are 155 and 125 dwellings respectively. Annual growth rates for new dwellings for non-Kuwaitis in residential and mixed districts are 110 and 1490 dwellings respectively. It should be noted that dwellings provided for Kuwaitis in residential are from the government, whereas all other dwellings are built by private sector (developers). Additionally, the household size is on average 7.5 persons for Kuwaiti households and 5.5 persons for non-Kuwaiti households (Kaye 2009). Another finding for greenfield development was that more new residential districts were created compared to new mixed use districts at a ratio of 8 to 1.

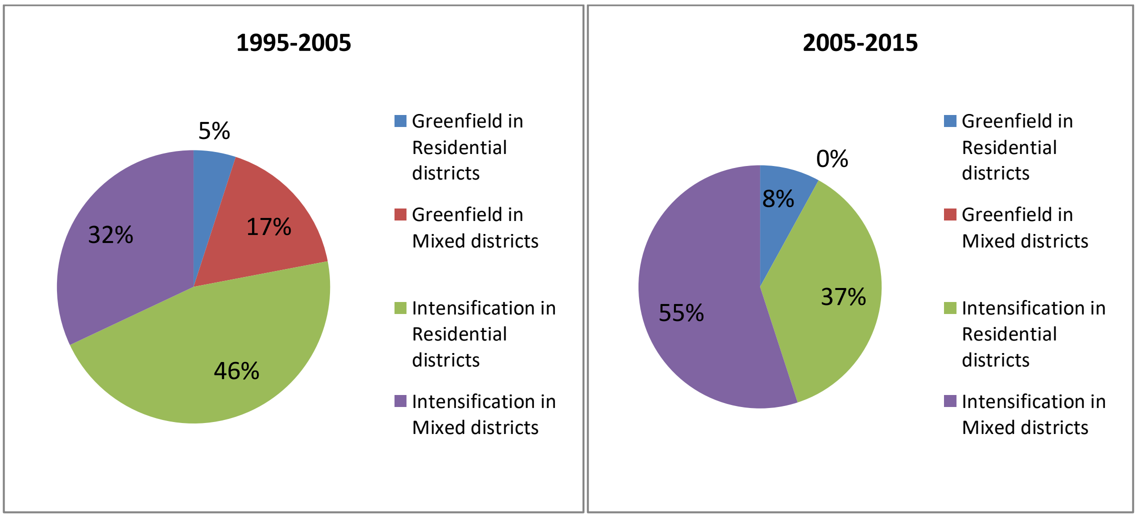

Figure 4-6: Comparison of greenfield and intensification development in Kuwait between 1995 and 2015

Assuming that these trends persist following a ‘business as usual’ scenario until 2050, greenfield districts alone will have difficulty accommodating growth due to the time it takes for construction works. Hence, over-spill growth is expected to occur at higher intensification rates; in other words, urban density needs to increase above historical figures to accommodate the growing population.

Additionally, after analyzing the historical data, a clear correlation between population growth and urban expansion as well as housing shortage can be seen. Specifically the correlation coefficient between Kuwaiti population and pending housing applications is 0.97 (between 1980 and 2015); this trend can be seen in Figure 4-7. In addition, the correlation coefficient of total population and urban area is 0.99 (between 1995 and 2015).

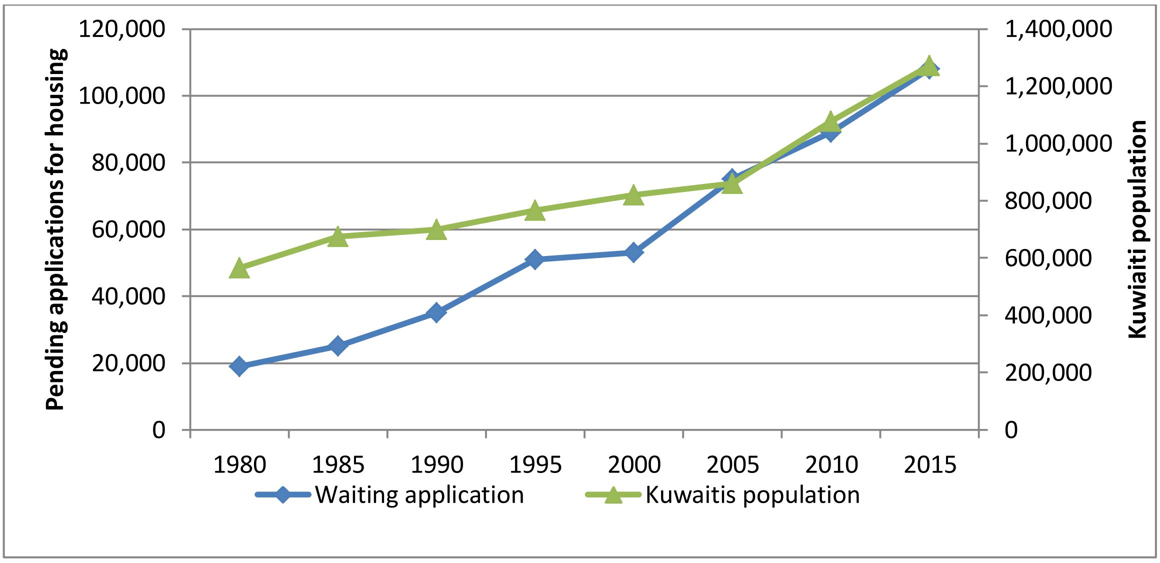

Figure 4-7: Correlation of population growth (citizens) and pending applications for housing according to historical data

Furthermore, the average annual rate of change of applicants from Kuwaiti families for new available housing was approximately 4.6% per year (based on historical data from 1980-2015). In 1980 there were approximately 3,000 new applications and in 2015 approximately 7,000 new applications. This results to a cumulative number of pending applications of 108,000 by 2015. In contrast, the average number public housing of dwellings (house or land) offered by the government was calculated and was found to be 2000 dwellings per year (PAHW 2015). These trends may be clearly seen in Figure 4-8.

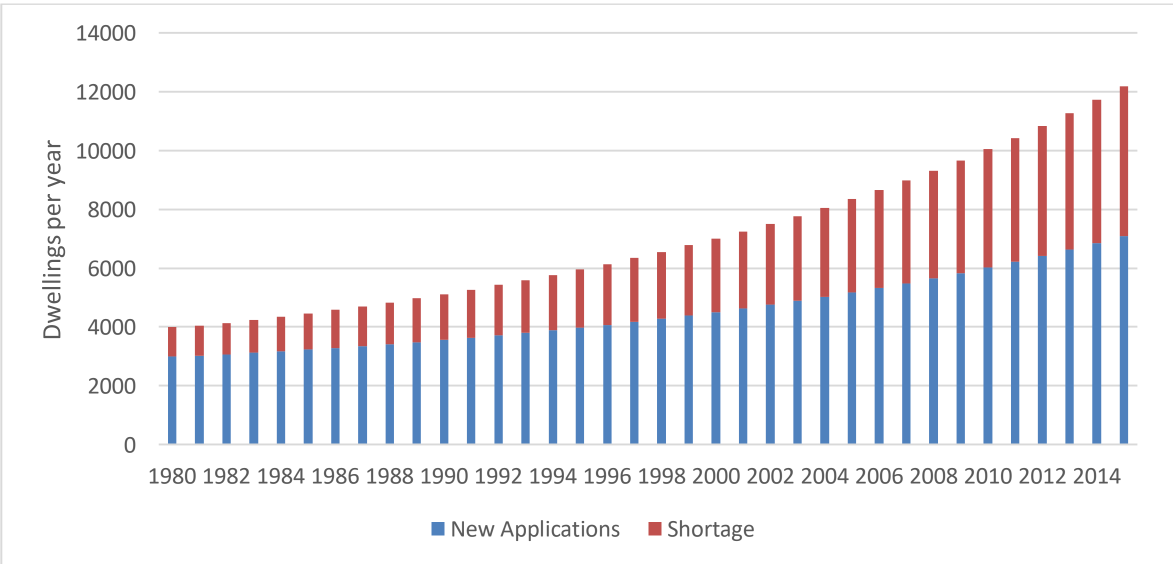

Figure 4-8: Comparison of new applications and housing shortage for each year between 1980 and 2014

Traffic accidents as mentioned earlier are used as a surrogate for traffic congestion impact. The accident data are available for police regions, where a police region is comprised of several urban districts (1-5 districts). Figure 4-9 shows police regions and traffic accidents for 2014. Statistical analysis reveals a correlation between traffic accidents and variables for: i) population, and ii) the number of contributing regions to traffic inflow relative to the CBD. A regression equation on accidents with explanatory variables for population (p-value <0.01) and level of traffic catchment (p-value 0.05) provided a measure of traffic accidents and congestion. Although a very crude indicator it intuitively captures the dominant traffic flow pattern of outer districts to CBD i.e. outer regions have less population and no traffic inflow from adjoining regions, whereas inner regions have higher population and many contributing traffic regions. The regression relationship is used later (see Figure 4-22) to predict future accidents.

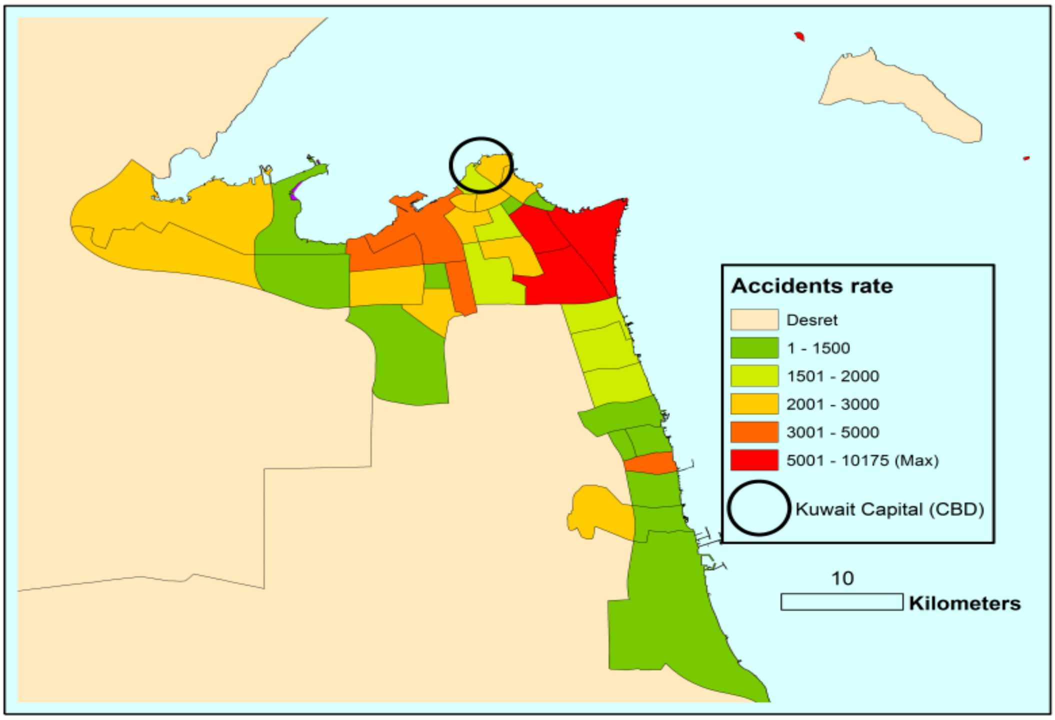

Figure 4-9: Accidents rate distributed on police regions in 2014

Traffic impact is a complex issue that needs a variety of government adaptations to predict and solve and it is certainly not possible to study it only in terms of urban growth. The literature confirms that congestion is considered extremely difficult to be forecast with limited available data (Bonabeau 2002; Bernhardt 2007); therefore the impact of traffic congestion will be calculated based on other congestion indicator data in the model in future work.

3.4 Agent Based Model parameterization

The ABM tool used in this study is the ArcGIS Agent Analyst extension. It is open-source software that was developed to integrate ABM tools with ArcGIS (Johnston 2012). In this framework, dynamic groups of agents interact with each other and their environment, and agents possess the ability to assess situations and behave based on a set of rules. In the context of urban modelling agents interact and change the environment for land uses over time (Veldkamp & Lambin 2001; Verburg et al. 2006). The ABM receives GIS data inputs related to land use, transport networks, demographics as well as population growth to simulate the future scenarios. Rules for changes in spatial units and interactions that affect their state, or the state of decision agents, were encoded in Java. ArcGIS Agent Analyst runs a simulation with scheduled execution of actions from the Java. This extension has been used in various studies and is recommended by many researches (Robinson et al. 2013; Dahal & Chow 2014; Haslauer et al. 2015).

As mentioned earlier, this research involves two scenarios:

1. A business as usual scenario: Follows historical trends with a fixed land policy by the government to open four new residential districts and a half mixed use district within a five year time step, and to distribute 2000 new dwellings to citizens' families per year as part of PAHW program.
2. An adaptive rule scenario: The government will assess to the housing shortage problem after the five year time step and react to adjust land policy. Specifically, if the number of remaining families in the PAHW waiting list is growing and the new dwellings cannot meet the housing demand, the government will release more residential districts and dwellings compared to the last 5 years' average.

As discussed earlier, an ABM with four distinct agent groups was used in this study. The agent groups have varying degrees of decision making power in matters of land use, according to the status quo in Kuwait.

The four groups of decision agents in the model are:

i) The Kuwait Government and planning authorities that have the power to create new areas for greenfield development. Opening up new areas follows planning policy. Moreover, in the adaptive scenario, the government will be an adaptive agent that will react to the housing shortage issue to tackle it.
ii) The developers (private sector), who are mainly Kuwaitis with enough wealth and power to

build houses, units, universities and shopping centers in the mixed districts as activity centers. In the proposed model, the private sector will act according to historical trends by building houses and high rise buildings mainly in the mixed use districts for Kuwaitis and non-Kuwaitis and a smaller number in the residential districts for non-Kuwaitis.

iii) Kuwaitis, who prefer living in residential districts (85%), can own land (70%), flats or houses, are eligible for PAHW grants and, until they receive the grant or best offer, have the option to temporarily live in the family home, i.e. as extended families. In addition, the driving forces of their behaviors are economic opportunities offered by the government, and traditional family cultures.

iv) Non-Kuwaitis who usually rent a flat or house preferably in mixed districts (65%) because they cannot possess their own real estate due to the Kuwait Government rules.

The main behavior simulated in both scenarios involves the spatial segregation of residents according to nationality. The segregation is a result of decision making process according to suitability criteria for residents groups. Besides, Figure 4-10 explains the agents and their relations.

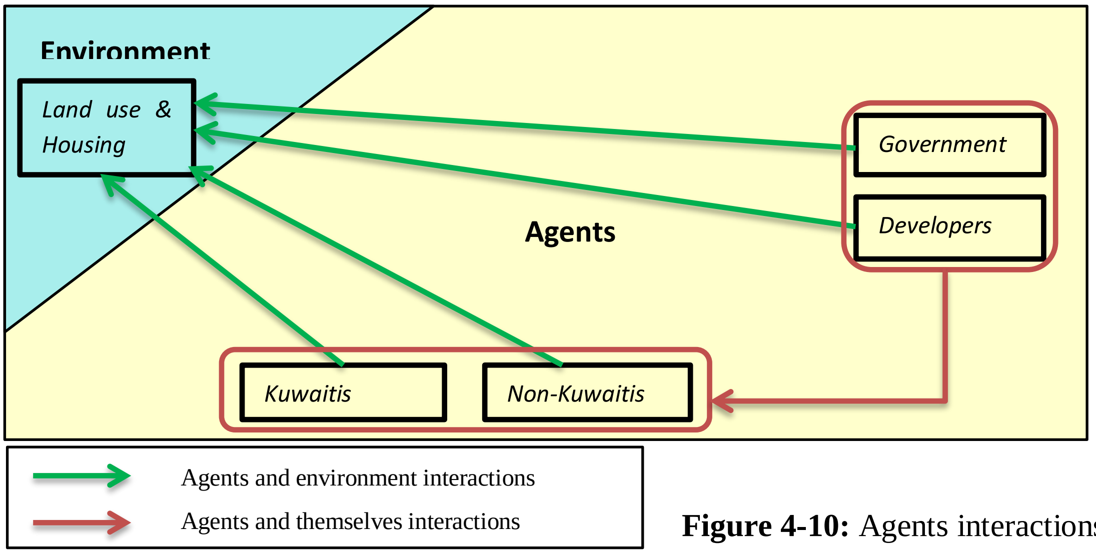

Figure 4-10: Agents interactions

It is worth mentioning that there are numerous reasons for family households of the Kuwaiti agent group living together, including:

- Financial reasons, due to the long waiting period for housing and expensive rent and land/property prices.
- Cultural and religious reasons, as Kuwaiti children are expected to take care of their parents when they reach senior ages. Furthermore, most families consist of at least 4 people (often more), which enhances close family ties (Ramadan 2016)

Before running the model, it was important to divide large areas outside existing development into small developable compartments (parcels) for future urban expansion, this was done with the Create *Fishnet* tool in ArcGIS. The size of the developable parcels was made approximately equal to the mean size of districts, which is a reasonable assumption since according to the historical data the average district size was found to be 5 km2, with a standard deviation of 2.6. The parcel grid can be seen in Figure 4-11.

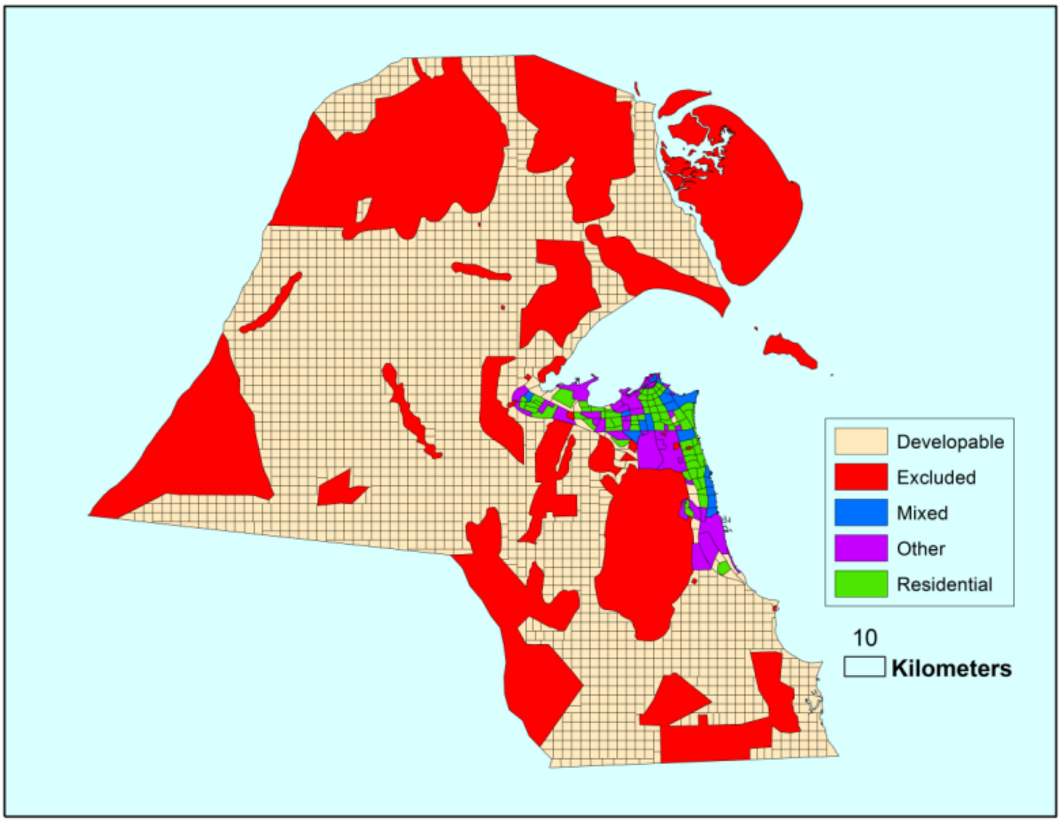

Figure 4-11: Parcels grid of developable areas after split using Fishnet tool

A suitability model was then used to estimate the annual future demand of land for urban development depending on historical growth (Malczewski 2004). Analysis found that development of districts was related to six variables:

i) *Infrastructure proximity* (3 variables) with distances to major street networks, the CBD and the coastline. These were calculated with the near distance tool in GIS.

ii) *Urban area proximity*. This was calculated with the near distance tool in GIS. However, this variable is dynamic, as it needs to be recalculated after each time step due to the changing sites of the urban area after the addition of new districts.

iii) *Weighted proximity to facilities*—hospitals, shopping malls, governmental offices, company offices, factories, and universities. This was calculated as the sum of ratios of facility size to distance for all (*n*) major facilities within the city limits:

Weighted proximity = $\Sigma_{i=1,n}$ *(size of facility*$_i$ */ distance to facility*$_i$*)*

iv) *Land costs of houses or apartments* for developable parcels. This was derived from annual sale and rent data published by Kuwait Finance House (KFH 2015) and was for the two main district types (residential and mixed). The data values were normalized to a suitability scale of 0 to 100, where 100 is the highest suitability value.

The suitability variables were combined in a linear weighted combination with weights derived from historical growth patterns (Malczewski 2004). These weights were derived by a trial-and-error process by examining growth patterns of districts from 1995 land uses to best match 2015 land uses. Further details are given in section 3.5 on calibration.

Both scenarios simulate changes in the urban form of Kuwait every 5 years until 2050 through land use changes driven by population growth, and behaviors/interactions by the decision agents. Hence, it will run for 35 iterations, representing each 5-year interval between 2015 and 2050. The new districts for development are selected from developable parcels based on their suitability. Population growth is allocated in the new districts and their distribution will match the current average ratios. It should be noted that projections about certain demographic data, and especially income, are very challenging to develop and beyond the scope of this work. Transition from a resource based to a service based economy, may have dramatic effects on the income of residents; however, this model attempts to examine the urban growth from a land use perspective alone. Table 4-1 summarizes the model parameters and their application in the model.

Table 4-1: Summary of model parameters

Parameter name	unit	Description
Population Increment	Persons	New residents from census projections added in groups of about 5,000 persons to districts in the intensification step.
Average capacity	Persons/ha	Average density of established districts from historical data; used to dictate growth capacity.
Annual new dwellings	Number of dwellings	Number of new houses and units constructed per year based on historical data during the greenfield development step (Kaye 2009).

Government reaction increase	%	Percentage increment to the number of new residential districts and new provided dwellings for 5 year time step (35%). Used only in adaptive growth scenario.
PAHW dwellings per time step	Number of dwellings	The number of lands and houses provided from the government calculated from historical data for periods of 5 years.
PAHW applications percentage of increment per time step	%	PAHW applications increasing by roughly 15% every 5 years calculated from historical data.
PAHW applications for government reaction	Number of applications	The number of PAHW applications required to initiate the government reaction step which is > 20,000.

3.5 Simulation algorithm

The simulations run according to a sequential algorithm. The algorithm consists of the following steps:

1. *Initialization:*

Initialization involves creating and binding the spatial environment to districts in the GIS, checking the validity of the parameters, loading data for the disaggregate population projections and initializing the model schedule to start in the year 2015.

2. *Preparation:*

This step contains several actions; the main one calculating the suitability of districts for growth and generating an ordered list of districts for processing based upon suitability. Also, setting the infill availability count for developed districts, this checks if they may accept new residents based on capacity. Besides, this step takes the 5 yearly forecast population growths for both Kuwaitis and non-Kuwaitis to be used in the following steps for new population allocation.

3. *Greenfield step:*

Developable districts may be converted to residential or mixed districts as greenfield development. The new developable districts selection process involves identifying a larger set of the best ranked developable districts, about twice as many required for allocation, and these were randomly sorted to reflect that there is some arbitrary uncertainty in the selection process. In addition, the population allocated to districts from the disaggregated 5 yearly population projection depends on the household sizes for Kuwaitis and non-Kuwaitis and district type (residential or mixed). This allocation is run depending on the scenarios:

i) Business as usual where this step selects four residential districts every 5 years and one mixed district every 10 years, which are the historical rates of development for each district type according to data from 1995 to 2014. More specifically, the population allocation for residential districts is: (155 $\text{dwellings}_{\text{Kuwaiti}}$ × 7.5 persons × 5yrs) + (110 $\text{dwellings}_{\text{non-Kuwaiti}}$ × 5.5 persons × 5 yrs) which is approximately 8,800 persons, and for mixed districts it is: (125 $\text{dwellings}_{\text{Kuwaiti}}$ × 7.5 persons × 5yrs) + (1490 $\text{dwellings}_{\text{non-Kuwaiti}}$ × 5.5 persons × 5 yrs) which is approximately 45,600 persons. This means, the new districts are filled by approximately 30% to their capacity and are expected to take more than 5 years to fill completely.

ii) Adaptive rule where the government reacts to the housing shortage problem and increases the number of new residential districts and dwellings (an increment of 35% was found to be reasonable) compared to the last time step. To activate the rule the models does a forward estimate of pending PAHW applications from running the next step (intensification), and if the estimated applications exceed the number of new dwellings it performs the increase of new districts. This represents a more reactive planning process to revise the master plan every 5 years by the Kuwaiti planning authorities. In addition, this step makes one major modification in the greenfield time step, which is to reduce the household size from 7.5 to 4 in the new residential districts. Historical data show that this happens when the government provides new dwellings for Kuwaitis, as they move from their parents' houses or rented dwellings to their new dwellings (shift from extended family to direct family).

4. Intensification step:

This step performs infill to assign population to any district with available capacity. Population is added from the disaggregated 5 yearly population projection by increments of 5000 people (in all districts except those that exceed the average population density) and then it loops through until all population growth has been assigned to a district. If population still exceeds capacity it goes to the spill-over step. This value of 5000 new residents was chosen after testing a range of options (from 500 to 10000) for simulation performance and not violating growth rules and capacity limits. Smaller increments slowed the simulation run time and larger ones violated rules for growth capacity in smaller districts.

5. Spill-over step

Spill-over occurs when there is new population not allocated to any district at the end of steps 3 and 4; in other words, if population exceeds the historical maximum districts' capacities it has to be accommodated with over-spill growth. Therefore, the spill-over population is tracked on a household level in a housing wait list (PAHW applications), and is then temporarily accommodated by increasing the intensification rate for all districts; this occurs often in Kuwait as new families stay with their parents due to housing shortages. Historical data show that there is an increase in the district densities, but there seems to be no regular pattern and hence a flat increase is applied across the districts. The spill-over action is implemented by increasing the maximum capacity rate for all districts by a small amount (0.0001 times existing capacity) and then repeating the intensification step until all the remaining population has been allocated. In simple terms, it allocates residents by repeating the intensification step in small increments. It should be noted that during the second scenario the spill-over step did not run, as there are more available dwellings and new districts than the business as usual scenario.

6. Calculate impacts step

This step produces results for the key impacts: housing shortage (PAHW applications) and traffic congestion. For the housing shortage impact, a simple equation was used to calculate the bending applications and the PAHW provided dwellings for each time step. Additionally, for the traffic congestion impact a regression analysis equation was used to predict the future accidents (for details, see supplementary information- Appendix D). Output maps and figures are programmed to show details about the current state of districts, such as how many districts were developed and how many residents settled in them. This step also ensures that all the new parcels have been created successfully. Figure 4-12 shows a flowchart of both scenarios' model architecture. Besides, a supplementary- Appendix D provides more details on the simulation algorithm for ABM.

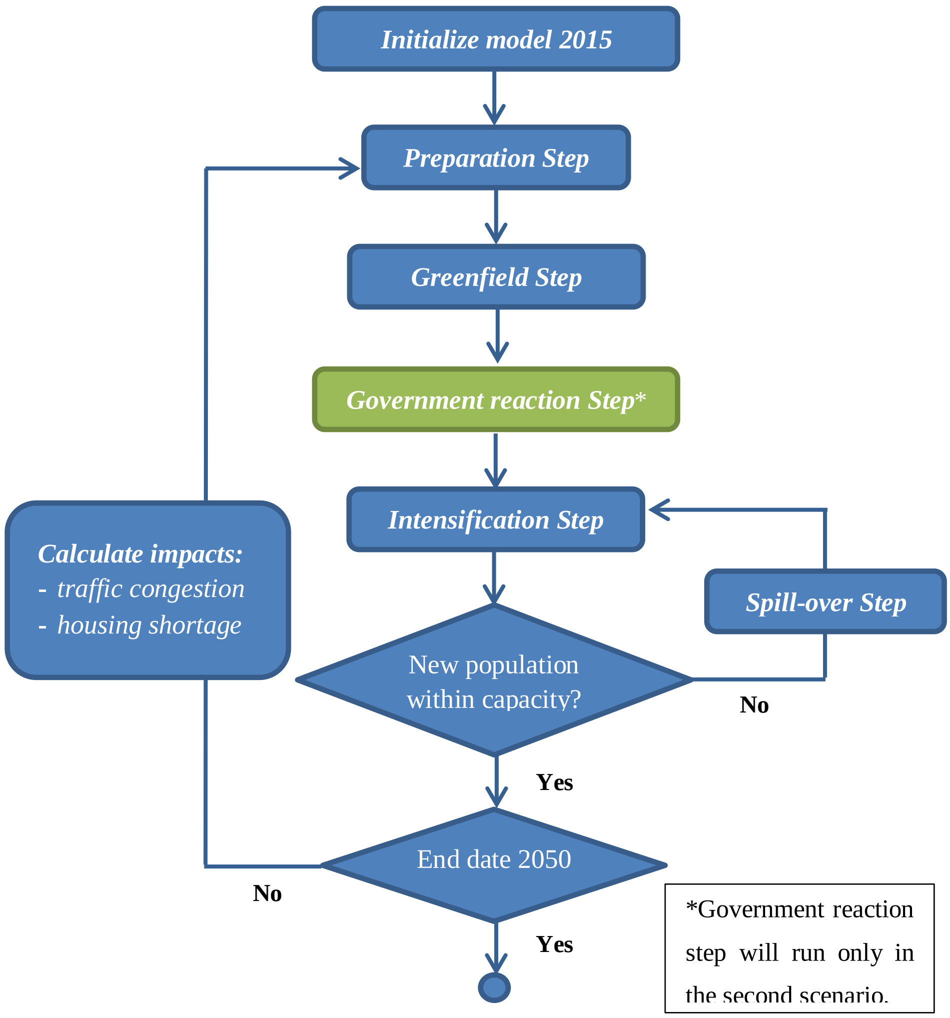

Figure 4-12: Simulation flowchart, including the adaptive step for the government reaction

3.6 Calibration

Calibration of the suitability weights used in the ABM for selecting districts to develop is needed to produce realistic outputs for the historical (business as usual) scenario and avoid biased outputs (Liu 2009; Voorde et al. 2016). The calibration of the ABM was carried out by running the model with 1995 data (Figure 4-13) to predict the spatial pattern of urban growth to 2015 (Figure 4-15), and comparing it with the actual growth pattern in 2015 (Figure 4-14). This was run over 50 times with different parameters to best match the simulated pattern of urban development with the real data. The selection of the parameters was made after considering the availability of existing historical data, past studies and the author's experience from residing in Kuwait. It was found that not all parameters provided significant weighting to produce the best fit of the simulated urban form to the real urban form in 2015, but it should be noted that they will be nevertheless useful in future simulations. Table 4-2 shows the weights of each parameter in the simulations that produced the best fit: 80% similarity of predicted with real urban form in 2015.

Table 4-2: Parameters used for calibration and respective weights for best fit iteration

Parameters	Weights values
Closeness to CBD	1.04
Closeness to coast line	0.5
Closeness to companies	0.01
Cost (rent and sale)	4.4
Closeness to factories	0.01
Closeness to government's offices	0.01
Closeness to hospitals	0.01
Closeness to shopping malls	0.01
Closeness to street networks	0.01
Closeness to universities	0.01
Closeness to the urban area	2
Total	10

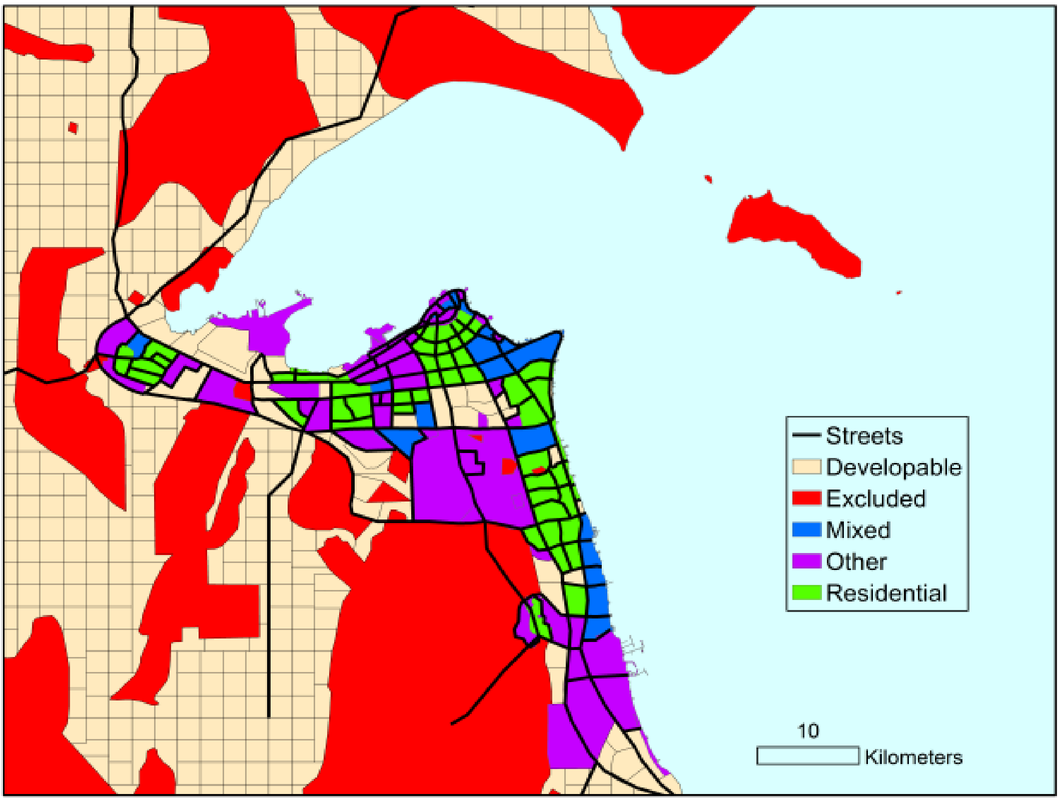

Figure 4-13: Kuwait land use classification in 1995

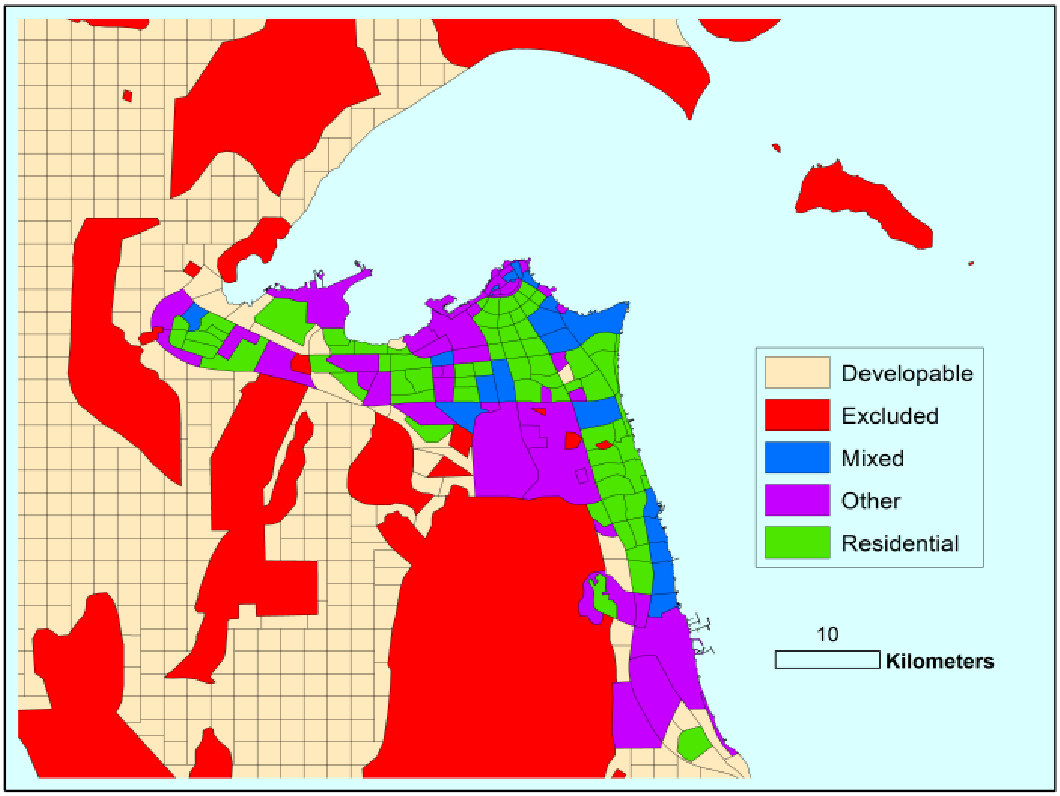

Figure 4-14: Kuwait land use classification in 2015 (real data)

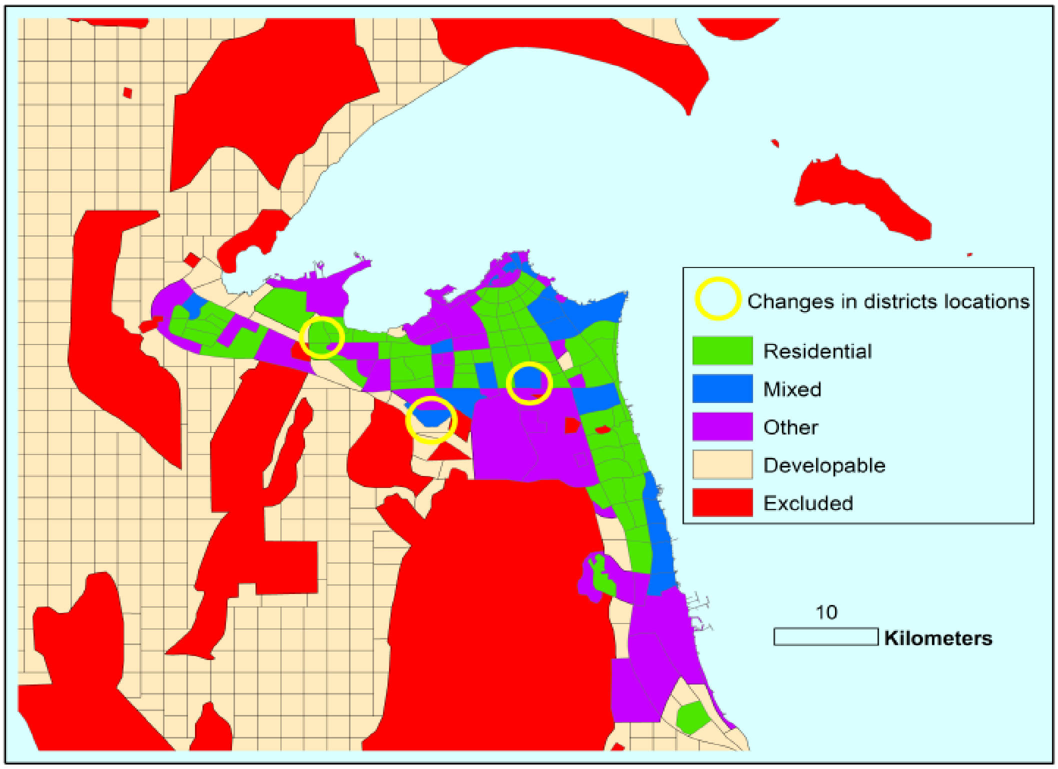

Figure 4-15: Kuwait land use classification in 2015 (simulation outputs)

It is worth mentioning that, while a higher weighting for proximity of mixed development to infrastructure was expected, in the end there was no significant difference in the weights used for allocating residential and mixed districts. The reason was that many of the older mixed districts came about by land conversion of residential districts, as part of a policy to make land available to land developers for investment.

The comparison of population distribution by nationality and land use type between simulations and existing development is seen in Figure 4-16.

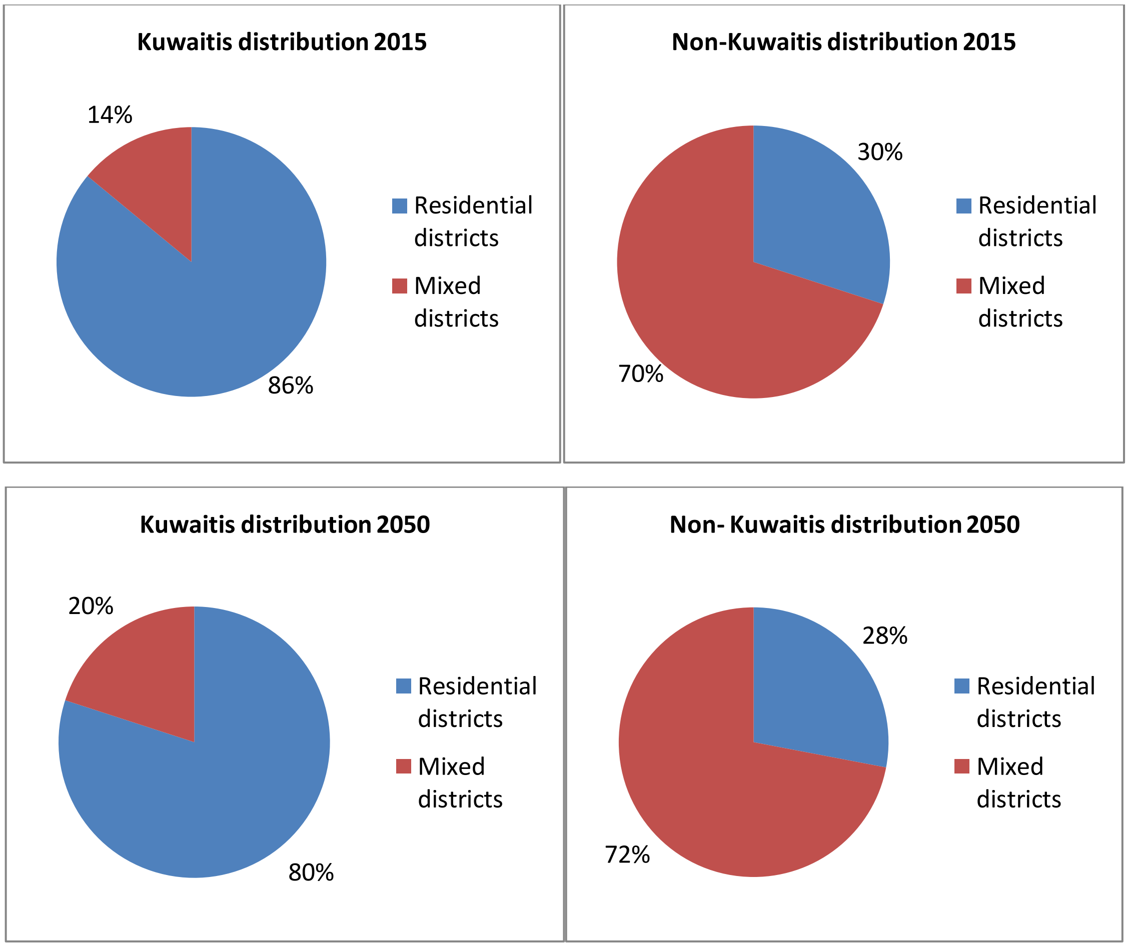

Figure 4-16: Comparison of population distribution and land use for 2015 and 2050 (projected)

4. Results

The results show notable differences between the two scenarios. The outcome maps from the first scenario simulation algorithm reveal that in 2050 there will be 32 new developed parcels (28 residential and 4 mixed districts), and their distribution is shown in Figure 4-17. While, in the second scenario, there will be 45 new residential and 4 new mixed districts in 2050, as can be seen in Figure 4-18.

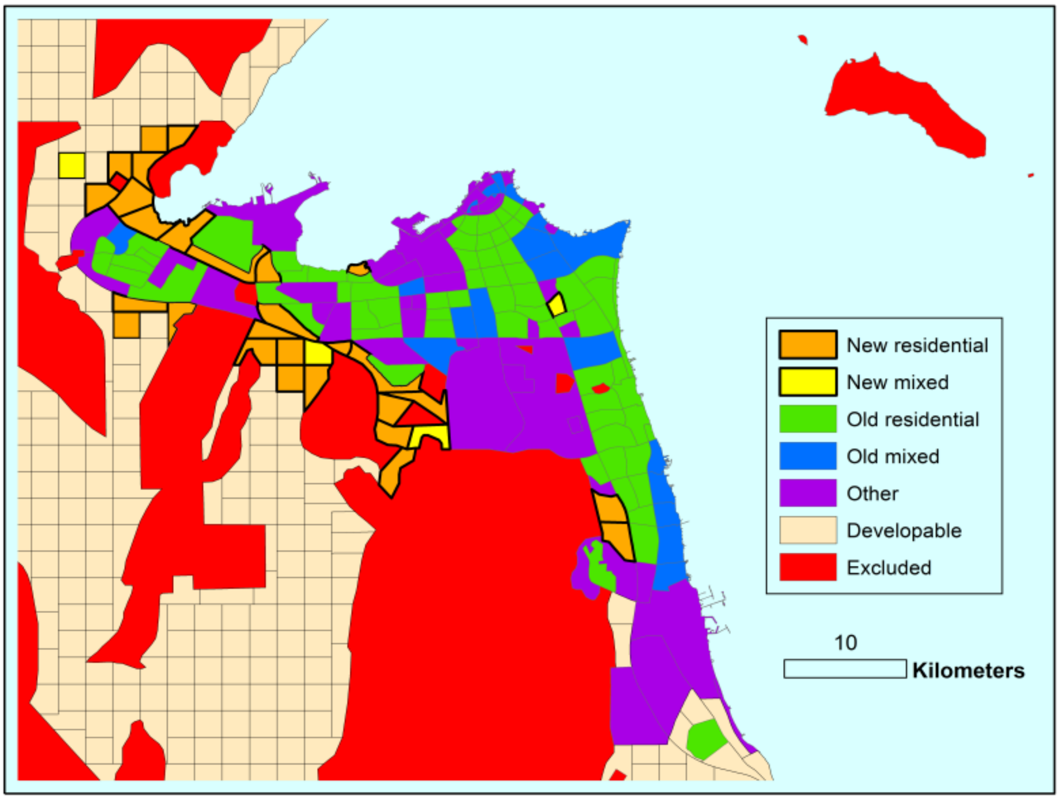

Figure 4-17: Kuwait land use map on 2050 (1st scenario output)

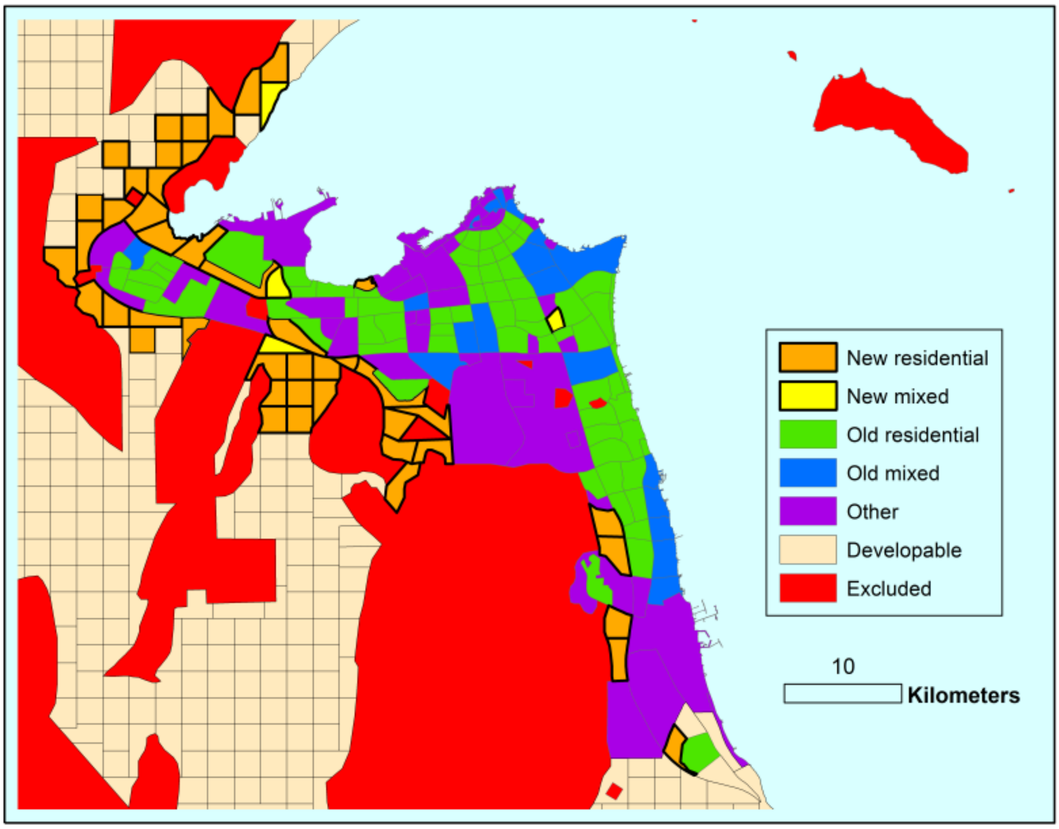

Figure 4-18: Kuwait land use map in 2050 (2nd scenario output)

The population growth appears to occur in the suburbs around the CBD, as most central districts are already very dense. Figures 4-19 and 4-20 show a population difference map compared to 2015 for both scenarios.

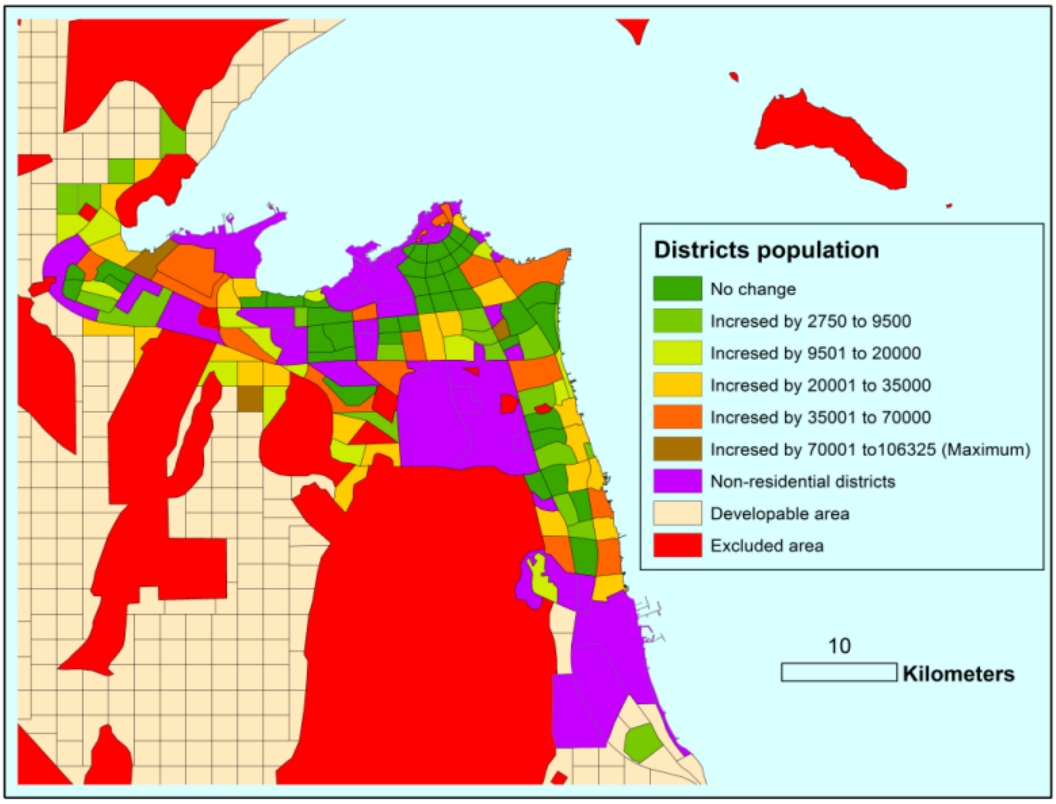

Figure 4-19: Population difference between 2015 (real data) and 2050 (simulation outputs) for 1st scenario

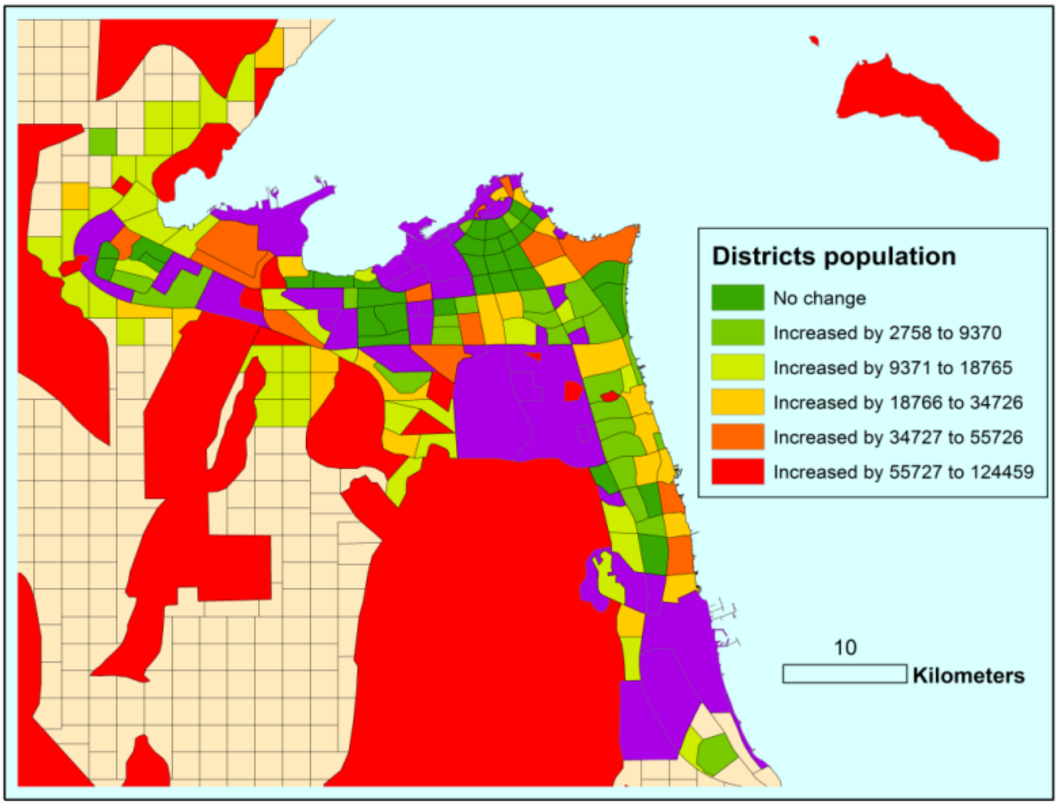

Figure 4-20: Population difference between 2015 (real data) and 2050 (simulation outputs) for 2nd scenario

In both scenarios, for the intensification process, 17 existing districts had significant population added and reached their full capacity. The district with highest population in 2050 was predicted to be Jleeb Al-Shuyoukh, which is currently the highest population district. The district with the lowest predicted population in 2050 will be Al-Bida with a total population of 3722, up from 1132 in 2015. In 2015, the least populated district was Abu Ftaira with total population of 53, and it is expected to host 33251 residents by 2050. North West Sulaibikhat, with no residents in 2015, will host 25011 by 2050. Furthermore, in 2015 the total population was 4 million, which was predicted to reach over 6 million by 2050 based on the KISR projection (Alramadan & Almusallam 2013).

Results suggest that the continuation of the same urban planning scheme for the next 35 years will aggravate the problems of housing shortage and traffic congestion. Housing shortages will remain at 2015 levels, with PAHW applications and dwellings provided by the government increasing by approximately 64% to almost 180,000 in the waiting list and 166,000 as total dwellings offered by the government until 2050 which means the government provided 70,000 new dwellings in 28 new residential districts. However, if the government agent reacts to solve the housing problem (second scenario), the housing shortage problem will be significantly improved by 2050 as the pending applications will only be 11,676 applications as the total dwellings offered by the government until

2050 is almost 302,000 which means the government provided approximately 205,000 new dwellings in 46 new residential districts. The projected waiting applications for both scenarios are shown in Figure 4-21.

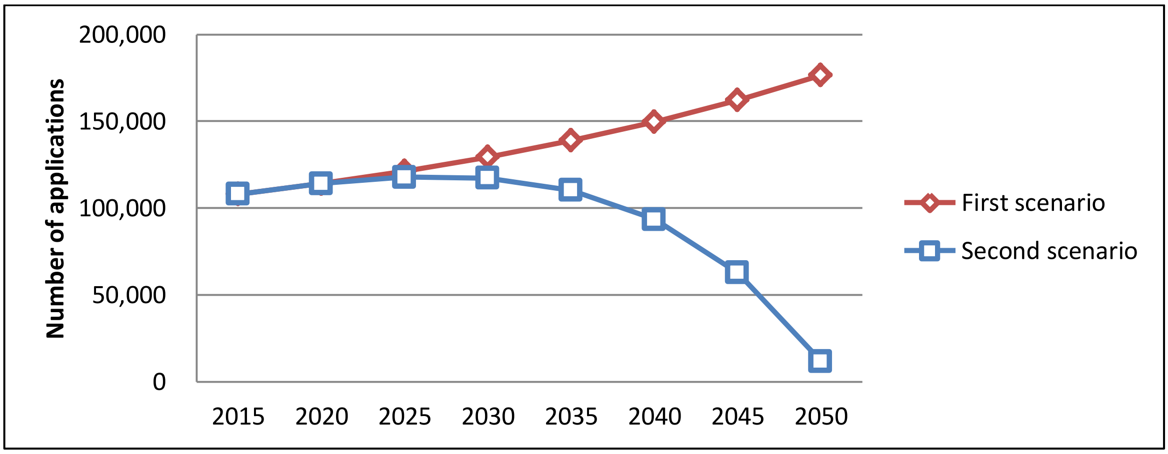

Figure 4-21: Projection of public housing demand in Kuwait to 2050 for both scenarios

On the other hand, accidents as an indicator for the traffic congestion will increase during the period 2014-2050, as more vehicles are expected to be on the streets, to reach almost 136,000. The increase is according to the regression model equation described in section 3.3, and based on a projected population of 6.24 million in 2050 as well as the distribution and number of districts and the level of traffic catchment to Kuwait capital (CBD). In the second scenario, opening more districts will result to increased traffic congestion as indicated by the number of accidents, which will reach 154,750 accidents. This is shown in Figure 4-22.

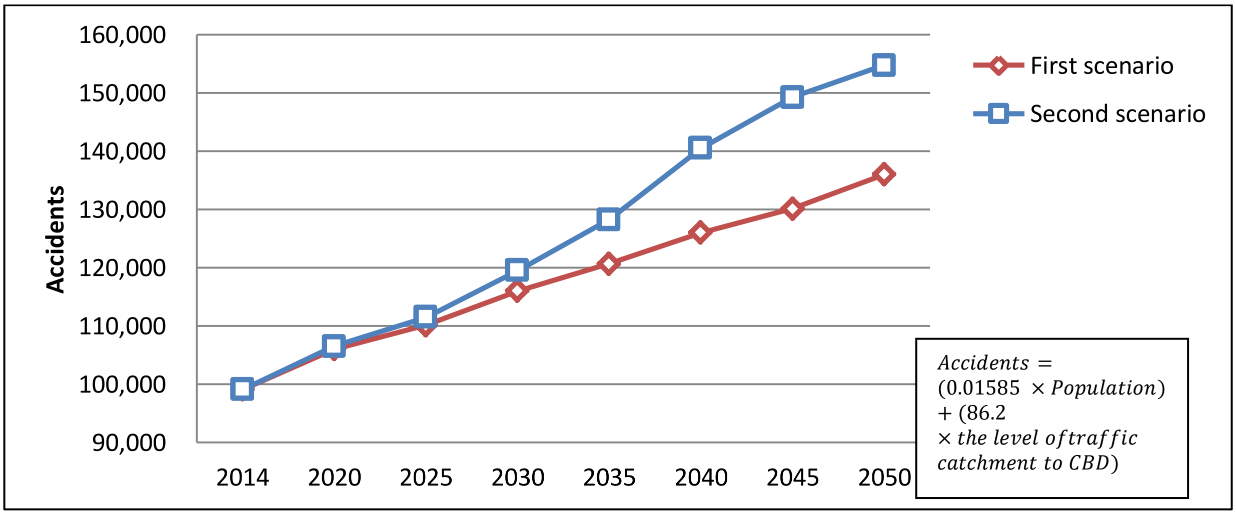

Figure 4-22: Accidents projection from 2014-2050 for both scenarios

The computational requirements for running the simulations were reasonable; each simulation run for our ABM in ArcGIS Agent Analyst ran in less than 5 minutes on an average desktop computer.

The software platforms and ABM extension appear to work smoothly and there were no integration issues.

5. Discussion and conclusions

The purpose of this study is to develop an urban planning tool to assess the impacts of future urban growth in Kuwait, by analyzing and enhancing available socio-economic data for urban modelling and disaggregating it to mapped land use districts classified by their growth capacity. Furthermore, it aims to develop a forecasting ABM to predict urban growth patterns and related growth impacts.

The primary research question of this study is to assess housing shortage with current urban growth policies in Kuwait to 2050, and if a more adaptive policy is better at reducing impacts. Modeling has indicated a positive answer to the research question.

By coupling the models with GIS, simulation results may help to identify and demarcate specific locations for future greenfield development and urban intensification given the existing planning policies. The results showed that if the future growth follows the historical pattern of radial development around the center of Kuwait, housing demand is expected to outstrip housing supply at a slightly higher rate (Figure 4-21), thus aggravating the issue over time. Specifically, families awaiting housing approvals were almost 108,000 in 2015, but will exceed 180,000 by 2050. The housing problem is not expected to be solved in the near future, due to the future uncertainty of oil prices, risk of war in the region and energy renewal developments such as solar power. However, in the second scenario where the government reacts to the housing shortage, the problem could be solved by 2050 according to the simulation results.

Likewise, higher population density means higher accident rates and traffic congestion. Urban sprawl and intensification, without addressing transportation issues, will lead to a significantly worsening situation; approximately 136,000 accidents are estimated in 2050. In the second scenario, when the government became more reactive to solve the housing problem by releasing more districts, this causes more urban sprawl with more impacts on the traffic congestion as there will be an increase in the number of projected accidents (154,750) in 2050. As mentioned earlier, the traffic congestion is more complicated issue compared to the housing shortage and it requires more data collection and analysis to fully understand.

These results represent development according to a ‘business as usual’ scenario following historical trends. Although this approach is not completely innovative from a modeling perspective, it does highlight important outcomes. In particular, it highlights that housing shortages, traffic congestion and accidents are not just a temporarily worsening situation in Kuwait and, without making significant changes to future urban plans and growth policies, the situation may get dramatically worse. The proposed approach for disaggregating national demographic data and using the ABM could be used to assess alternative urban plans and growth policies related to settlement and transportation that may address the negative impacts.

From a technical perspective, the proposed approach for disaggregating socio-economic data to simple spatial types worked adequately in modelling future growth. For instance, by classifying districts according to their development status (undeveloped, greenfield and intensification) it was possible to disaggregate national figures for population growth and allocate growth to districts based on their development capacity. The use of districts in ABM spatial environment worked well to relate land use to urban activities and infrastructure, and formed the basis for developing a suitability model for selecting new development and allocating the disaggregated population.

The use of an ABM for modelling urban growth also worked according to expectations. Autonomous agents included decision makers that define the processes and interactions through which growth occurs on the environment (districts) representing the spatial context of urban growth. In this paper, the model design contains features such as adaptation, objective, prediction, stochasticity and observer variables. A description of the model design based on an ABM protocol (Grimm et al. 2010) is given in the supplementary Appendix D.

Among the issues encountered was that the use of a suitability model and historical allocation weights were not adequate for representing policies that encouraged land use conversion over time. Trend data alone cannot model future land use conversion; however, the ABM allows one to speculate on conversions. The same could be said for the way land use was related to the demographic composition of districts between Kuwaitis and non-Kuwaitis. The demographic makeup of district types was captured well, but not the interactions that occur as lack of housing becomes acute and people make decisions based upon family connections (mostly for Kuwaitis) and affordable housing (for Kuwaitis and non-Kuwaitis).

A major limitation of the proposed model is the assumption that infrastructure remains unchanged over the simulation period. While this is clearly not likely, it was a necessary assumption in order to keep the complexity of the model at reasonable levels. Future work may enhance the validity of the simulations by adding dynamic infrastructure changes, which are expected to affect land use by 2050. Another limitation of the model design was that particular agent interactions, such as competition between land development agents, was not included. This is reasonable as in Kuwait the government, now and in the near future, has a strong influence over land development including private sector involvement.

With the results of the ABM simulations in hand, it will be possible to propose changes to the current center-focused approach for urban expansion in Kuwait, and to offer alternatives such as a multi-nucleated urban form as it is proposed in the new master plan, 2030 in Kuwait. Future work will seek to obtain further data on the public opinion for problems of traffic congestion and housing shortages, and their preferences for future urban plans for Kuwait. Moreover, interviews and surveys will be held with decision makers (government planners), the private sector (developers and investors) and residents (Kuwaitis and non-Kuwaitis) for a better understanding of their behaviors, to enable rules for land use conversions and interactions to be set.

Chapter findings

This chapter initially helped identifying the key decision makers affecting urban growth in Kuwait in the past, namely the government planning authorities, as identified in section 2.2. Traditionally, the government controls urban growth with decisions and policies contained in their master plans. It was found that the private sector and the community both have minimal engagement and effect in urban development decisions.

This chapter also identified the future growth impacts in Kuwait if existing trends of expansion around the existing urban area were to continue. The results showed that expanding urban areas according to historical trends, then the traffic congestion and housing shortage will be aggravated over time. This necessitates examining other possibilities of urban development, such as creating new cities.

The simulation of the business as usual expansion confirmed that the existing social, economic and land use data in Kuwait may be used in urban automata models to predict growth patterns and subsequent impacts after they were better mapped, disaggregated and spatially integrated. This is a somewhat unexpected result, given that no prior studies have been proposed for predicting urban growth and its impacts in Kuwait. The proposed predictive model can be used for simulations of alternative scenarios. The simulations findings indicated the importance of using and integrating urban modelling tools in the planning process, instead of relying solely on conceptual designs and statistics, which has been the case with previous master plans in Kuwait.

For more information on the model algorithms, the ABM codes and data the reader may refer to Appendix D.

Chapter 5 : Projection for new city future scenarios- A case study for Kuwait

Chapter outline

This chapter contains the research to model urban growth and its impacts in Kuwait according to the master plan 2030. The work presented in this chapter continues to be aligned with the overarching theme of the thesis; specifically it enhances both the conceptual understanding of the factors of urban growth and the practical applicability of urban modelling in addressing existing and future issues. The content is based on an article published in Heliyon Journal. The findings contribute towards addressing the following research questions:

1. Who are the key decision makers affecting the development of the most recent master plan in Kuwait?
2. What are the main impacts of growth according to the Kuwaiti government and residents?
3. How will urban growth according to the new master plan affect the impacts identified in the previous question?
4. How well can automata (ABM) simulate existing and future urban systems, based on master plan policies and guidelines?

The research highlights of the chapter include:

i) Identifying the key urban growth impacts that concern the authorities and residents in Kuwait and influence their decision making, namely traffic congestion and state founded housing shortage.
ii) Assessing the effectiveness of the construction of new cities that will be applied in the new master plan, in addressing the traffic congestion and housing shortage.
iii) Examining the effects of any delays in construction or infrastructure projects effectiveness in addressing traffic congestion and housing shortage.

Projection for new city future scenarios- A case study for Kuwait

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Abstract

The creation of new cities is a planning approach adopted in several regions around the world, in order to accommodate urban growth. New cities are typically constructed according to well-thought out, centralised plans in areas without any prior development. However, whether the development of these new cities is able to address existing urban issues more effectively than traditional methods such as intensification, is currently an unanswered research question. Several Arabian Gulf countries, such as Kuwait are considering the construction of new cities to address urban issues, specifically the traffic congestion and housing shortages. In Kuwait, the master plan for these construction projects was developed solely by state authorities without any public participation or urban modelling that may have provided a more well-rounded view of the potential impacts and effectiveness.

This paper aims to address these research opportunities of investigating the effectiveness of new cities in addressing traffic congestion and housing shortage, as well as the potential to integrate public opinions in urban development in the form of a model. Towards that end, the study proposes an Agent Based Model (ABM) that will allow simulating the population distribution and urban growth impacts of new cities in Kuwait by 2050. The methodology involves collecting primary data via interviewing the key government stakeholders of urban development and surveying the residents in order to collect the model inputs. In Kuwait's society, citizens and non-citizens form two distinct resident groups with often very diverse needs and lifestyles; hence the survey responses will differentiate between them. The data from the interviews and surveys from both resident groups will be incorporated as agent behaviours in the ABM. The simulations examine a multitude of scenarios for the new cities, involving construction delays and infrastructure project delays. The

results indicate that the impacts of constructing new cities will be favourable across all different scenarios in terms of alleviating the traffic congestion and housing shortage compared to a business as usual approach of existing urban centre expansion. Furthermore, the survey responses confirm that the resident perspectives closely align with the government's priorities in the master plan for the new cities, further improving the chances for the successful project implementation. The methodology and findings may be applied in cities in the Gulf area or elsewhere with similar urban issues.

1. **Introduction**

Urban growth is a result of the global population rising and the ever-increasing appeal of cities to house the majority of people (United Nations 2015). Cities offer a significant range of opportunities and life quality improvements to their residents; however, living in a city is not without any challenges. Among the most common issues city-dwellers have to face globally are traffic congestion (Glaeser & Kahn 2004; Duranton & Turner 2012), low housing affordability (Chen et al. 2011; Isma'il et al. 2015), social imbalance (Farber & Li 2013; Zhao 2013; Pereira et al. 2014) and environmental degradation (Irwin & Bockstael 2004; Seto et al. 2010; Sypharda et al. 2011; Arouri et al. 2012; Seto et al. 2012). The physical shape of a city, or urban form, and the ways it expands directly affect the severity of these issues (Broitman & Koomen 2015). As such, there is a growing research interest in the field of urban systems on how modern cities grow and expand; for instance, the mobility patterns of city dwellers and the commute times are strongly correlated to the spatial patterns of existing and new residential developments (Camagni et al. 2002).

While the ways cities grow differ according to their geographic location, history, political and economic conditions (Kaiser et al. 1995), they tend to follow similar patterns. Urban growth may manifest as outward radial expansion of the urban form (Biddle et al. 2006; Newton 2010) or upwards as urban intensification of existing districts (Melia et al. 2011). Intensification is associated with increasing the population density in existing city districts, for instance through the construction of high rise buildings (Broitman & Koomen 2015). This results in a more compact urban form, which is often considered more desirable than outward expansion (Bronstein 2009; Caragliu et al. 2011; Echenique et al. 2012). Some of the stated benefits of intensification are: easier access to the workplace and public services, lower car dependency, avoiding costs for extending transport infrastructure, reduced degradation of the local environment and lower levels of residential segregation (Dieleman & Wegener 2004; Crooks 2010; Newton 2010). An alternative to within-city urban expansion or intensification is through the creation of new satellite cities at the periphery of existing centres (Wang et al. 2011). The main advantage of new cities is that they may be better planned and balanced according to the needs of a growing population. For instance, transport constraints in older cities with road connections and infrastructure that cause severe traffic congestion may be addressed with planned new cities. Figure 5-1 illustrates different types of urban growth and the resulting types of cities.

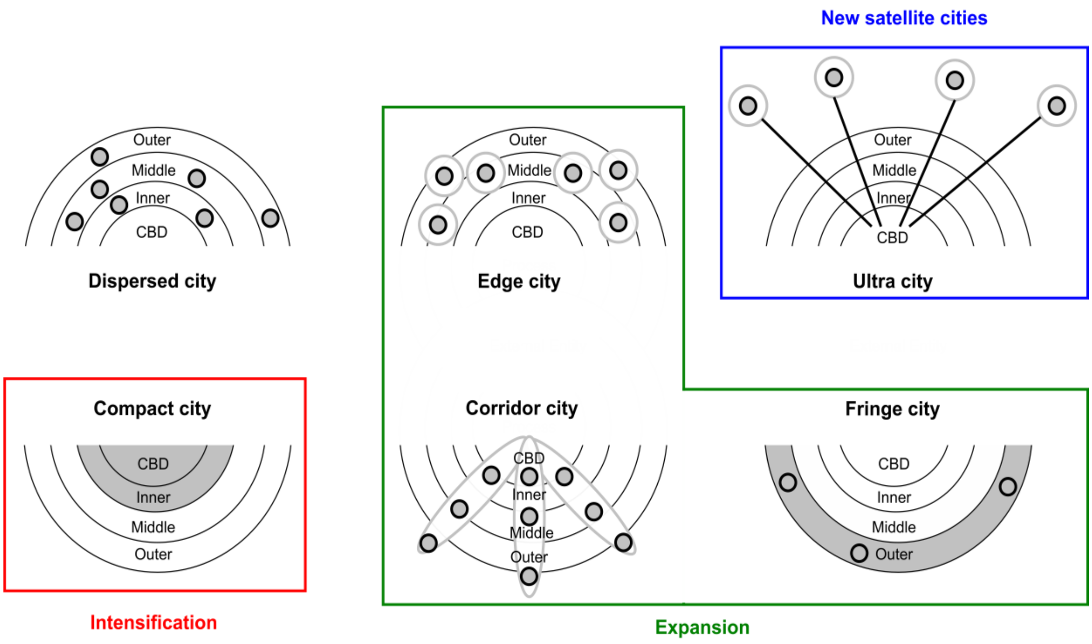

Figure 5-1: City types based on urban growth types adapted from (Petersen 2002).

New satellite cities are developed for a number of reasons: i) establishing a new capital such as Putrajaya in Malaysia and a proposed capital in Egypt (Moser 2010; Monks 2016), ii) creating new residential districts to accommodate urban growth, and iii) developing special purpose districts for financial, tourism or entertainment activities like in Qatar and Dubai (Tok et al. 2015).

New cities may be linked to existing ones via public transportation systems, such as train or light rail (Campos & Rus 2009). Train connections have several advantages such as reliability, fast average commute speed and less pollution compared to motor vehicles; and are considered vital for the successful integration of new cities (Dun 2014). However, constructing new cities also has risks; such as the high initial capital cost and their viability for attracting enough new residents (Moreno & Blanco 2014). Furthermore, new city projects are sensitive to delays, commonly associated with large construction projects, such as from budget limitations, shortage of labour, poor scheduling or unfavourable weather. These delays may prove to be detrimental to the success of a new city and its planned benefits (Al-Tabtabai 2002; Assaf & Al-Hejji 2006; Singh 2010; Soliman 2010) Therefore, it is imperative to carry out extensive modelling about the feasibility of new cities and potential issues in order to minimise the risks.

Urban simulation has been used in many instances for both new and existing city development to empirically analyse future impacts (Waddell 2002; Sivakumar 2007; Batty 2009; Liu 2009) and to predict future spatial trends of urban and population growth under various scenarios (Batty 2007; Crooks & Castle 2012). In order to simulate urban growth, urban models typically need various types of disaggregated data related to land use, population, infrastructure and transportation (Batty

2012). Additionally, data on population mobility and settlement patterns is needed to model the dynamic aspects of urban growth (Camagni et al. 2002). Consideration of urban dynamics is important in order to model the way cities evolve as a result of the collective interactions of individuals and the urban environment (Benenson & Torrens 2004). The ability to collect data related to urban dynamics and use them in models, gives rise to the concept of "smart cities". In smart cities information about transportation patterns, population and resource flows can be gathered from buildings, individuals and corporations and used as feedback in urban models to further improve the efficiency of existing urban systems and simulate the effects of different expansion scenarios (Rodríguez-Núñez & Periáñez-Cañadillas 2016).

In the literature, most case studies of urban modelling are for cities in Europe, the US or East Asia. However, cities in the Arabian Gulf countries experience rapid urban growth too, and issues related to traffic congestion (Rizzo 2014; Aldalbahi and Walker 2015), housing shortages (Alshalfan 2013) and segregation by nationality between Arab citizens and foreign workers (Khalaf 2006; Gardner et al., 2014) are becoming more dirsuptive. Traditionally urban planning is guided by conceptual approaches in Arabian Gulf countries, and lack data analysis and modelling to predict outcomes (Abu-Ayyash 1980; Rizzo 2014; Alghais & Pullar 2017a). In addition, there is a lack of consultation with residents, and hence little to no information about the concerns of residents and their preferences of how new development is planned. Urban development has followed a business as usual approach resulting in greater urban expansion, which has not addressed existing urban issues and lead to further deterioration of urban liveability. For instance, previous research for Kuwait (Alghais & Pullar 2017a) has shown that if the current trends of growth persist then traffic congestion and housing availability issues will be aggravated; and that modelling provides a means to make planning adjustments to avoid these issues. The key issues identified are: limited number of public transportation options (currently only bus), high car dependency, and government housing policies that limit the choices for new housing (UNDP 2009; Alshalfan 2013; Al-Nakib 2014a; Dakkak, 2016).

This paper presents a new urban simulation model that is used to investigate whether establishing new cities may solve the current urban issues in Arabian Gulf countries. This is a contemporary question as many Arabian Gulf countries plan to establish new cities in the near future (Gulf News, 2010; Rizzo 2014; Summers, 2016). Kuwait is used as a case study as the government plans to establish 12 new urban centres that will be independent from the sole existing urban area of Kuwait City (Keay 2012). Figure 5-2 shows a map of Kuwait and the new proposed cities locations according to the new master plan. The paper will simulate the development of the new cities in the master plan to model balanced growth and assess impacts.

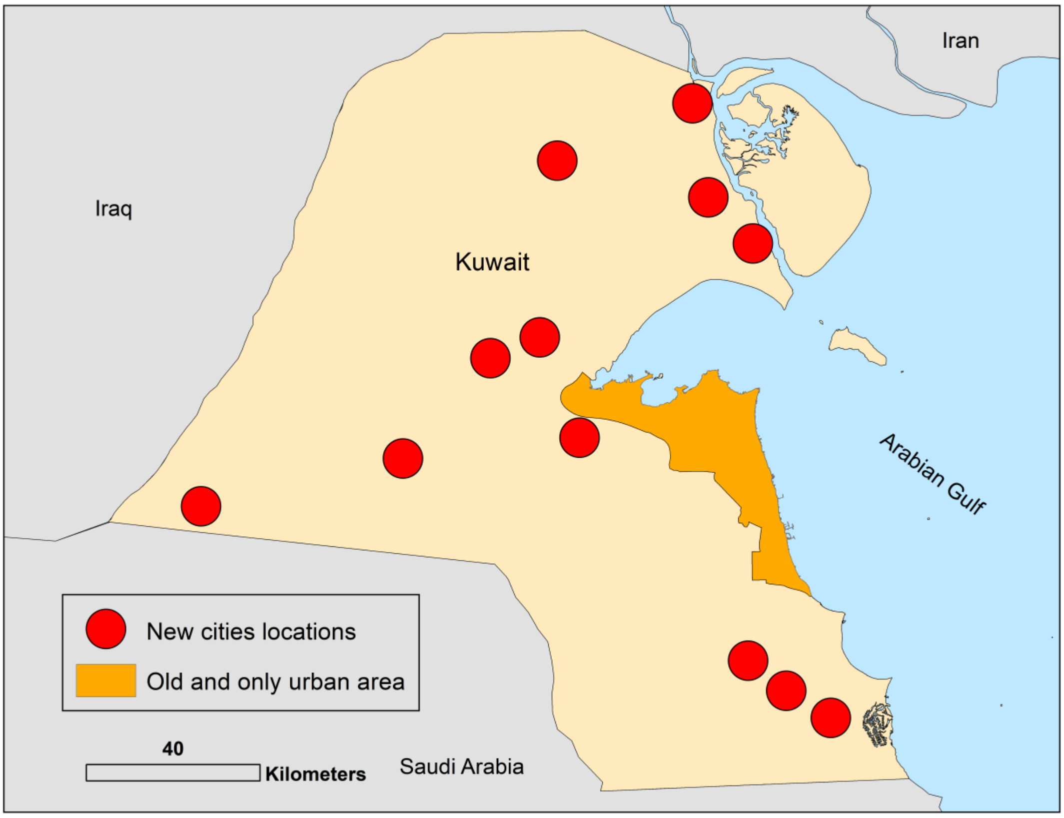

Figure 5-2: Kuwait map and new cities locations.

The proposed model uses disaggregate urban data, a survey of residents and interviews with key stakeholders as inputs to simulate new cities and minimize negative growth impacts. The primary research questions formulated in this paper are:

a. What are the key issues of urban growth that affect future planning and concern the local government and residents in Kuwait?
b. Will establishing new cities be more effective in solving these key issues compared to expanding existing urban areas?
c. What are the main concerns related to the new cities projects according to the planning decision makers in Kuwait?
d. How can residents that are willing to move to the new cities be allocated?

It is worth mentioning that the work presented in this study is an extension of a published conference paper (Alghais and Pullar 2017b).

2. Materials and methods

2.1 Interviews with key decision makers

In Kuwait there is only limited public information on the key political and economic forces that shape urban growth, therefore we undertook interviews with government officials and private sector representatives to understand the perspectives of urban decision makers. Surveys given to targeted participants and their responses helped in understanding the role of the state and private sector in developing urban plans. The questionnaires were developed with closed-ended questions in English and Arabic. Additionally, the interviews assisted with identifying the main perceived negative impacts of urban growth according to the government, and any concerns for the new cities projects. Finally, the process enabled the collection of state data that were not available in government official websites.

The participants (13 in total) were important decision makers representing the key planning ministries and organisations in Kuwait; these included the Kuwait National Assembly (Parliament), Kuwait Municipality Council, Ministry of planning, Kuwait Central Statistical Bureau, Traffic department- Interior Ministry, Council of Ministries General Secretariat, Oil Ministry, Public Authority for Housing Welfare and Ministry of Public Works.

In addition, representatives from the private sector (4 in total) were also interviewed, specifically General Managers or Companies Executive Officers (CEOs) from construction and consultation companies, real estate developers and traffic consultancies.

The findings from the interviews are summarised in Table 5-1.

Table 5-1: Summary of interview key findings

Question	Summarized Response
What is the planning approach in Kuwait and what is the role of the authorities in the planning process?	The main planning approach is based on the master plan and the role of the authorities is distributed according to disciplines. Final decisions are made by the Council of Ministries.
What are the main concerns about the development of new cities?	There is lack of cooperation and coordination between the planning authorities. The government fully controls

	the funding for the new cities. There are concerns about potential delays in train and new cities construction.
Is the plan modelled or evaluated by any tool?	There are no simulations or modelling tools used to evaluate the new plan.
What is the role of private investors in the projects?	Private sector's role is limited to consultations and projects execution.
What is the role of residents in the projects?	The resident perspectives are not taken into account and there is no future plan for community participation.
What are most important urban issues?	Housing shortage and traffic congestion.
What is the importance of new cities in solving the issues?	New cities are expected to solve the housing shortage and traffic congestion issues.
What is the plan for public transportation?	There is no plan for upgrading or expanding the existing bus system. A new train system will be established to link the existing urban area with the new cities. The planning authorities are doubtful on the government's willingness on establishing the train network.
Will nationality segregation be addressed in the new plan?	There are no plans to address segregation in the new cities.

The interviews showed that traffic congestion and housing shortages are the main officially recognized urban issues, and these are intended to be solved with the latest master plan. However, there is neither quantitative assessment nor modelling to verify this. There was also the possibility of project delays for establishing the train network and new city construction, and concern on what consequences this may have. These concerns were shared with those interviewed in the private sector, but it was confirmed that they had a minimal role in developing the new master plan and influencing its execution.

For these reasons, we decided to develop an urban simulation model that could run multiple scenarios to model urban growth as urban intensification in Kuwait city along with developing new cities at locations identified in the master plan without expanding the existing urban area. The simulation needed to be able to assess impacts on traffic congestion and housing shortages as new cities are opened and better train transport is made available; and additionally to assess the effect of delays from projected completion dates in the master plan. More details on the modelling and scenarios can be found in later section 2.3.

The simulation model is driven over time with official estimates of population forecasts and movement of people in line with historical settlement patterns, but it was also important to obtain data from people on their concerns and preferences on places to live. The next section describes a survey of people living in Kuwait, both Kuwait citizens and the larger non-Kuwaiti work force without national citizenship. This information is used along with the historical settlement patterns to allocate people to the new cities as new population growth and existing population movement.

2.2 Survey with people

As the new cities were planned mainly for residents, the authors decided it was necessary to survey them. In the surveys, citizen and non-citizen residents were treated as separate groups. The citizen group was the primary group for simulating the housing shortage impact, as the problem is mainly related to them. On the other hand, the traffic congestion is a problem that affects both citizens and non-citizens.

The survey extracted resident opinions and preferences for settling in new districts based on suitability weights collected directly from both groups. Residents below 18 years old and non-citizen servants were excluded from the survey, because they are not the decision makers and in most cases they can only follow their parents or employers. The survey was written for Arabic and English speakers. The whole process was online and delivered through social media such as Twitter, Instagram and WhatsApp, as these application networks are used extensively in Kuwait (Tawfik et al. 2015). More than 2000 invitations were sent with an expected response ratio of 20% (Smith, 2013) to statistically achieve a design confidence level of 95% (+/- 5% margin of error) and standard deviation of 0.5.

The survey stayed open for 2 months. During that time, 879 responses were collected from Kuwaitis, which provide a 3% of margin of error, whereas 406 responses were collected from non-Kuwaitis, which provide a 5% of margin of error (Barlett et al. 2001). Table 5-2 shows a summary of the survey respondents.

Table 5-2: Survey respondents' data sheet

Classification	Nationality	
	Citizens (Kuwaitis)	Non-citizens (Non-Kuwaitis)
Number	879	406
Gender	Male: 52% Female: 48%	Male: 71% Female: 29%
Age	<18-34: 53% 35-49: 29% 50->60: 18%	<18-34: 60% 35-49: 29% 50->60: 11%
Employment status	Student: 16% Employed: 64% Unemployed: 3% Retired: 13% Other: 4%	Student: 27% Employed: 59% Unemployed: 4.5% Retired: 0.5% Servants: 5% Other: 4%
Monthly income*	< 500 K.D: 11% 500-999 K.D: 18% 1000-1500 K.D: 33% > 1500 K.D: 38%	< 500 K.D: 46% 500-999 K.D: 37% 1000-1500 K.D: 12% > 1500 K.D: 5%
Marital status	Never married: 30% Married: 63% Divorced: 6% Widower: 1%	Never married: 38.5% Married: 55.5% Divorced: 4% Widower: 2%

Educational background	Less than bachelor degree: 25% Bachelor: 61% Post graduate degree: 14%	Less than bachelor degree: 36% Bachelor: 53% Post graduate degree: 11%

*****1K.D = 3.3 USD

The main findings from the survey are summarized in Table 5-3.

Table 5-3: Summary of survey key findings

Question	Summarized Response
What are the two most important urban issues in Kuwait (in descending order of importance)?	For citizens: 1- Housing shortage 2- Traffic congestion For non- citizens: 1- Traffic congestion **2-** Housing shortage
What is the time in years you had to wait to obtain a dwelling from the government? (Kuwaiti group)	The average time was 10 years.
Can residents buy a new house by themselves without using PAHW?	93% of Kuwaitis disagree and claim that house prices are unreasonably high.
Is there a housing shortage problem in Kuwait?	75% agree that there is a housing problem.
Is the waiting time for PAHW applications reasonable?	87% disagree, and claim that the waiting time is not reasonable.
Should public opinion be considered for new development and planning decisions?	85% of residents (citizens and non-citizens) believe their opinion should be considered.

What is your current preferred commuting mode? (own vehicle, bus, taxi, walking, cycling or motor cycling)	99% of citizens' said that they preferred to use their own vehicle. 89% of non-citizens said that they preferred to use their own vehicle.
What is the average time delays due to traffic congestion when commuting?	18 minutes.
Is traffic congestion perceived as serious problem in Kuwait?	94% of total residents agree.
Is there congestion even outside working hours, for example at night?	86% of total residents agree.

The survey confirmed that the main negative impacts resulting from urban growth and affecting residents are traffic congestion and housing shortage. This finding is aligned to the government planning authorities' response.

It was noted that the majority of residents were interested in being involved in the planning process. However, the government does not intend to involve them in its near future plans. The main reason behind this is the high degree of centralization in decision making processes in Kuwait (Madbouly 2009). However, a more detailed analysis of the reasons of low public involvement in Kuwait is beyond the scope of this study.

Moreover, it was possible to extract information about the citizen and non-citizen groups to be used as inputs in the model. The main behaviours for citizens and non-citizens can be seen in Table 5-4.

Table 5-4: Resident behaviours according to the survey responses

Behaviours	**Residents groups**	
	Kuwaitis	**Non-Kuwaitis**
Preferred district type	88% prefer to live in residential districts.	52% prefer to live in mixed districts.
Movement to the new cities	38% of residents plan to move, 24% do not plan to move whereas 38% of them are neutral or don't know.	

Time spent on current dwelling	60% of residents have been in their current residence location for more than 5 years.
Future train user %	70% of residents would like to use the train system in their future trips after it established in the future.
Nationality segregation	44% of residents prefer to live in more segregated districts, whereas 28% of them prefer to live in less segregated districts.
Suitability parameters rankings	1- Land value 2- Closeness to the old urban areas 3- Closeness to new cities CBDs 4- Closeness to street networks 5- Closeness to train stations 6- Closeness to airports

From Table 5-4 it is can be seen that there are plenty of residents willing to move to the new cities and use the train system in the future. Details about the suitability parameters that will be used to model the resident allocation in the new cities can be found in section 2.5.

It should be noted that this project's interviews and surveys were approved as complying with the Australian National Statement on Ethical Conduct in Human Research and University of Queensland Regulations in 16/2/2016. Furthermore, based on the responses collected from both the government and residents it was clear that there is a necessity to simulate the new cities approach and assess it in terms of its potential to solve the main urban issues. In addition, the model can help with understanding to what extent the negative impacts may be reduced with the new train network and examining how delays in construction projects may influence the future key negative impacts.

2.3 The urban model

As discussed earlier, there are several urban simulation tools developed to simulate and predict future urban growth, such as Land Use and Transportation Models (LUTM), Cellular Automata (CA) and Agent Based Models (ABM) (Sivakumar 2007; Batty 2009). Each of these models has its advantages and disadvantages in terms of simulation flexibility and complexity (Goetzke 2014; Crooks 2015). In this study, it was necessary that the model would be able to simulate new cities and residents movements, as well as assess future negative impacts (traffic congestion and housing shortage) in the case study area. Based on the interview responses and resident surveys, it was obvious that the model in this study should be able to simulate top-down driven urban growth as dictated by the master plan. In addition, it should allow residents to be allocated according to bottom-up rules that can be derived from their preferences for settlement and movement to the new cities. Additionally it should be able to simulate the group interactions between each other and with the land use.

Thus, Agent Based Models (ABM) was selected. ABM has been widely advocated in urban planning research (Benenson 2004; Beuck et al. 2007; Gaube & Remesch 2013; Murray-Rust et al., 2013; Jordan et al. 2014). The agents represent different groups that function autonomously and can make independent decisions, as well as interact with other agents and their environment (Aliaga 2012; Crooks & Heppenstall 2012). In ABM, agents may be groups such as residents, developers or urban planners (Crooks 2015), and the environment is the land on which changes occur. Urban development is a process administered through the decisions of planners (Knox & McCarthy 2012), who may be simulated easily as an agent group in ABM. Furthermore, interactions with the changing urban environment are carried out by different groups according to their needs and priorities.

There are certain rules that affect agent behaviour and their relationships with other agents and their environment. These rules are typically based on ‘if-else’ statements that are activated when a specified condition has been met. Agent actions can be standardised and “learned” by the simulation framework, making the agents autonomous. Scheduling agents’ behaviours takes place synchronously or asynchronously over a period of time that could be from seconds to decades (Crooks 2015). The environment within agents live, commute and interact can be analysed at various spatial scales, as well as over different time frames. In this model, the environment is the land use districts.

The benefits of ABM include its ability to model local interactions within dynamic urban systems from a bottom-up perspective and its flexibility in terms of geospatial model development (Crooks & Heppenstall 2012). Therefore, the agents affecting urban planning in the simulations of this work may be seen in Table 5-5.

Table 5-5: Agent groups used in the simulations

Agent group	Actions	Behaviours/ Rules
Government planning authorities	Responsible for urban planning and the development of new districts and transportation infrastructure. Opening new dwellings for the citizens group.	Based on new master plans policies and data collected from interviews.

Citizens (Kuwaitis)	Moving from older to new districts. Applying for housing from the government group.	Prefer to settle in residential districts (surveys).
Non-citizens (Non-Kuwaitis)	Moving from older to new districts.	Prefer to settle in mixed use districts (surveys).

The ABM described in this work was combined within ArcGIS by using Agent Analyst extension ArcGIS (Johnston 2012) that has been a staple in similar research studies (Robinson et al. 2013; Dahal & Chow 2014; Haslauer et al. 2015). The simulations will run in seven 5-yearly time steps between 2015 and 2050, Figure 5-3 shows the model design flowchart.

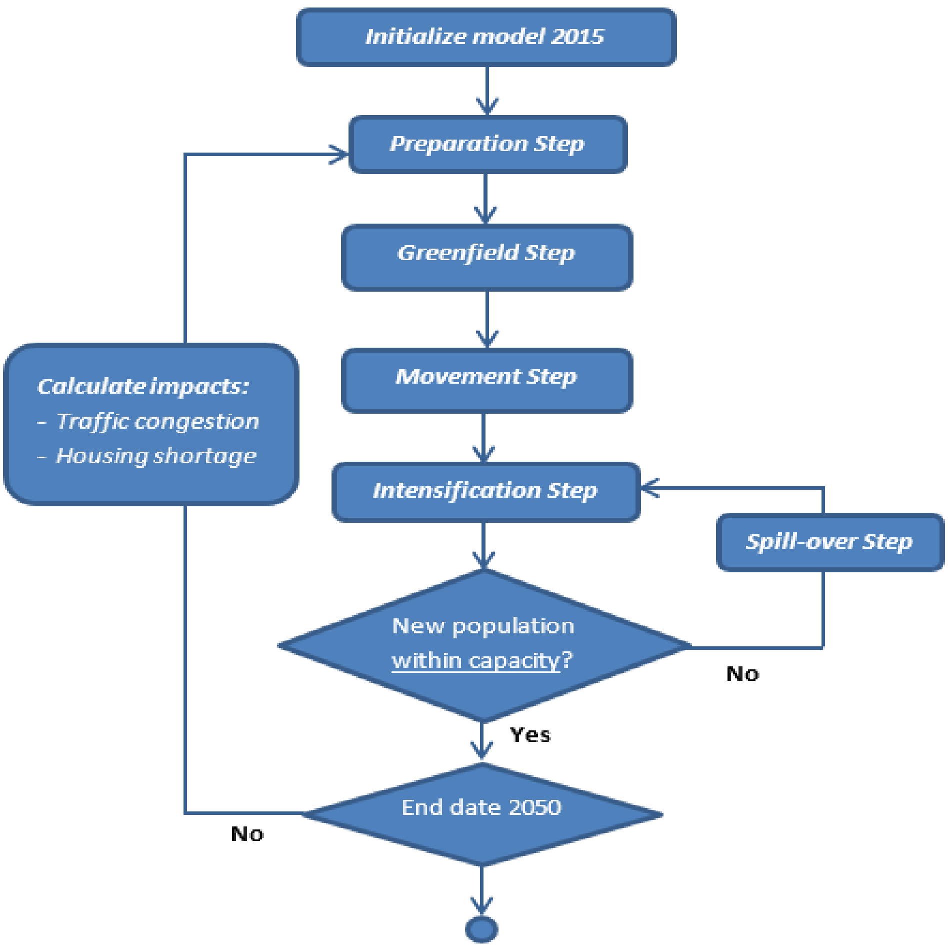

Figure 5-3: Simulation algorithm flowchart.

The model assumes that population and land use distribution are going to evolve as planned by the Kuwait Municipality from a top-down perspective and according to resident responses in the survey (bottom-up perspective) (Helbig et al. 2015). The model will simulate the population movement from old urban areas to the new cities, as well as future traffic congestion and housing shortage issues.

Different scenarios for the development of new cities were simulated in the methodology of this work with the following variations:

- Delays in construction of a major new city.
- Delays in construction of four minor new cities.
- Effectiveness of train network in reducing traffic congestion.

Therefore, six scenarios were simulated in total and the different outcomes were recorded. Table 5-6 shows the setup of the scenarios.

Table 5-6: Details of simulation scenarios

Scenario number	**Inputs**				
	Construction delays			***Train network***	
	No	*Major city*	*Minor cities*	*Yes*	*No*
1	☑			☑	
2	☑				☑
3		☑		☑	
4		☑			☑
5			☑	☑	
6			☑		☑

2.4 Data preparation and disaggregation

The data collected from the government planning authorities and used in the ABM includes:

i) GIS data, such as existing road networks and district land use borders
ii) Demographic data about population and nationality distributions obtained from the Kuwait Central Statistical Bureau (KCSB) and the Public Authority for Civil Information (PACI),

iii) Housing related data, such as the number of applicants and the supply of dwellings from the government based on figures supplied from the Public Authority of Housing Welfare (PAHW),
iv) Future demographic data with aggregate projections for the period 2015-2050 from the Kuwait Institute for Scientific Research (KISR), and
v) The new master plan obtained from the Kuwait municipality.

According to Batty (2012) simulating future urban development requires disaggregating statistical and spatial data. The first step towards disaggregation was adding the data collected from surveys and interviews to the attribute tables of each district or as parameters and values of the model. Each new city was segmented into districts based on the master plan or according to the new street network. The new districts were classified to residential, mixed use, business centres and other. The districts were also classified to new proposed or old districts in a format that can be read by the model. The outcome of this segmentation step can be seen in Figure 5-4.

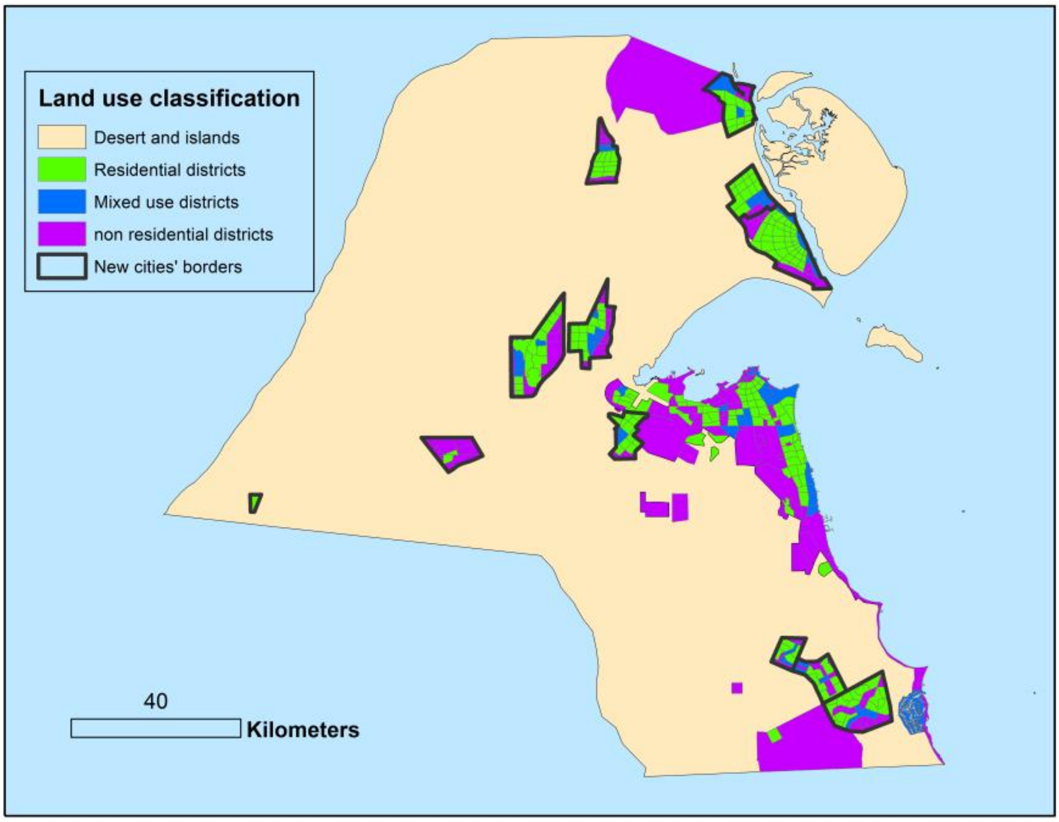

Figure 5-4: New land use classification.

Following that, the new dwellings and overall capacity for the new cities into the new segmented districts was simulated. In this step, it was assumed that the total number of the dwellings and the capacity were evenly distributed between the districts in the new cities. New city locations, train stations and transportation networks were then superimposed on the resulting map. Figures 5-5 and 5-6 show the outcome maps from this step.

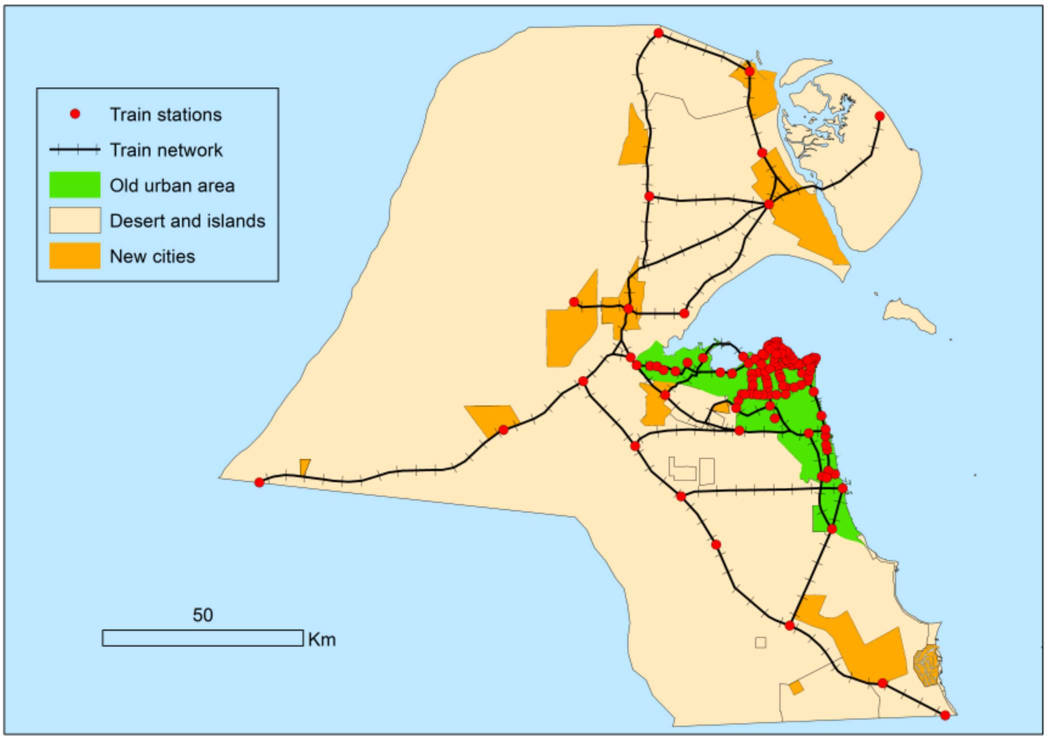

Figure 5-5: New train network and stations.

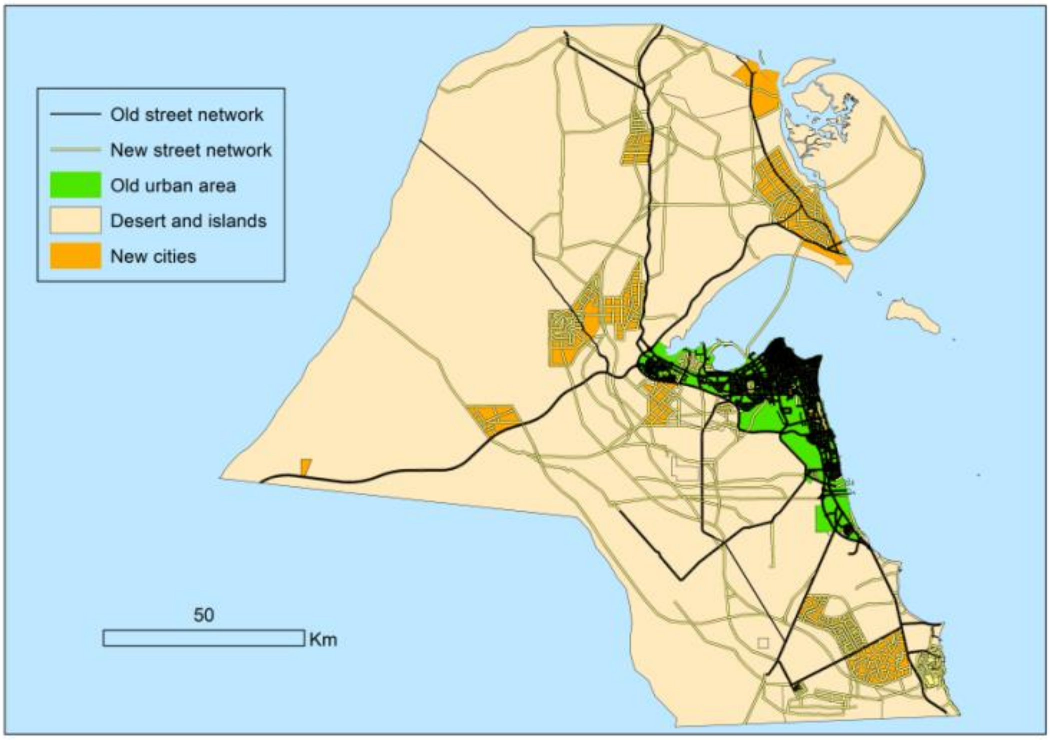

Figure 5-6: New road network.

2.5 Suitability weights for new cities

A land suitability model was used to allocate the residents in the new cities and determine the order of establishing new cities and infilling their districts. To achieve a realistic allocation, the model uses a number of preferential criteria based upon proximity to: CBD for new cities, old urban area, train stations, airports and street networks. In addition to closeness parameters, land value was also considered. The aforementioned parameters were ranked by the residents in order of importance as seen in Table 5-4 and then used to determine the weights of each criterion.
Transforming the residents' responses from the surveys into weights was done via Analytic Hierarchy Process (AHP) (Nyerges & Jankowski 2010). The final weights can be seen in Table 5-7.

Table 5-7: Suitability parameter rankings and weights according to the resident's agents

Parameters	Rank	Weight %
Land value	1	38
Closeness to the old urban areas	2	25
Closeness to new cities CBDs	3	16
Closeness to street networks	4	10
Closeness to train stations	5	6.5
Closeness to airports	6	4.5

The values of these weights were calculated for each new district separately. For the closeness parameters, the *Near* tool was used. The values were normalised to values between 0-100 relative to the maximum closeness (100 suitability value). For the cost parameter a statistical report (KFH 2015) was used to identify the land value for each existing district. The highest land value was assigned with a suitability value of 0. The land value in new cities is calibrated to be higher if it is near to existing urban areas. In addition, the land value was assumed to increase linearly by 5% per time step.

2.6 Traffic Congestion Index

As there is no historical traffic congestion data in Kuwait, we used traffic data shown on Google maps (traffic tool) along with land use data to develop a simple regression model for predicting traffic congestion for future development. The Traffic Congestion Index (TCI) was calculated according to the following steps:

1. Model explanatory variables indicative of traffic congestion (Abdullahi & Pradhan 2015; Chen 2016; Choi & Lee 2016) were mapped from available data at a district scale for: i) population density, ii) street density, iii) closeness to existing urban areas, and iv) closeness to train stations and networks (applied in future predictions only).
2. The dependant model variable for traffic congestion (TCI) was observed from current data in Google Maps traffic tool and summarised to a district scale; a congestion indicator (Marfia et al. 2013; Solé-Ribalta et al. 2016) on a point scale from 1 to 100 was developed as follows:

    - No or low congestion level (0-24%) = 25
    - Medium congestion level (25-74%) = 75
    - High congestion level (75-100%) = 100

    The level of congestion was recorded for major streets along in each district at 3 different times (Sunday 8am, Sunday 2pm and Thursday 8pm). The maximum level was taken as the district congestion level. It should be noted that Sunday mornings and afternoons were selected as Sunday is a normal working and school day and typically congestion during these times is very high. Thursday evening was also selected as it is the first weekend night and residents spend time driving to leisure and shopping venues. The traffic data were recorded weekly for 8 continuous months between January and August 2016. The outcome map of this step can be seen in Figure 5-7 and it was applied in the model as 2015 input data. A linear regression model was developed; the results are summarised in Table 5-8.

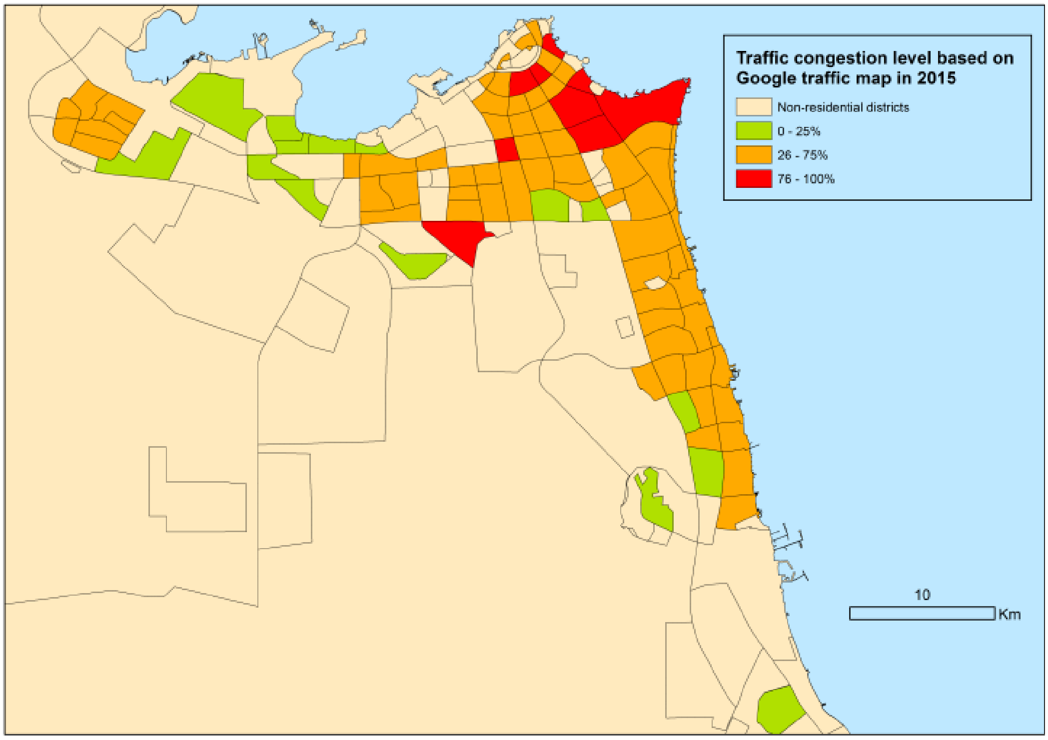

Figure 5-7: Traffic congestion level per district in 2016.

Table 5-8: Summary output from linear regression with zero set at origin

	Coefficients	***Standard Error***	***t Stat***	***P-value***
Proximity to existing urban area	0.612814	0.039217	15.62606	2.34E-28
Population density	0.447435	0.144343	3.099793	0.002528
Street density	0.361718	0.132327	2.733509	0.007436

The TCI for new districts were calculated at each time step based on the regression coefficients applied to projected explanatory variables, according to the following equation:

$$\mathrm{TCI} = (\mathrm{proximity} \times 0.612814) + (\mathrm{population\ density} \times 0.447435) + (\mathrm{street\ density} \times 0.361718) \quad (1)$$

2.7 Parameters and assumptions for simulation algorithm

The parameters used in the government scenario model steps (explained below) are summarised in Table 5-9.

Table 5-9: Simulation parameters

Parameter name	Description	Application
Kuwaitis & non-Kuwaitis distribution %	Population distribution according to nationality based on historical trends.	Movement, intensification and Spill-over steps.
Average capacity of existing districts (Persons/ha)	Average capacity for adding people to district based on the historical data average.	Movement and Intensification steps.
Maximum capacity of new cities' districts (Persons/ha)	The maximum population that a new district can have based on the master plan disaggregated data.	Movement and Intensification steps.
Population ratio of new districts in the opening time step	The maximum population percentage of the maximum capacity that a new district can have during the opening time step (in the first 5 years).	Movement step.
Movement %	The percentage of people who will move to the new cities based on the survey data.	Movement step.
Traffic congestion index (TCI)	The average TCI for all districts in each time step.	Impacts calculation step.
Train % TCI	The percentage that will be deducted from the TCI of a district close to a train station based on the survey data.	Impacts calculation step.
Suitability parameters' weights (dimensionless	The suitability weights of parameters based on the survey data as seen in Table 5-7.	New cities creation, intensification and

from 0-10)		spill-over steps.
Pending housing applications	The number of pending housing applications in each time step based on data collected from the interviews.	Impacts calculation step.

For modelling the scenarios, the following adjustments were made:

- Train % TCI: This is the percentage deducted from the TCI of a district close to a train station based on the interview data. This percentage was initially assumed to be 5% as the decision makers regarded this is the expected ratio of car commute trips replaced by of train trips. However, the survey results showed that 70% of residents consider taking the train. This ratio provides a very optimistic prediction, but it is probably not an accurate one, as desire to use the train does not necessarily mean it will be used in all trips. Therefore, the Train % TCI in the simulation was double the government's proposed percentage (10%).
- Movement: Although 38% of residents expressed willingness to move, this will likely occur over some time. Hence in the simulation scenarios, the group of residents willing to move was evenly spread over the simulation time steps to (5.5% per year).

2.8 Simulation steps

The simulation steps for all scenarios were as follows:

1. *Initialization:*

Initialization involves creating the environment (spatial land use districts) in GIS, initialising the default parameters values, loading data for the disaggregate population projections and initialising the model schedule to start in the year 2015.

2. *Preparation and calculation step:*

This step contains several actions; the first action is calculating the average capacities of existing districts and setting the infill availability count for existing and new districts, which determines whether they may accept new residents. Furthermore, the suitability of districts for opening is calculated.

3. *New cities creation step:*

In this step, the first action opens the districts in the new cities based on the master plan open dates and start populating them with new Kuwaitis & non-Kuwaitis from the disaggregated 5 yearly population projections using increments of 5000 people. The allocation is based on the district suitability.

4. *Movement step:*

People move to new districts based on suitability as assumed from the AHP. To calculate the number of moving residents, firstly the number of available Kuwaitis and non-Kuwaitis for movement are calculated based on the following equations:

$$\begin{aligned} &Available\ Kuwaitis\ for\ movemet \\ &= Movement\ Percentage \\ &\times Total\ Kuwaitis\ in\ old\ districts \end{aligned} \tag{2}$$

$$\begin{aligned} Available\ non - Kuwaitis\ for\ movement \\ &= Movement\ Percentage \\ &\times Total\ non \\ &- Kuwaitis\ in\ old\ districts \end{aligned} \tag{3}$$

Then, Kuwaitis and non-Kuwaitis are moved to the new cities' districts (residential, mixed-use and CBDs) according to the Population ratio of new districts in the opening time step (20% of the Maximum capacity of new districts) based on the following equations:

$$\begin{aligned} &Actual\ Kuwaitis\ for\ movement \\ &= Population\ ratio\ of\ new\ districts\ in\ the\ opening\ time\ step \\ &\times Available\ Kuwaitis\ for\ movement \end{aligned} \tag{4}$$

$$\begin{aligned}&Actual\ non-Kuwaitis\ for\ movement \qquad (5)\\&= Population\ ratio\ of\ new\ districts\ in\ the\ opening\ time\ step\\&\times Available\ non-Kuwaitis\ for\ movement\end{aligned}$$

Following that, a movement calibration action runs to ensure that the distribution percentages of Kuwaitis and non-Kuwaitis in residential and mixed-use districts are similar to the pre-set distribution percentages. Typically, the nationality distribution in residential districts is 55% and 45% for Kuwaitis and non-Kuwaitis respectively and in mixed districts it is 9% and 91% for Kuwaitis and non-Kuwaitis respectively. The number of residents is recalculated in the case that the number of actual moved residents exceeds the average capacity of the new districts in the opening time step. Based on historical data, the capacity for Kuwaitis in residential and mixed districts is 40 persons/ha and 20 persons/ha respectively. For non-Kuwaitis in residential and mixed districts the capacity is 30 persons/ha and 2,000 persons/ha respectively. Finally, the actual moved residents are removed from old districts.

5. *Intensification step:*

This step performs infill to assign population to any (old or new) district with available capacity. Population is added from the disaggregated 5 yearly population projection in increments of 5000 people and allocates them in districts based on their suitability weights. If population growth exceeds the capacity of all districts the model accounts for the difference in the next spill-over step, otherwise it continues on to the next period for growth.

6. *Spill-over step:*

The Spill-over step is a mechanism in the simulation algorithm that initiates when it is not possible to add new dwellings so the only solution would be to increase the density in the old developed districts. This step checks whether there are Kuwaitis or Non-Kuwaitis still in the waiting lists in the end of each time step. If there are, a loop will start to call the previous infilling step and add more residents to the old districts until the waiting list empties. This is achieved by increasing the average capacity of the old districts by 0.0001 person /hectare. If delays in constructions of new cities occur, this step will run until all waiting population is allocated to existing districts.

7. *Impacts calculation step:*

This step produces the predictions for the key urban issues: housing shortage and traffic congestion. Output maps and figures are produced to show details about the population, districts and the future impacts in each time step. Figure 5-7 shows a flowchart of the model architecture.

A more thorough explanation of using ABM for analysing urban growth in Kuwait was explained in earlier work by Alghais and Pullar (2017a). The difference in the current model is that it includes a movement step (step 4) for allocating population to new cities and other minor modifications for alternative transportation options with train network.

3. Results

3.1 Traffic congestion

The population density in scenarios 1 and 2 the population density will be 5.3 persons/ha and in scenarios 3-6 it will be approximately 6 persons/ha. This shows that even with delays the population density will decrease compared to the population density in 2015 (13.5 persons/ha), which in turn is expected to mitigate traffic congestion as density is a variable that indicatives traffic congestion (see section 2.6). Figures 5-8 to 5-11 show the population distribution maps.

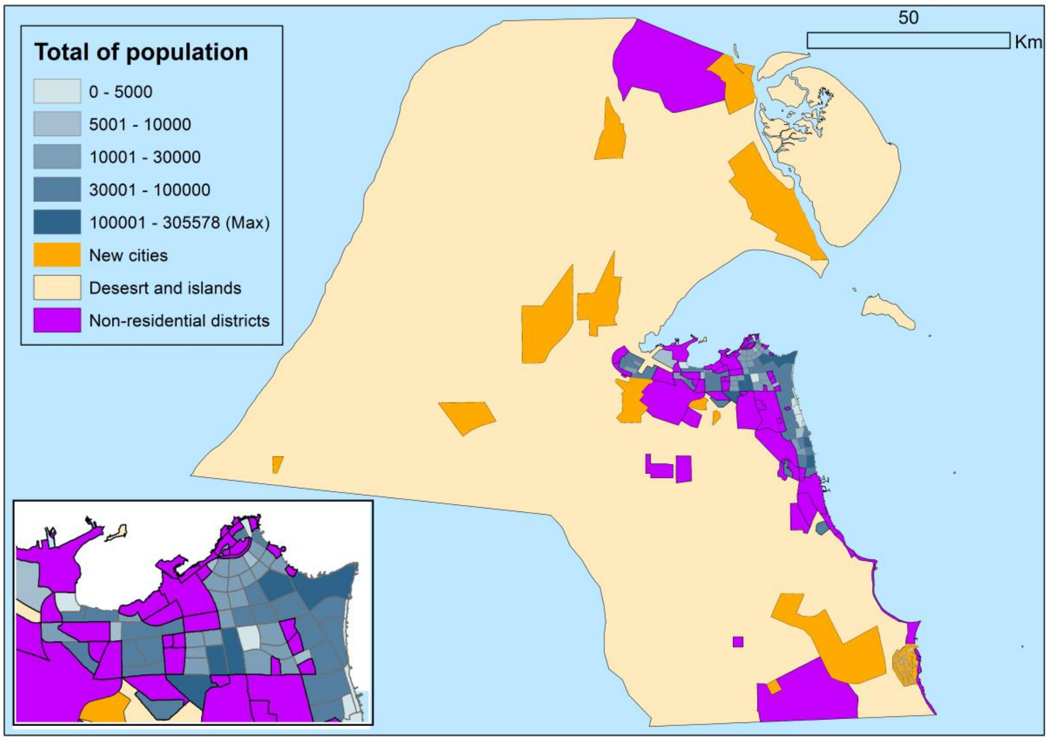

Figure 5-8: Population distribution in 2015.

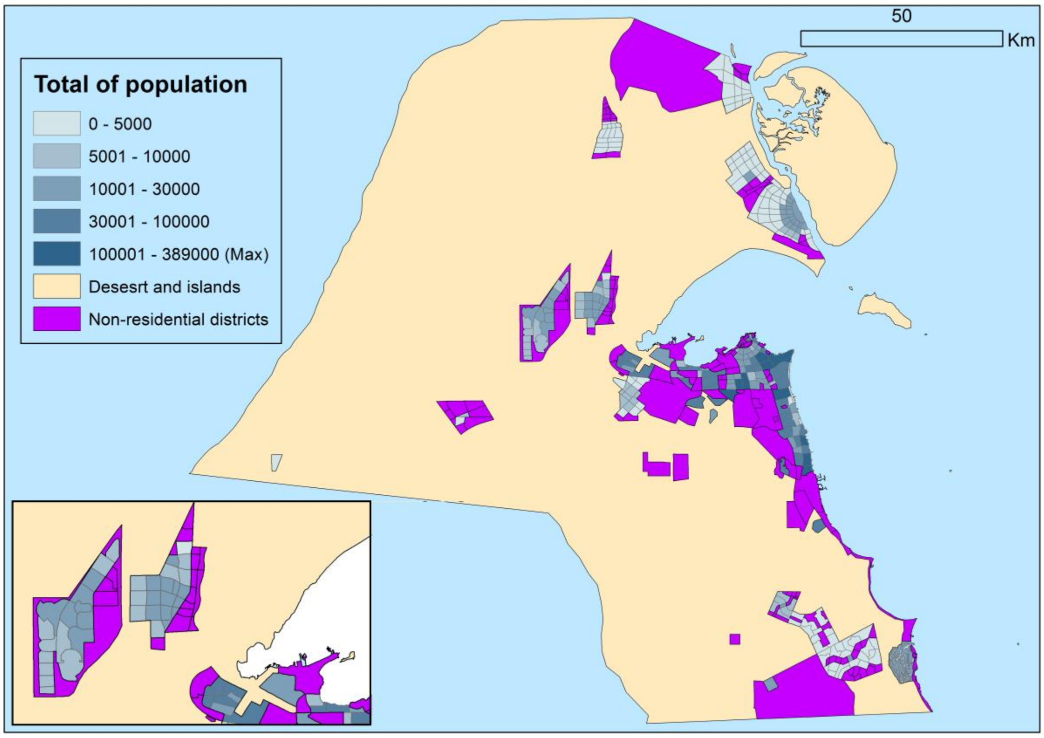

Figure 5-9: Population distribution in 2050 in scenarios 1-2.

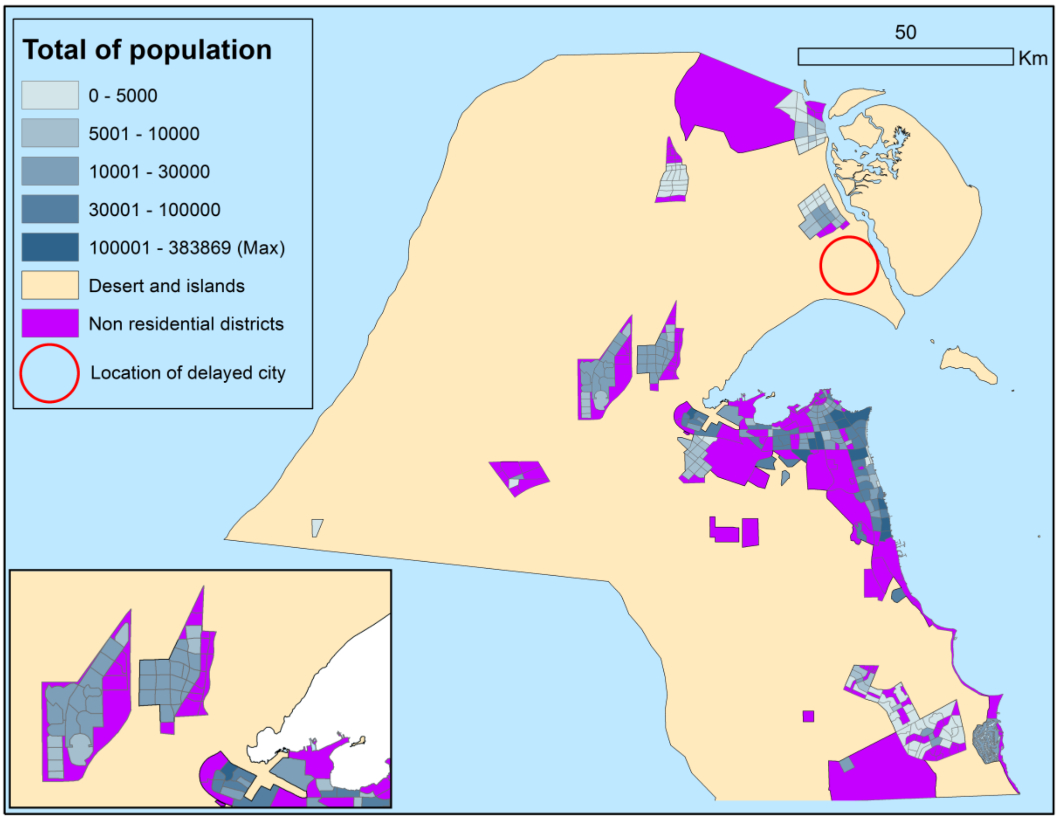

Figure 5-10: Population distribution in 2050 in scenarios 3-4.

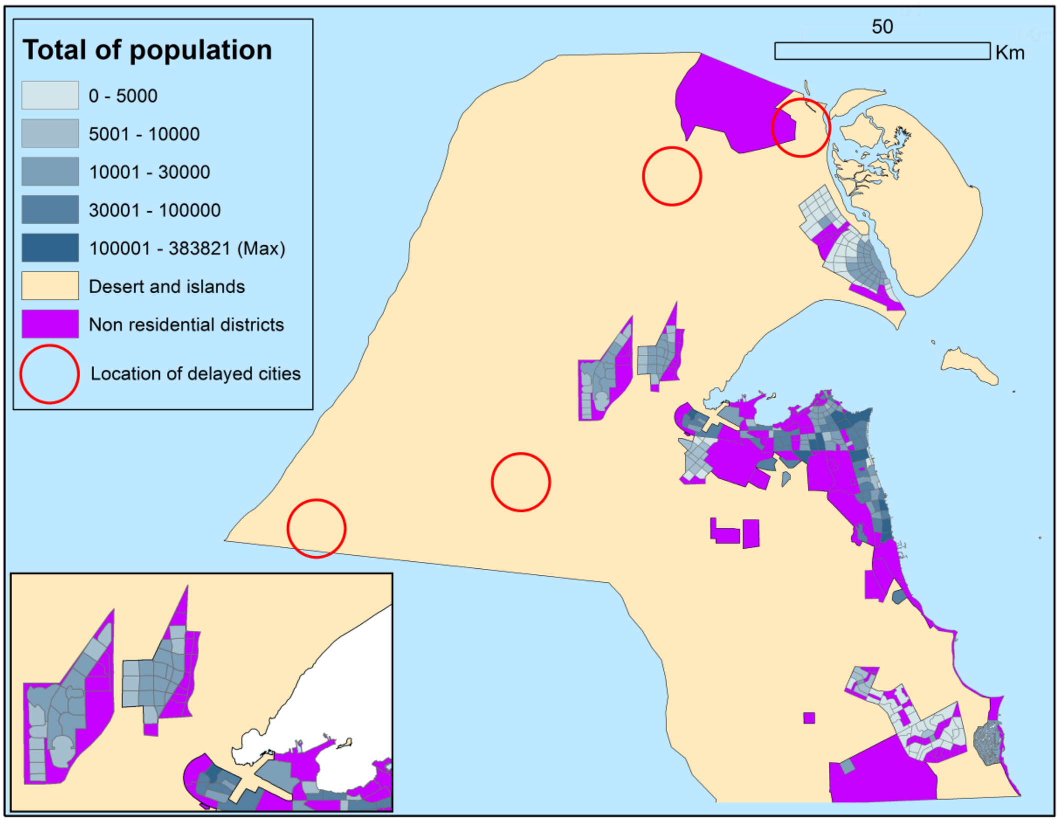

Figure 5-11: Population distribution in 2050 in scenarios 5-6.

Indeed, by comparing the current situation with the scenario results the simulations showed a significant reduction in traffic congestion in 2050 for scenarios 1and 2. Specifically, the predictions show that in 2050, the TCI may be as low as 35-50%. If delays in construction occur, the TCI will be still lower than 2015. Figures 5-12 to 5-14 compare the congestion predictions for of the simulation scenarios.

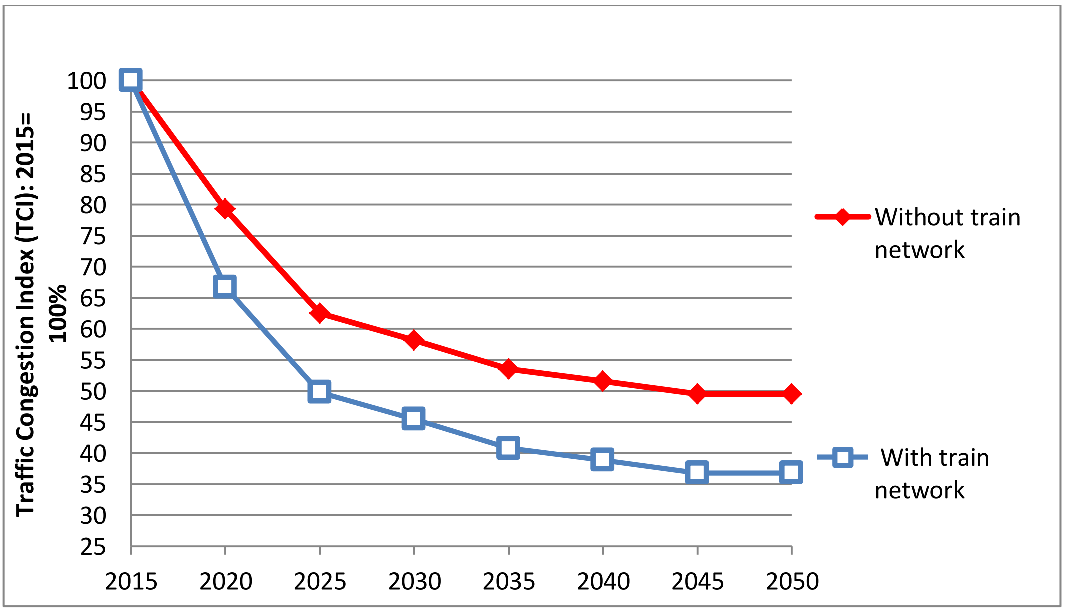

Figure 5-12: Comparison of TCI in scenarios (1 and 2) without construction delays.

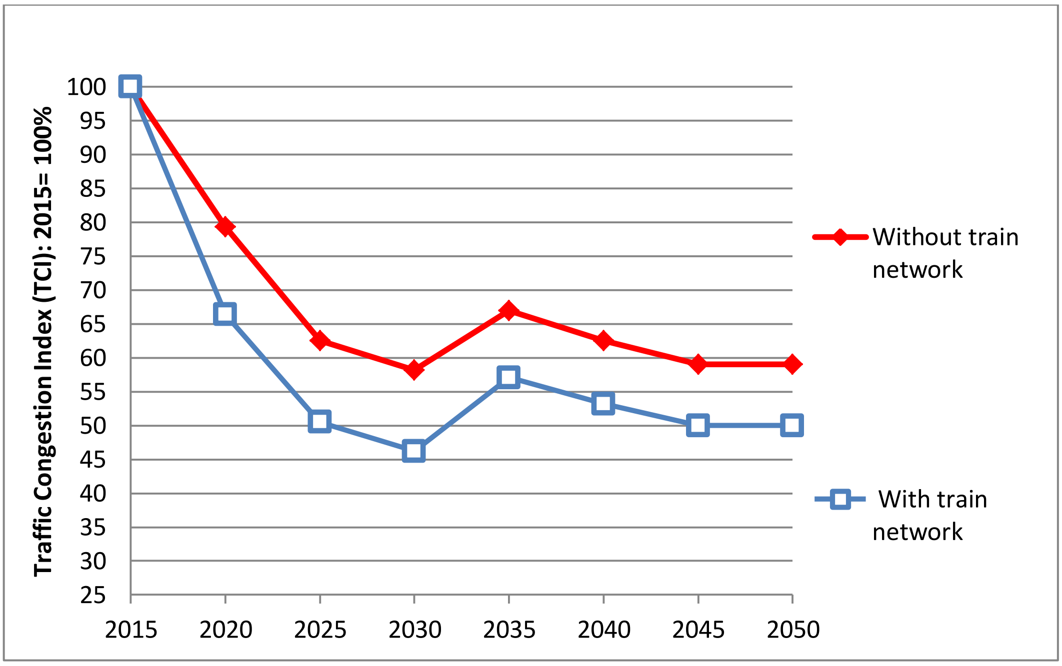

Figure 5-13: Comparison of TCI in scenarios (3 and 4) with construction delays in the major city.

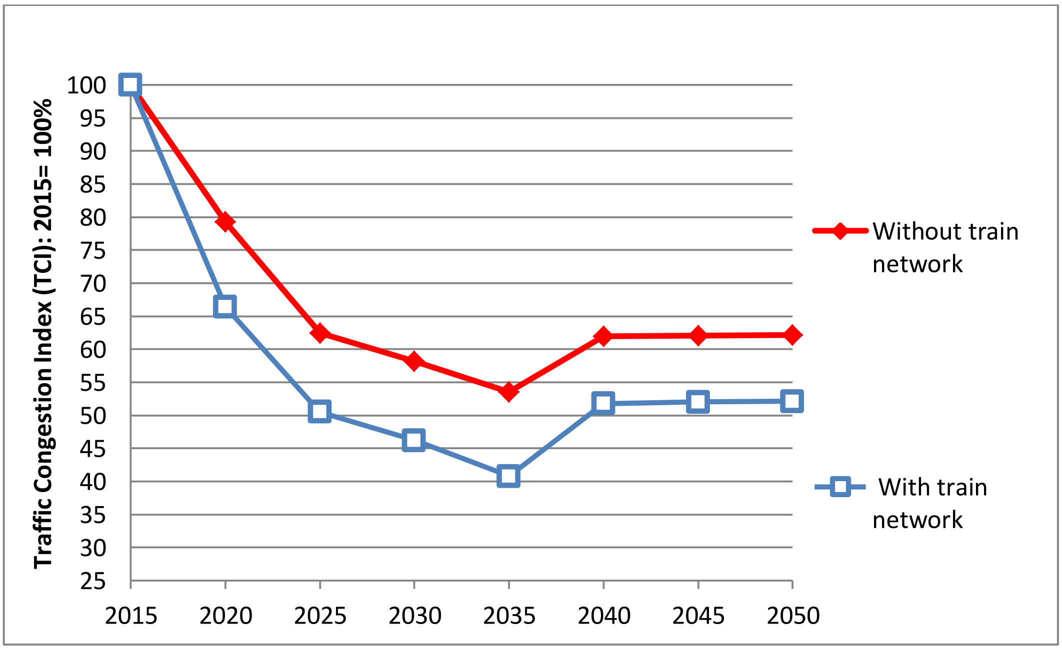

Figure 5-14: Comparison of TCI in scenarios (5 and 6) with construction delays in the minor cities.

3.2 Housing Shortage

The impact of developing new cities on housing shortage according to the simulations depends mainly on any delays. Figure 5-15 shows the impacts of delays in the construction of minor cities on the supply of dwellings and housing applications.

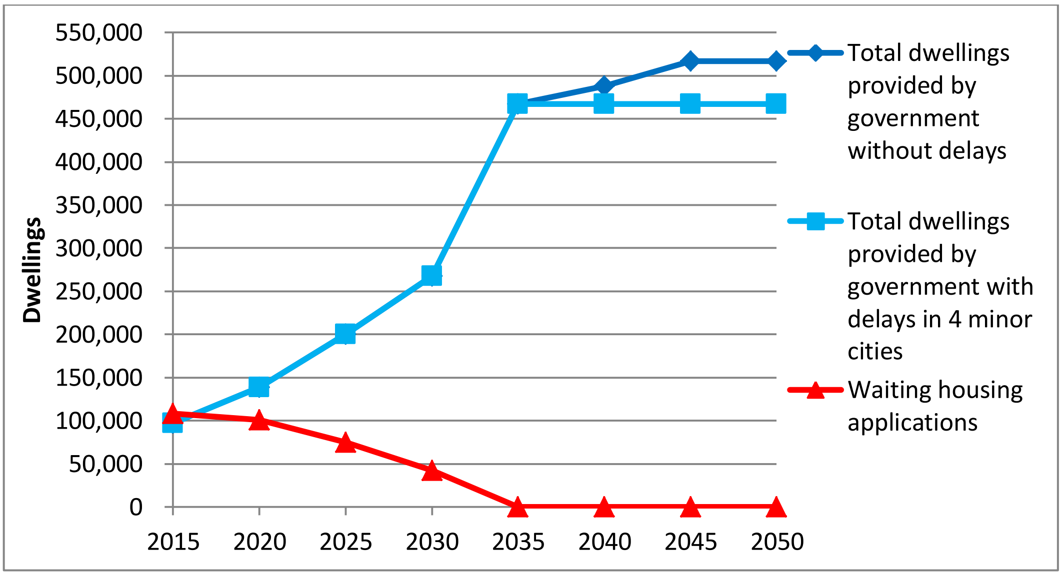

Figure 5-15: Housing demand and supply in case of no delays and with delays in 4 minor cities.

The results showed that without delays the housing shortage problem will be solved by 2035. However, if delays in the construction of the major city occur, the housing shortage problem will persist. In fact, the predictions show that in 2050, the pending applications for housing may reach up to 108,000 as shown in Figure 5-16.

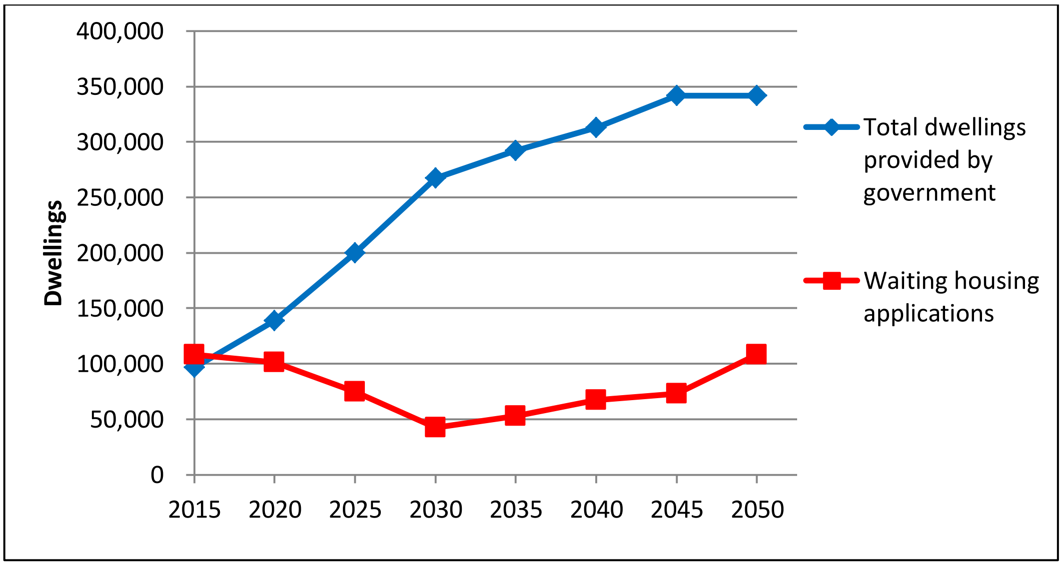

Figure 5-16: Housing demand and supply with delays in the major city construction.

Finally and regarding the nationality segregation, the results showed that according to the simulations in 2050 the new cities will be less nationality segregated than the current urban areas. The respective maps based on the average of the six scenarios can be seen in Figure 5-17.

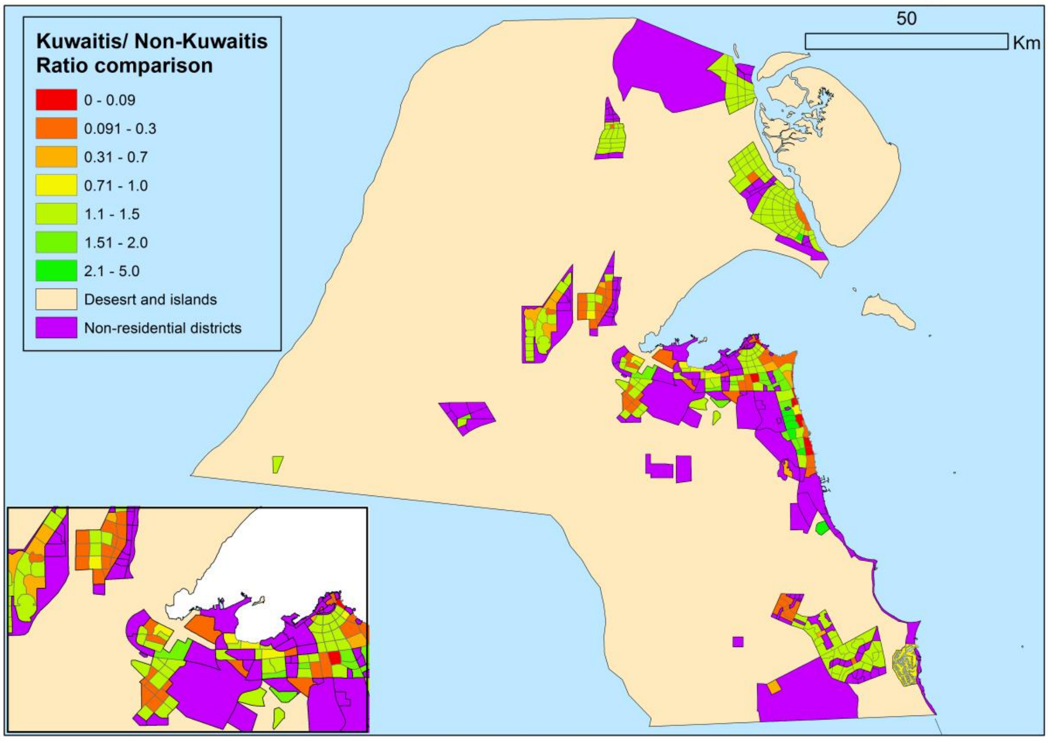

Figure 5-17: Population distribution average (citizens and non-citizens ratio) in 2050 in scenarios 1- 6.

4. Discussion and conclusion

The main purpose of this study was to assess if developing new cities addresses growth issues and specifically the urban issues of traffic congestion and housing shortage in Kuwait. The simulations and predictions of the situation by 2050 were carried out with ABM in a GIS environment. The results of this study showed that using urban modelling to assess future plans of developing new cities is essential to help predict urban and population growth trends. The ABM used in this paper has proven particularly effective in assessing the potential impacts of urban growth (congestion, housing shortage and transport efficiency). Furthermore, the ABM was able to model the drivers of population changes as postulated in the new master plan, forecast the population growth in the case study area and match it with a spatial pattern of urban settlement that was defined by the resident survey responses.

The first research question attempted to identify the key issues of urban growth in Kuwait. The interviews carried out with the local government representatives and the survey responses from residents indicated that traffic congestion and housing shortage are the most important issues, and solving these is the main goal of the new master plan. The interviews with the planning authorities also revealed that the government does not use any urban modelling or simulation technology in their planning process, which raises the concerns about traffic congestion and housing shortages significantly.

The second research question asked whether establishing new cities is an effective development strategy in addressing urban growth and the aforementioned issues. The results showed convincing support for establishing new cities as urban growth form in Kuwait. Specifically, assuming that the construction of new cities is completed without delays and according to the initial master plan, the results indicate a reduction of 60% in traffic congestion compared to 2015 levels and no housing shortage before 2050. These predictions require establishing a modern train transportation system on time according to the master plan. The feasibility of this urban development type (new cities) depends heavily on the availability of funding for the intensive capital investment stage. Hence, the methods and findings may be generalized for other Arabian Gulf countries, such as Dubai and Qatar, which have adequate government funding support.

In regard to the third research question, the interviews and survey responses showed that the main concern related to the success of the new proposed cities was a delay in construction. Those interviewed expressed their worries about whether the completion of new cities and the proposed train network will be done in a timely fashion as planned, given the long history of delays in past construction projects in Kuwait. The simulations have shown that delays will indeed have detrimental effects on traffic congestion and housing availability. Delays in development of one major new city were associated with the worst outcomes in regards to traffic congestion and housing shortage. However, even with construction delays, the traffic congestion and housing shortage issues will be better compared to the business as usual scenario of infilling and expansion of the existing urban areas (Alghais & Pullar 2017a).

Finally, the online surveys, used for the first time in Kuwait, allowed residents to have a say in the urban planning process. The survey responses allowed the collection of data directly from the residents and the integration of this information in the model as behaviours and rules for the citizen and non-citizen agents. Hence, it was possible to allocate the residents that expressed willingness to move to new cities in a reliable pattern based on primary data.

The survey responses and simulation results showed that a sufficient number of residents is willing to move to the new cities and the housing shortage will be very likely solved in line with the expectations of the master plan. The results also showed that there are more residents willing to use the new train network than the government initially assumed, which means that the traffic congestion should be lower in the future. This emphasizes the importance of the completion of the new train system without any delays. Certain issues stemming from the results analysis in this work that may be investigated further in future work include a more detailed modelling of the nationality segregation and each resident group's preferred district type and location. Additionally, further integration of survey responses in urban planning may be considered to assist the government and satisfy the public's desire for participation in more direct ways. Regardless, the evaluation the new master plan and it impacts was carried out for the first time in Kuwait and the results of this work may provide the government with significant recommendations.

Chapter findings

This chapter confirmed that the key decision maker in the new master plan is still the Kuwaiti government. The research showed that the private sector has no role in developing the new master plan, except for a few consultations with the government agent.

Moreover, traffic congestion and housing shortage were found to be the most important issues that concern planning authorities and affect their future policy making. Via surveys, the local residents responded that congestion and housing shortage are their top perceived urban issues as well.

The simulations based on a simple transport model combined with automata elements showed that creating new cities around the country according to the master plan will yield improvements compared to the continuation of existing city expansion. Specifically the models indicated a reduction of 35-50% in traffic congestion and no housing shortage by 2050. However, these improvements assume no delays in construction of the new cities and establishing a modern train transportation system on time. If delays actually occur, then the models show that the housing shortage problem will persist. The predictions show that in 2050, the pending applications for housing may reach up to 108,000 depending on the severity of delays. Even without the train network the congestion levels will be reduced by 50% comparing to 2015, due to the lower urban density.

The model findings show convincing support for establishing new cities in Kuwait and it appears that there are enough residents willing to move from the established urban centre to these new cities.

However, there are some issues not studied in the master plan and that must be investigated further, such as the residents' preferred district type, the effects of segregation between citizens and non-citizens, the new cities' locations and how closely they match the preferred locations of residents and finally determining the risk of Ghost cities. All these issues are addressed in Chapter 6.

Besides, for more details of interviews and surveys in Chapter 5, the reader may refer to Appendices A and B.

Chapter 6 : Accounting for peoples' preferences in establishing new cities: A spatial model of population migration in Kuwait

Chapter outline

This chapter contains a research to model urban growth in Kuwait according to elements of the master plan 2030 combined with local resident preferences and needs. The resident inputs were obtained via surveys, which is a novel research endeavour in Kuwait. The findings contribute towards addressing the following research questions:

1. How may inclusion of the resident preferences in the master plan influence the outcomes of urban growth in Kuwait?
2. What are the differences in preferences between citizens and non-citizens in Kuwait?
3. How well can automata modelling simulate urban systems based on bottom-up inputs from the local residents?

The research highlights of Chapter 6 include:

i) Surveying Kuwait's residents to extract their opinions, preferences, demands and needs in regards to urban development and growth.
ii) Modelling the residents' preferences about their future settlement locations and district type in the new master plan model as behaviours and rules in an ABM.
iii) Simulating future nationality segregation levels according to resident surveys and establishing that it can be reduced compared to 2015 levels.
iv) Identifying that the main differences in preferences between citizens and non-citizens are related to district type (mixed or residential) and the location.
v) Establishing that the potential risks that may cause Ghost cities to appear according to the willingness of residents to move are minimal.
vi) Assessing the online survey effectiveness as a tool to engage the public with urban planning issues in Kuwait.
vii) Evaluating the new master plan from the resident perspectives and providing recommendations to Kuwait's government about the new master plan.

Accounting for peoples' preferences in establishing new cities: A spatial model of population migration in Kuwait

Abstract

Modelling of internal migration to new cities is challenging, yet necessary to ensure that these newly established urban areas will be populated and function as intended. In the State of Kuwait, there is a unique set of push and pull factors: government subsidised housing for citizens, the existence of a single urban area, and the initiation of a new and ambitious master plan for the construction of 12 new cities, which are expected to attract not only locals, but also international residents and businesses. On top of these factors, there is an unusual demographic situation, as non-citizens outnumber Kuwaiti citizens by a factor of 2.3, with these groups having widely different preferences in terms of housing. Currently, there is no plan to take these resident groups' opinions into consideration for the new cities project.

The current study simulates the impacts of the involvement of residents in urban planning. Samples from resident groups participated in targeted surveys and useful answers were extracted in relation to the migration likelihood, push and pull factors that may affect their decisions, spatial preferences for new cities and their opinions on segregation by nationality. The responses were transferred in an Agent Based Model, and the simulations showed significant differences to the official projections for 2050 without the public responses. The findings may be utilised by the authorities to modify the master plan accordingly.

1. Introduction

Kuwait is an Arabian Gulf country that has experienced a rapid population growth in the last decades mainly driven by international migration (Al-Nakib 2016). This has led to the suggestion that new cities be established in the region, which in turn raises questions about the optimal location of the cities, their desirability by the locals, and whether they would result in migration from all segments of the population.

Predicting migration and future population distribution are essential for the successful development of new urban areas, the provision of affordable housing and creation of new job opportunities (Black & Henderson 1999). The majority of migration research conducted in industrialised and developing countries focus on the economic concerns for metropolitan areas experiencing urban growth; such as New York (Chen & Rosenthal 2008), Auckland (Maré & Timmins 2003) and Delhi (Chandrasekhar & Sharma 2015). The underlying driver of the movement of people is mostly economic, especially for new employment opportunities (Greenwood 1997; Todaro 1980; Chandrasekhar & Sharma 2015).

In Arabian Gulf countries and specifically in Kuwait, economic-driven migration may not be significant due to its plentiful resources (oil and natural gas) and relatively small size leading to relatively uniform distribution of wealth. In fact, the drivers behind internal migration in Kuwait and similar Arabian Gulf countries as a geographical phenomenon are largely unknown. The reason for this is mainly the lack of data about internal migration. In the past, urban growth in Gulf cities was mainly driven by city expansion and intensification and no independent cities were developed (Rizzo 2014; Alghais & Pullar 2017a), which suggests that the drivers of internal migration could differ substantially from other industrialised societies. In these situations, internal migration was limited in magnitude and when present, it was over very short distances and between regions with minor differences; hence the lack of migration data was not causing any profound negative impacts.

Recently however, and as many new cities are planned to be constructed in Arabian Gulf countries (Gulf News, 2010; Summers, 2016), the lack of internal migration data is becoming a more serious issue. The motivations and decisions of residents to move to new urban areas must be understood in order to guarantee the project's success. Towards that goal, collecting data directly from a survey targeting residents in Kuwait is a novel solution implemented in this paper. The survey responses can provide important new insights into internal migration in Arabian Gulf countries. Additionally, the survey results can also be used to predict and simulate the internal migration in the case study city of Kuwait and provide a more practical view on the new cities future state. Finally, and in order to validate the findings with a theoretical background, the responses will also make it possible to identify the main reasons behind resident choices in the context of push and pull factors theory.

Push-Pull theory of migration is used to identify the factors driving migration at origins and destinations (Lee 1966). Traditional urban theories on the drivers of internal migration, which are linked to economic trends may not be relevant in Kuwait's case and such as alternative urban theories are employed instead to explain resident settlement preferences (Geyer 1996; Rees et al. 2016).

In modern industrialised societies, it is common for government planning authorities to regulate push and pull factors for instance by offering new public sector jobs, or subsidising housing markets in new planned cities in order to achieve a balanced population distribution (Cervero & Duncan 2006; Shen 2013). In the modern era internal migration is usually more subtle and attempts to provide indirect incentives to potential movers (Chernina et al. 2014).

Urban planning that does not thoroughly consider the drivers of internal migration may result in costly and unsuccessful urbanisation policies. Generally, this is not an issue in cases where development planning is transparent and conducted in harmony with the market trends and community participation (Mahjabeen et al. 2009; Amado et al. 2010). However, there are several countries, where planning is centralised and there is little in terms of public engagement, making predictions about internal migration speculative at best. In the case of Kuwait, the involvement of the public in planning and land use decisions is limited or in most cases non-existent. The implications of the lack of public involvement in Kuwait (or any similar case) may lead to:

i) Lack of sufficient number of people migrating to new cities and hence resulting in uninhabited cities, or
ii) Stagnated growth for new cities if a lower than expected numbers of people settle in the new cities.

One notable example of the risks of excluding the public opinion in planning is the construction of Ghost Cities in China: complete cities established with full infrastructure, but without any residents (Yu 2014). It can be argued that if the Chinese government had involved residents in the planning process and before any decisions were made, Ghost Cities may not have occurred, as there would be a solid understanding of the internal migration trends, preferences of residents and job availability. Adding to the problem, largely heterogeneous population groups with different preferences and needs may respond very differently in regards to push or pull factors. Settling new cities raises other issues such as achieving socially integrated communities; this is typically described as segregation by wealth, race or nationality. In Kuwait, segregation by nationality is prevalent due to land use policies.

The Kuwait government is launching a project for developing new cities for its current and future residents (Kuwait Municipality 2009). This study recognises and investigates this research opportunity related to assessing the importance of public participation in urban development, identifying the push and pull factors and modelling the impacts of establishing new cities on residential segregation. This paper attempts to study future internal migration in Kuwait, which we believe typifies trends in other Arabian Gulf countries. The research questions addressed in this paper are:

a. Will future planned city areas attract sufficient population for settlement?
b. Do people's preferences on migration and future cities differ from the government plans, and potentially avoid problems of creating ghost cities?
c. Will removing land use policies that separate Kuwaitis and non-Kuwaitis change future settlement patterns?

This will be done by simulating the migration to new cities in Kuwait under different scenarios, including scenarios where public opinion for urban development is considered. The preferences and responses of the two resident groups (citizens and non-citizens) in Kuwait in relation to housing and migration obtained via an online survey and are integrated as behaviours in a simulation model. Finally, simulation outcomes are assessed in terms of their effectiveness in addressing a key urban issue in Kuwait, the level of residential segregation

2. Background

2.1 The value of participatory planning in urban development

Among the most important issues in urban planning is failing to meet project goals due to differences between community stakeholders' perspectives, especially when resident opinions are not included in planning (Gualini 2015). In order to prevent this, many cities have amended their systems to involve the public in the planning and decision making processes of urban development. This may be done through consultations with community committees, open forums, public meetings and citizens surveys (Kelly, 2010).

The aforementioned methods are referred to as participatory or comprehensive planning. Participatory planning involves the residents in the decision making processes in an attempt to develop successful urban development (Fagence 2014). The benefits of participatory planning include promoting the notion of democracy, and validating the decision making processes. However, there are also disadvantages, such as increased complexity and costs. Projects with participatory planning are mainly limited to small scale development (Brown 2012; Cilliers & Timmermans 2014). Integrating public opinion at neighbourhood level may be done through public surveys or web questionnaires (Evans-Cowley & Hollander 2010). For large scale regional development projects in cities, state or national level, the decision making is centralized and state controlled, with inputs from studies and consultations with experts (Kelly, 2010; Levy 2015). Kuwait does not have a framework of comprehensive planning, but as a country it is small enough to conduct a form of participatory planning with public engagement conducted via a tailored online survey, the details of which are presented in section 3.

2.2 Modelling internal migration to new cities

Several internal migration models have been developed in recent decades based on the individual migrants' behaviours and decision making. These models implement behavioural theories using decision rules such as the random utility theory, game theory, economic theory or the theory of planned behaviour. On the other hand, models that simulate migration are purely empirical. Such models are based on direct observation or collected data from key stakeholders (Klabunde & Willekens 2016). In this paper a purely empirical internal migration model is developed based on the outcomes of a resident survey, which in turn attempts to identify push and pull factors driving migration.

Modelling internal migration to evaluate and check the validity of future development decisions can be done through simulating future locational patterns of migrant destinations (Batty 2009). The majority of urban models deal with small scale development projects, such as selection of residential housing (Guo and Bhat, 2001; Habib and Kockelman 2008). These urban residential-choice models use questionnaires to generate outcomes of future residential movements (Huang et al. 2014). Migration modelling may also be carried out with the help of Agent Based Modelling (ABM) (Klabunde & Willekens 2016). ABM is considered as one of the most suitable options, as it can convert small scale behaviours to larger scale spatial outcomes (Batty 2007, Crooks & Heppenstall, 2012).

ABM has been widely used for modelling urban planning and future development assessment around the world (Benenson 2004; Beuck et al. 2007; Gaube & Remesch 2013; Murray-Rust et al., 2013; Jordan et al. 2014; Crooks 2015). Agents represent autonomous entities that have the ability to make independent decisions and may be individuals or groups, such as residents, developers or urban planners (Aliaga 2012; Crooks & Heppenstall, 2012).

ABM can simulate stakeholder (agent) decisions and preferences as actions and interactions between the agents and their environment by 'what if' statements in a spatial simulation. Scheduling agent behaviours and decisions may take place over a period of time that could range from seconds to decades. The environment within agents live, commute and interact can also be simulated at various spatial and temporal scales, (Brunsdon & Singleton 2015). The advantages of ABM include its ability to simulate micro level interactions within dynamic environments from a bottom-up perspective, its ability to handle heterogeneous agents and its flexibility in terms of geospatial model development (O'Sullivan et al., 2012; Crooks 2015). Due to the successful implementation of ABM in numerous studies, it was selected to predict the future impact of the master plan in Kuwait.

Spatial modelling with ABM's is important in urban planning for understanding the way cities grow with internal urban intensification or outward expansion, and for assessing potential negative impacts such as traffic congestion and housing shortage (Wang et al. 2011; Alghais & Pullar 2017a); This paper explores the use of ABM's with GIS to model the establishment of new cities; three scenarios were simulated in the ABM:

1- Government scenario: Simulates the urban development of new cities based on the government's plans alone (without any public participation). Segregation is simulated according to the business as usual approach.
2- Resident scenario: Simulates urban development of new cities based on the resident preferences as extracted from the online survey. Segregation is simulated according to the resident responses.
3- Global Cities scenario: Simulates urban development of new cities based on the resident preferences as extracted from the online survey. Segregation is simulated according to the Global Cities plan (no segregation in new cities, only mixed districts).

For each of the above scenarios, nationality segregation levels and the potential of limited internal migration to new cities will be assessed. The outputs are expected to help in evaluating the new master plan and understanding the future internal migration trends in Kuwait.

2.3 Case study background

Kuwait is used as case study in this paper. Kuwait has a population of 4.5 million living in an area of 17,818 km2 and the non-citizens make up for 70% of the total population (PACI 2017). The government plans to establish 12 new urban centres independent from the sole existing urban area of Kuwait City, but as of the date of this paper none as yet have been implemented (Keay 2012). In 2007 the government established a program titled "Kuwait Vision 2035" in order to transform

Kuwait as the major financial and trade centre of the region by 2035 (Al-Diwan Al-Amiri 2016). A major component of this plan is the development of new transportation modes, including a train network to link the old urban area with the new cities (Lowe & Altrairi 2013). Figure 6-1 shows the new cities locations.

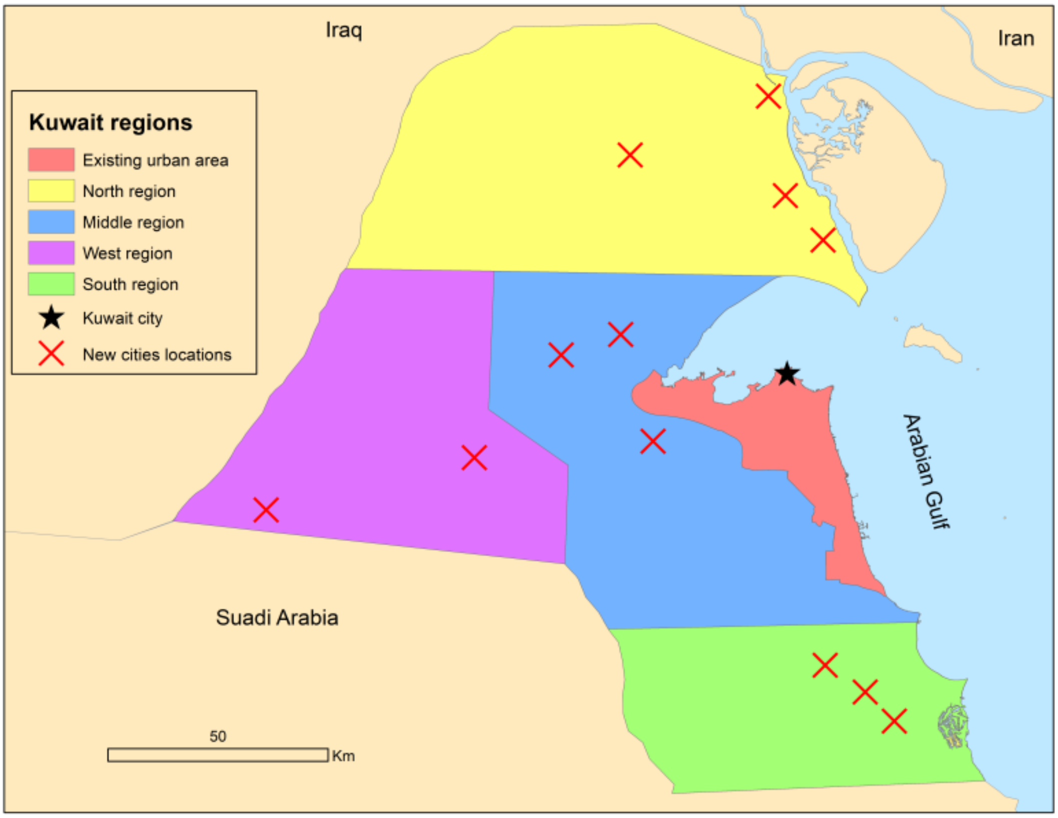

Figure 6-1: Kuwait regions and proposed new cities locations

The most important issues identified for developing the new plan according to the government were housing shortages and traffic congestion (Alghais & Pullar 2018). However and according to the planning authorities, future development decisions were made without any input from the residents. Another distinct issue in Kuwait is the high residential segregation between citizens and non-citizens. This nationality segregation is due to the following reasons (Khalaf 2006; Gardner et al. 2014):

a. The government policy of offering free dwellings to citizens in specific residential districts.
b. The right to own a house is limited to Kuwaitis and Arabian Gulf citizens only (Alshalfan 2013).
c. The differences in district type and dwelling type preference between citizens and non-citizens: Kuwaitis prefer residential districts and large plot size houses; whereas, non-Kuwaitis prefer mixed use districts and apartments (Alshalfan 2013; Dakkak 2016; Alghais & Pullar 2017a).

The population proportion in mixed districts is 9% Kuwaitis and 91% non-Kuwaitis. In residential districts, non-citizen numbers are still notable, but the majority is living in their employers' (citizens) dwellings as servants. The high levels of segregation can be seen in Figure 6-2 for all districts.

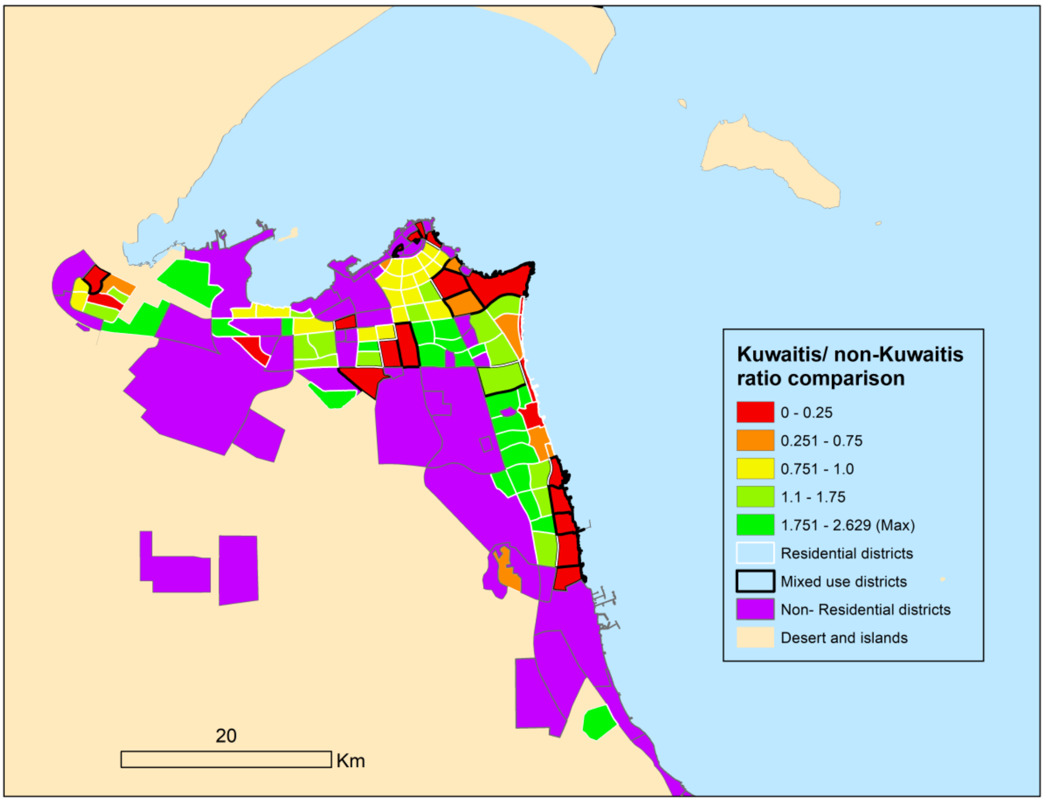

Figure 6-2: Kuwaitis/ non-Kuwaitis distribution in 2015

2.4 Modelling urban development in Kuwait

Due to the relatively small area and population of Kuwait, the high ratio of non-citizens and the existence of a single urban area, the drivers of internal migration are not clearly understood. Furthermore, there is a lack of data to understand the future of internal migration to the new cities, as there has been no significant internal migration occurrence in the past in Kuwait as explained earlier.

From the literature, and to the best knowledge of the authors, there are potential institutional destination pull factors that may attract citizens to move to the new cities in Kuwait; specifically the provision of housing welfare (lands or houses that are almost free) from the government (Alshalfan 2013). As of 2017, plans to offer new housing in the new cities have been confirmed (PAHW 2017). Other factors attracting residents to new cities may be the creation of job opportunities, the opening of large areas for private sector investments, opening branches and new government offices and new education institutions (KDIPA 2016). Push factors at the origin may include the high cost of living in established areas close to the capital, the long-time of commuting (traffic congestion) and the long waiting list for government supported housing. Pull factors may include the desire to live in areas with similar cultural backgrounds, live close to families and relatives and their current work locations (Al-Arfaj 2016).

Cultural diversity is a rather controversial topic with a range of political and social dimensions. In a country with a high number of foreign residents like Kuwait, even internal migration is likely to trigger unpredictable effects and may undermine social solidarity in previously culturally uniform regions. For instance, non-Kuwaitis (South Asians or Egyptians) often concentrate in one district and so do Kuwaitis from the same tribe (Khalaf 2006; Brettell & Hollifield 2014). Generally speaking, Kuwaiti clusters are found in residential districts and non-Kuwaiti clusters in mixed use districts. Segregation according to nationality may compromise the plan of making Kuwait the financial and trade centre of the region, as it assumes Kuwait's new cities will be global cities attracting people from around the world. If social segregation between citizens and non-citizens is increased it may also make citizens feel as minority in their country and generally creating a non-integrated society (Khalaf 2006; Gardner 2011).

With the above points in consideration, a research opportunity for Kuwait is clear. The new master plan of establishing new cities has not been modelled in terms of:

a. Push-pull factors at the origin (existing urban areas) and destination (new cities).
b. Resident willingness to move to new cities.
c. Effects of nationality segregation.
d. New master plan approval by the public.

This paper is part of a larger project that contains two additional scenarios (business as usual scenario: following the historical trends of urban development plus the new master plan scenario: following the government assumptions and perspective) (Alghais and Pullar 2015; Alghais & Pullar 2017a; Alghais and Pullar 2017b; Alghais & Pullar 2018) The new master plan has been evaluated in previous papers from the government perspective without including the residents' opinions and based on the authorities' assumptions. The results showed that the plan will provide positive outcomes in terms of housing shortages and traffic congestion if the new cities and the train network can be established on time without delays (Alghais & Pullar 2018).

3. Data and Methodology

3.1 Resident surveys

3.1.1 Survey design

Due to the lack of data about internal migration and its drivers in Kuwait, it was necessary to conduct a survey for residents to obtain primary data. According to Brown and Robinson (2006), data collected directly from residents may be used to identify and understand their preferences and behaviours. The survey questions should be direct, easy to understand and designed in a way that avoids statistical bias. To meet these prerequisites, the survey participants were identified as residents (both Kuwaitis and non-Kuwaitis), above 18 years old and excluding any servant who lives in their employers' home. Furthermore, residents who can understand Arabic or English were selected, as these are the most common languages in Kuwait. Due to the differences between the citizens and non-citizens, the survey participants were separated into two groups (citizens and non-citizens) and two separate question sheets were developed. Table 6-1 shows the population details for each survey group in 2015.

Table 6-1: Survey target

Nationality	Total Population	Aged older than 18	Population after excluding servants	Arabic or English speakers
Kuwaitis	1,307,605	701,741	701,741	701,741
Non-Kuwaitis	2,931,401	2,446,844	1,784,766	1,249,336

The survey invitations were sent via social media including Twitter, Instagram and WhatsApp, as these applications are the most commonly used in Kuwait (Tawfik et al. 2015). More than 2000 invitations were sent to obtain a 95% confidence level, +/- 5% confidence interval (Margin of error) and standard deviation equal to 0.5, as the expected response ratio was 20% according to Smith (2013).

The survey was online and stayed open for collecting responses for 2 months. 879 responses were collected from Kuwaitis, which represent a 3% of Margin of error, whereas 406 responses were collected from non-Kuwaitis, which represent a 5% of Margin of error (Barlett et al. 2001).

According to Klabunde and Willekens (2016) Push and pull factors of internal migration are outcomes of people’s decisions in terms of migration. Push factors in the origin location refer to any pressing issues that adversely affect resident lifestyles, such as traffic congestion, unemployment, lack of safety or unaffordable housing. All these may cause locals to consider migration to a different location. On the other hand, pull factors at the origin refer to residents’ ties to their community, families and workplace. Pull factors in the destination, refer to any condition that attracts residents to that location; common examples of pull factors include family ties (if family resides in a different location), employment opportunities, access to high quality education and healthcare and natural environment. Intervening obstacles that may affect internal migration include geographic distance, opportunities present in between the origin and destination or administrative difficulties (for instance obtaining permits) (Muñiz et al. 2010).

Eleven key questions were developed that investigate internal migration decisions and locational preferences. These questions relate to the theoretical model of push and pull factors. Question 1 was developed to extract the residents’ decisions about migration. Questions 2-5 and 11 were designed to understand the main drivers of their decisions (migrate or stay); or in other words the push-pull factors of origin and destination locations. Question 6 and 10 were designed to obtain the residents’ preferences about district type and future migration locations. Finally, Questions 7-9 served the purpose of collecting inputs and parameters for the migration model. A list of these questions can be seen in Table 6-2.

Table 6-2: Survey questions for residents

<table>
<tr><th>Q</th><th>For Kuwaitis</th><th>For non-Kuwaitis</th><th>Question type</th></tr>
<tr><td>1</td><td colspan="2">Kuwait government is planning to develop new cities outside the existing urban area. I am considering moving to these new cities within the next 5-10 years.</td><td>Likert scale from 1 – 5 with 1 being the least favourable (strongly disagree) to 5 being the most favourable (strongly agree).</td></tr>
<tr><td>2</td><td colspan="2">I am considering moving because of financial reasons i.e. lower real estate cost or new employment opportunities. (If answer was Strongly agree or Agree in Question 1).</td><td>Likert scale from 1 – 5 with 1 being the least favourable (strongly disagree) to 5 being the most (strongly agree).</td></tr>
<tr><td>3</td><td>I am considering moving because of social or other reasons i.e. to be near to relatives or friends, change of family size or to obtain free dwelling provided from the government. (If answer was Strongly agree or agree in Question 1).</td><td>I am considering moving because of social or other reasons i.e. to be near to relatives or friends or change of family size. (If answer was Strongly agree or agree in Question 1).</td><td>Likert scale from 1 – 5 with 10 being the least favourable (strongly disagree) to 5 being the most (strongly agree).</td></tr>
<tr><td>4</td><td colspan="2">I am not considering moving because of financial reasons i.e. living near to work or living cost is reasonable. (If answer was Strongly disagree or disagree in Question 1).</td><td>Likert scale from 1 – 5 with 1 being the least favourable (strongly disagree) to 5 being the most (strongly agree).</td></tr>
<tr><td>5</td><td colspan="2">I am not considering moving because of social or other reasons i.e. to be near to relatives or</td><td>Likert scale from 1 – 5 with 1 being</td></tr>
</table>

	friends or own a house/ apartment. (If answer was Strongly disagree or disagree in Question 1).	the least favourable (strongly disagree) to 5 being the most (strongly agree).
6	*Preference for what region of Kuwait:* I prefer to reside in residential districts (Fiha, Surra or Audiliya) rather than mixed districts (Salmiya, Hawalli or Khaitan).	Likert scale from 1 – 5 with 1 being the least favourable (strongly disagree) to 5 being the most (strongly agree).
7	Household size	Choosing number from 1-20.
8	Number of servants residing in my household's premises	Choosing number from 0-10.
9	*Preference for locational features:* Please order the following criteria/ elements based on your demands and wishes: Closeness to government services such as ministries and organisations. Closeness to public services such as shopping malls, hospitals, universities and others. Closeness to the sea/ beaches. Closeness to the existing urban area. Closeness to airports. Closeness to public transportation (bus or train networks). Low cost of dwellings (purchase or rent).	Ordering (From 1= Most important to 7= Less important).
10	Please choose your first preference for settlement location based on your demands and wishes: Stay inside the existing urban area. New city in the North side of Kuwait. New city in the Middle side of Kuwait.	Single choice answer.

	New city in the West side of Kuwait. New city in the South side of Kuwait.		
11	Which of these factors may affect your decision of not moving from the existing urban area and make you change your answer to a new city? (If in question 10, answer was a.) - High pressure on land and property values in the existing urban area. - Housing shortages in the existing urban area. - Very long commuting times in the existing urban area. - High rates of accidents in the existing urban area. - All needed public services provided in the new city. - Open a branch of your job in the new city. - New modern train network established. - Larger house sizes in the new city.	Which of these factors may affect your decision of not moving from the existing urban area and make you change your answer to a new city? (If in question 10, answer was a.) - High pressure on land and property values in the existing urban area. - Housing shortages in the existing urban area. - Very long commuting times in the existing urban area. - High rates of accidents in the existing urban area. - All needed public services provided in the new city. - Open a branch of your job in the new city. - New modern train network established.	Multi-choice answers.

3.1.2 Data processing

The survey data was firstly disaggregated in different age and nationality categories. A separate category for servants was implemented, as they live in their employers' dwellings and do not have the ability to make any decision for migration.

The agent groups formed and used in the ABM were:

1- Kuwaitis- teenagers (<18).
2- Kuwaitis- young adults (18- 34).
3- Kuwaitis- middle aged (35-49).
4- Kuwaitis- seniors (>50).
5- Non-Kuwaitis- teenagers (<18).
6- Non-Kuwaitis- young adults (18- 34).
7- Non-Kuwaitis- middle aged (35-49).
8- Non-Kuwaitis- seniors (50->60).
9- Servants (non-Kuwaitis).

These population categories were assigned to actual agents in the ABM, the details of which are presented in section 3.2.1. A possible sampling problem of bias may arise as it is expected that more young adults will be attracted to participate rather than seniors. To make sure this statistical bias is avoided, a correction technique called post-stratification weighting adjustment (ATLAS 2009) was used to ensure that the sampling is stratified to the population demographics. The adjustment factors were gender, age and nationality. To determine any significant differences between citizens and non-citizens in their responses, a single way ANOVA test was utilised. Table 6-3 summarizes the differences and similarities between Kuwaitis and non-Kuwaitis based on the ANOVA test. For more details for the survey responds, see -supplementary materials in Appendix E.

Table 6-3: Differences and similarities between Kuwaitis and non-Kuwaitis

Qn	Is there a significant difference between citizens and non-citizen responses? (one way ANOVA)	Interpretation
1	There were no statistically significant differences between group means ($F(1,1232)= 0.088$, $p = 0.767 > 0.05$).	Nationality does not affect intention to move to new cities.
2	There was a statistically significant difference	Economic pull factors are more

	between group means ($F(1, 456) = 13.117$, $p = 0.000 < 0.05$).	important to non-citizens.
3	There was a statistically significant difference between group means ($F(1, 456) = 11.218$, $p = 0.001 < 0.05$).	Social and other pull factors are more important to citizens.
4	There were no statistically significant differences between group means ($F(1, 279) = 3.005$, $p = 0.084 > 0.05$).	Same economic reasoning for staying for both groups.
5	There were no statistically significant differences between group means ($F(1, 279) = 1.059$, $p = 0.304 > 0.05$).	Same social and other reasons for staying for both groups.
6	There was a statistically significant difference between group means ($F(1, 1008) = 594.208$, $p = 0.000 < 0.05$).	Kuwaitis prefer residential districts, whereas non-Kuwaitis prefer mixed districts.
7	Not applied	Not applied
8	Not applied	Not applied
9	Not applied	The ranking of criteria is different between citizens and non-citizens.
10	There was a statistically significant difference between group means ($F(1, 916) = 4.177$, $p = 0.041 < 0.05$).	Preferred locations of settlement are different between citizens and non-citizens.
11	Not applied	The same push and pull factors affect both groups' decision of moving.

Figure 6-3 shows the preferred migration destinations according to the survey results (Question 10) from the existing urban area to new regions.

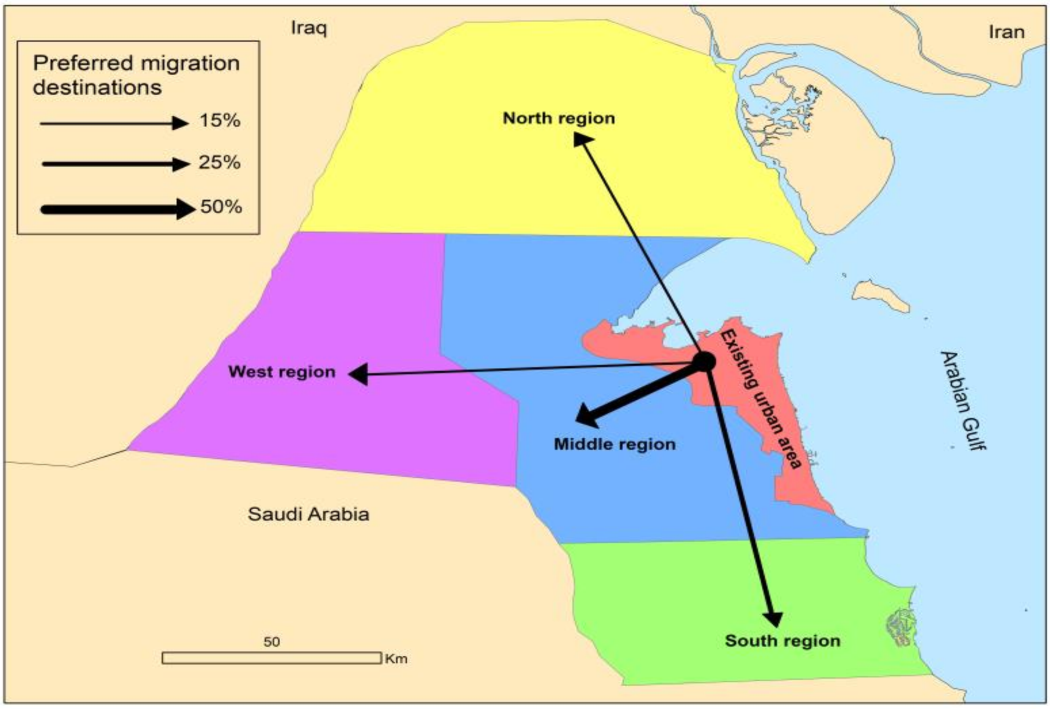

Figure 6-3: Migration destinations preferences from survey (Question10)

3.2 Model and Scenario Design

3.2.1 Model design and concept

There are several tools available for ABM that describes simulation models in terms of agents, environment, scheduling, interacting and rules and behaviours (Crooks & Castle 2012; Johnston 2012; Abar et al. 2017). Integrating agent interactions and the spatial movement of these agents was challenging with available ABM tools so the model was implemented in a programming language, namely Python, which is integrated with GIS software. The implemented model follows the same procedures and simulation control as supported in ABM tools, but allows a higher level of coupling with spatial data as provided by GIS. There were two spatial scales in the model: national and district. The simulations run in 5-yearly intervals from 2015 to 2050, for a total of 7 time steps. The model assumed that population and land use distribution are going to evolve according to three different scenarios as mentioned earlier. Table 6-4 explains the details of these scenarios.

Table 6-4: Scenarios characteristics

<table>
<tr><th rowspan="2">Scenario</th><th colspan="4">Characteristics</th></tr>
<tr><th>Modelling type</th><th>Establishing new cities</th><th>Migration</th><th>Nationality segregation</th></tr>
<tr><td>1</td><td>Top-down</td><td>Based on government authorities plans.</td><td>Based on government assumptions and expectations.</td><td>Based on government district spilt policy and historical trends.</td></tr>
<tr><td>2</td><td rowspan="2">Bottom-up</td><td colspan="2" rowspan="2">Based on resident preferences, demands and choices as extracted from the surveys.</td><td>Based on resident preferred district type as extracted from the surveys.</td></tr>
<tr><td>3</td><td>All new districts are similar and there is no spilt policy or preferred resident district type.</td></tr>
</table>

The model involves two types of agents:

a. Decision agents (government planning authorities).

b. Resident agents (mobile agents able to migrate from existing urban areas to the new cities).

The resident agents are divided into two categories (citizens and non-citizens). These categories were further classified into 9 classes, according to the factors discussed in 3.1.2. Table 6-5 shows the agents groups.

Table 6-5: Model's agents

Agent	Classes	Actions	Behaviours
Government authorities	-	Establish the new cities in scenario #1.	Responsible for urban planning and establishing new cities and infrastructure.
Citizens (Kuwaitis)	Teenagers	Stay in current residence or migrate to new cities with their parents.	Have no ability to make any decision independently.

	Young Adults	Have the ability to change the order of establishing cities based on their preferences and needs (in scenarios #2 and #3). Choose to stay in current residence or migrate to new cities.	Prefer to settle in residential districts. High chances of migration.
	Middle aged		Prefer to settle in residential districts. Average chances of migration.
	Seniors		Prefer to settle in residential districts. Low chances of migration.
Non-citizens (Non-Kuwaitis)	Teenagers	Stay in current residence or migrate to new cities with their parents.	Have no ability to make any decision independently.
	Young Adults	Have the ability to change the order of establishing cities based on their preferences and needs (in scenarios #2 and #3). Choose to stay in current residence or migrate to new cities.	Prefer to settle in mixed use districts. Low chances of migration.
	Middle aged		Prefer to settle in mixed use districts. Average chances of migration.
	Seniors		Prefer to settle in mixed use districts. High chances of migration.
	Servants	Stay in current residence or migrate to new cities with their employers.	Have no ability to make any decision independently.

Each of the nine resident agents was represented as resident agent locations (point features in GIS) for spatial visualization of migration in the model (each point = 100 persons). The environment was represented as a polygon feature class that includes the land use as districts. Figure 6-4 shows the model flowchart.

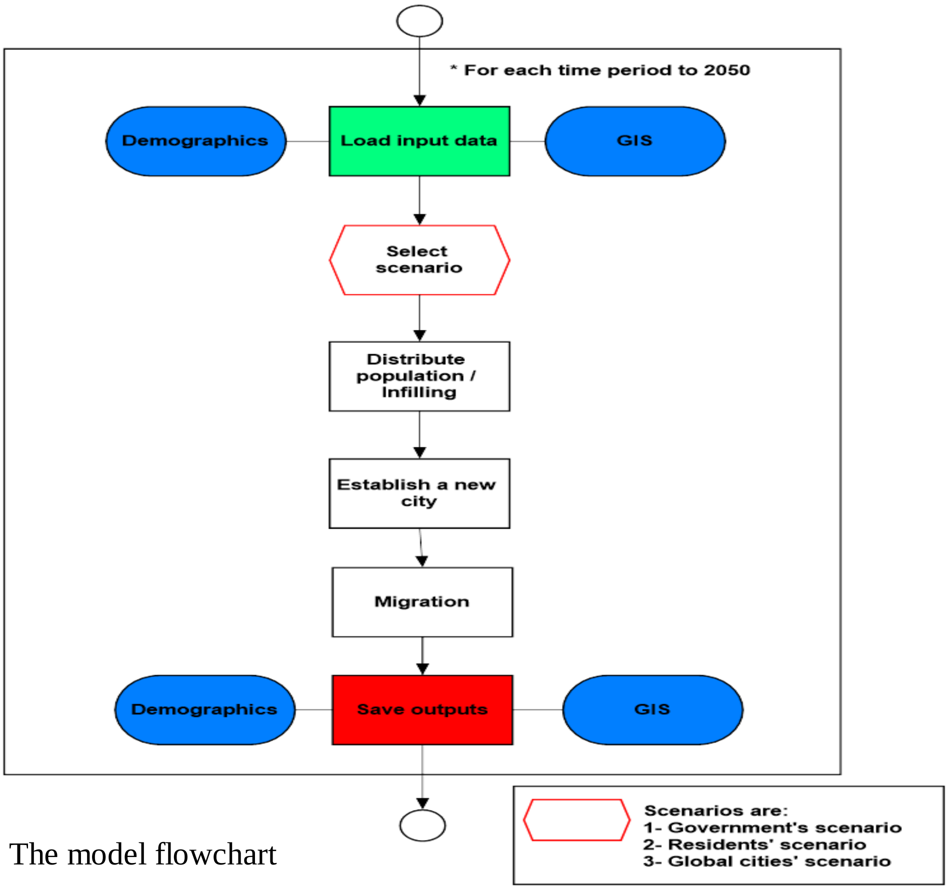

Figure 6-4: The model flowchart

The decision-making process in modelling typically involves two steps: firstly, an assessment of the choices about migration and secondly the transformation of the assessment results into an action (Klabunde & Willekens 2016). However, in this simulation and as data was directly collected from the residents, the decision-making process includes three steps.

The first step is about establishing or not establishing new cities according to the number of people willing to move, as derived from the surveys. The threshold percentage of residents willing to move, above which new cities are established is 50% of the new city establishment capacity (Alghais & Pullar 2017a). The second step applies the migration decision as collected from the responses to Question 1. Finally, in the third step the resident migration actions are carried out to any new location based on their preferences as collected from Questions 9 and 10. These actions occur under a few important conditions:

a. There are vacant lots in the district.
b. Migration may be only towards the new cities (old districts can be occupied by residents in infilling step).
c. The residents that would want to migrate to the new city exceed the aforementioned threshold percentage.

Certain assumptions had to be made during the model design, due to lack of data and to promote realistic representation of the urban development in Kuwait. These assumptions are summarized in Table 6-6.

Table 6-6: Model main assumptions

Assumption	Reason	Effects
Employment opportunities, public services, housing and infrastructure distribution are spatially uniform in new cities.	Stated in Kuwait municipality's master plan and Public Authority of Housing Welfare's dwellings provision plan.	There are no resident preferences based on these parameters.
Distributing resident age classes and servants in existing suburbs was based on averages.	Lack of data.	All existing districts have the same distribution of age groups and servants.
Current resident preferences will be applied in all future time steps.	Lack of future data.	Each time step will has the same preferred locations and district type and migration ratio.
New cities will be initially filled 25% of its maximum capacity via internal migration.	According to historical data new cities need more than 5 years to be occupied by residents.	New city will initially house only a few residents and will be filled via infilling in the following time steps.
No financial and political changes that may increase instability will occur.	Outside of scope of this paper.	Stable conditions for urban development practices.
The maximum capacity of existing districts will be the same as 2015.	Lack of data.	Existing districts will not host more residents than in 2015 (could be less).
Household size for Kuwaitis is 7 (assuming 2 parents, 3 kids and 2 servants)	Based on the survey averages.	This will affect the establishing new cities action.
Household size for non-Kuwaitis is 5 (assuming 2 parents, 2 kids and 1 servant)	Based on the survey averages.	This will affect the establishing new cities action.

3.2.2 Model inputs

The model uses two types of spatial and population data to simulate population migration: 1) locational suitability parameters and 2) model demographic variables.

The locational suitability parameters were calculated with the *Near* tool in ArcGIS and according to existing and future infrastructure. Costs were calculated with the help of real estate annual reports (KFH 2015). Suitability weights were determined by using the Analytic Hierarchy Process (AHP) (Nyerges & Jankowski 2010); this involved transforming the resident survey responses from Question 9 into weights. The weights affect the decision of establishing new cities in scenarios #2 and #3 and affect the distribution of residents in all scenarios based on their preferences. The suitability weights can be seen in Table 6-7 (top rows presents parameters ranking similarity and lower rows shows the differences).

Table 6-7: Locational suitability parameter rankings and weights

Parameter Ranking	Kuwaitis	Non- Kuwaitis	Weight
1	Lower cost of dwellings (purchase or rent).	Lower cost of dwellings (purchase or rent).	35%
4	Closeness to government services.	Closeness to government services.	10.5%
7	Closeness to airports.	Closeness to airports.	3%
2	Closeness to the existing urban area.	Closeness to public services such as shopping malls, hospitals, universities.	24%
3	Closeness to public services such as shopping malls, hospitals, universities.	Closeness to the existing urban area.	16%
5	Closeness to the sea/ beaches	Closeness to public transportation (bus or train).	7%
6	Closeness to public transportation (bus or train).	Closeness to the sea/ beaches	4.5%

The model's demographic input variables include future demographic data with aggregate projections from 2015-2050 by nationality and age group (Alramadan & Almusallam 2013) and allowed predictions for international migration, death rates, birth rates and nationalization (the process of obtaining Kuwait citizenship). This data may be modified over time. Variables collected from the surveys, but do not change over time, were classified spatially and can be seen in Table 6-8.

Table 6-8: Collected input variables

Variables		Residents' agents					
		Citizens			Non-citizens		
		Young Adults	Middle aged	Seniors	Young Adults	Middle aged	Seniors
Migration Desire %		40%	35%	35%	44%	36%	45%
Preferred region	Existing urban area	42%	41%	53.5%	54%	53%	49%
	North region	9%	11%	2.5%	6%	7%	2.5%
	Middle region	36%	32.5%	31%	25%	20%	29%
	West region	5.5%	4%	8%	9%	7%	0%
	South region	7.5%	11.5%	5%	6%	13%	19.5%
Preferred district type	Residential	92%	91%	94%	36.5%	30%	28%
	Mixed	8%	9%	6%	63.5%	70%	72%
Household size		7			5		

3.2.3 Model Algorithm

The algorithm steps for the simulations (see Figure 6-4) are as follows:

1- Initialization: Firstly, the spatial environment is created in GIS, initialising the default parameter values and input variables, loading population projections and initialising the model schedule to begin in 2015.
2- Preparation and calculation: This step includes calculations of the suitability weights for the new cities and the districts inside new cities and calculations for the threshold for opening the new cities.
3- Infilling: This step allocates new residents to old districts (including new open districts if any available) with available housing capacity. Residents are distributed based on their agent class and in way that is aligned with the age distribution averages. The numbers of

residents are converted into resident agent locations points in the map (i.e. for each residential classes as in Table 6-5). For scenarios #2 and #3, new cities will opened only if the survey participants state that such new cities can meet their needs and expectations. Figure 6-5 shows the difference in algorithm steps when deciding whether to open a new city or not at each time step.

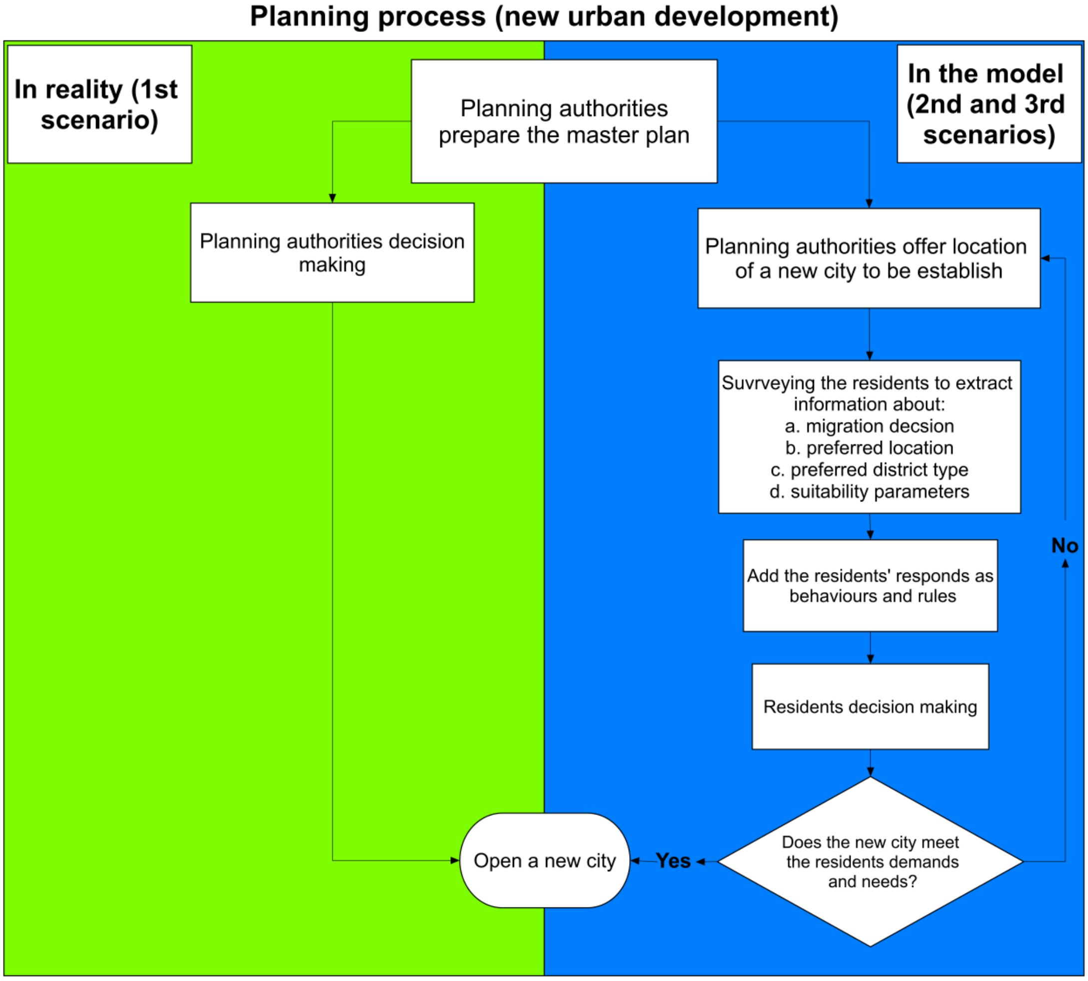

Figure 6-5: Framework of involving residents in future plans model

4- Selecting the scenario: The user may select which scenario will be simulated at this stage.

5- Establishing a new city: for scenario #1 cities will be established according to the master plan. For scenarios #2 and #3, suitability weights, numbers and desires of residents, as well as new city capacity and threshold percentage will be taken into account.

6- Migration: This will be done by moving the resident agents from the old urban area to the selected city. The initial migration will fill 25% of the new city's capacity. Agents will be added to the new districts based on suitability weights. In addition, residents under 18 years old and servants will follow their parents/employers according to average household size. Finally, the residents that moved to new cities will be removed from the existing urban area.

7- Segregation distribution: This step will be different depending on the scenario.

Scenario	Segregation Distribution
1	As per the current distribution ratio averages.
2	According to survey responses (Question 6) (resident preference of district type).
3	Uniformly to all new districts (all being mixed type).

8- Calculation of nationality segregation outcome: the ratio of Kuwaitis to Non-Kuwaitis can be calculated at this step as:

$$Nationality\ segregation\ ratio = \frac{Total\ Kuwaitis\ in\ mixed\ districts}{Total\ non - Kuwaitis\ in\ mixed\ district}$$

At the end of each time step output maps, tables and figures are produced to show the simulation results for the population distribution and migration patterns, new city development stages and nationality segregation levels. Details about the ABM in this paper follow the ODD (Overview, Design concepts, Details) protocol can be seen in the supplementary materials- Appendix E (Grimm et al. 2010).

4. Results

Results shown in this section are the average or mode values out of 35 runs of the model. Figure 6-6 summarizes the main outputs for each model scenario.

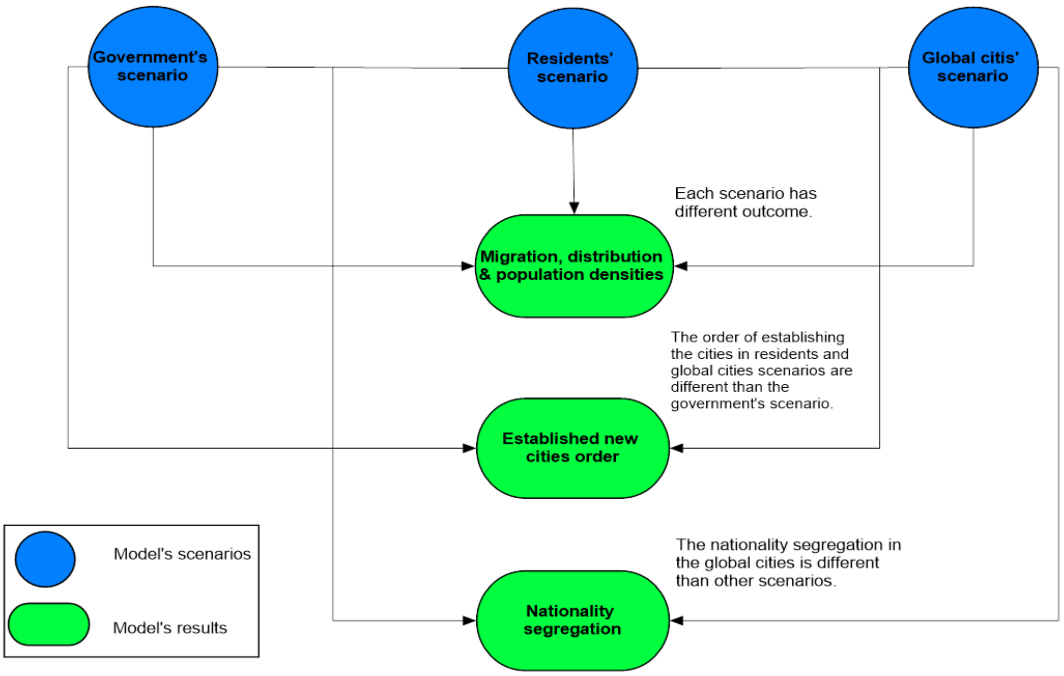

Figure 6-6: Model's results differentiations

The results section will present the model's results for the different scenarios in three different outcomes: a) future migration, distribution and densities in 2050, b) the order of establishing the new cities and c) the future nationality segregation levels. Therefore, Table 6-9 shows the predictions for density and demographics of 2050 for each scenario compared to the current situation (2015).

Table 6-9: Scenarios predictions of demographics and distributions

Scenario	**Preferred primary residence regions**					
	Citizens			**Non-citizens**		
	Young Adults	**Middle aged**	**Seniors**	**Young Adults**	**Middle aged**	**Seniors**
Current (2015)	Existing urban area			Existing urban area		
#1 (2050)	1.Existing urban area 2. Middle 3. South	1. Existing urban area 2. Middle 3. North		1.Existing urban area 2. Middle 3. South	1. Existing urban area 2. North 3. Middle	1.Existing urban area 2. Middle 3. South
#2 (2050)	1. Existing urban area 2. Middle 3. North	1.Existing urban area 2. North 3. Middle		1.Existing urban area 2. Middle 3. North	1. Existing urban area 2. North 3. South	1.Existing urban area 2. Middle 3. North
#3 (2050)	1.Existing urban area 2. North 3. Middle	1. Existing urban area 2. Middle 3. North		1.Existing urban area 2. Middle 3. North	1. Existing urban area 2. North 3. Middle	1.Existing urban area 2. Middle 3. North

According to the survey responses, the South region ranked higher in preference, however simulation results showed that the North region will host more residents. This is due to the suitability weights of the North region that are higher than the South region cities and the fact that North region cities have higher capacities and hence may host more residents. The West region does not appear to be in the top 3 regions for any group, due to its high distance to the current urban area and the coast. The Middle region is the second most preferred in most cases, most likely due to its closeness to the existing urban area and existing public services. Finally, the existing urban area is still predicted to be the most highly preferred region for all the residents even by 2050. Based on the future resident distribution in Table 6-9 possible reasons behind these outcomes are:

1- Survey data or simulation such as:
   a. The simulation period is not long enough for the new city pull factors to reach high level of desirability.
   b. The residents are concerned about delays in new cities projects
   c. The residents prefer to be stay close to their current work places and current public services.
2- Real world reasons such as:
   a. Senior citizens who own a dwelling do not desire to move.
   b. Young citizens who live in their parents' dwellings are content with their current situation.
   c. Push factors of the existing urban area affect only young and middle aged residents.

Although the population is expected to be higher in 2050 compared to 2015, the urban density will drop by more than 50%. Figure 6-7 shows a typical output map for middled age citizen distribution in 2050.

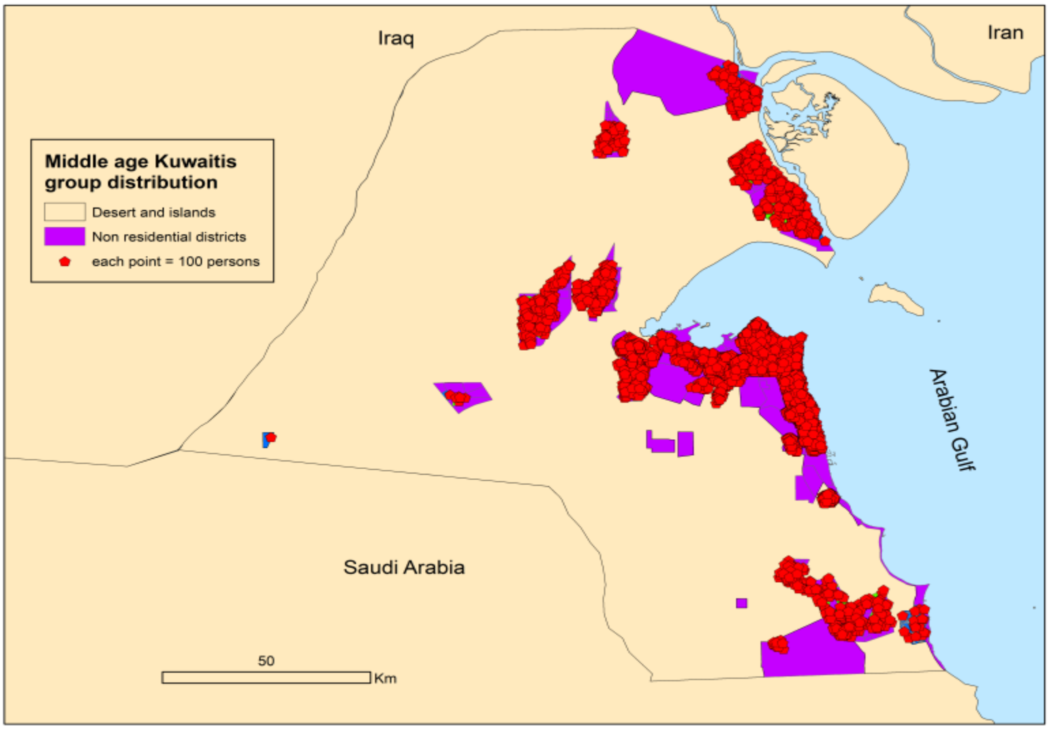

Figure 6-7: Agent group distribution in 2050

Figures 6-8 and 6-9 show the population distributions maps and highlight any differences between the scenarios.

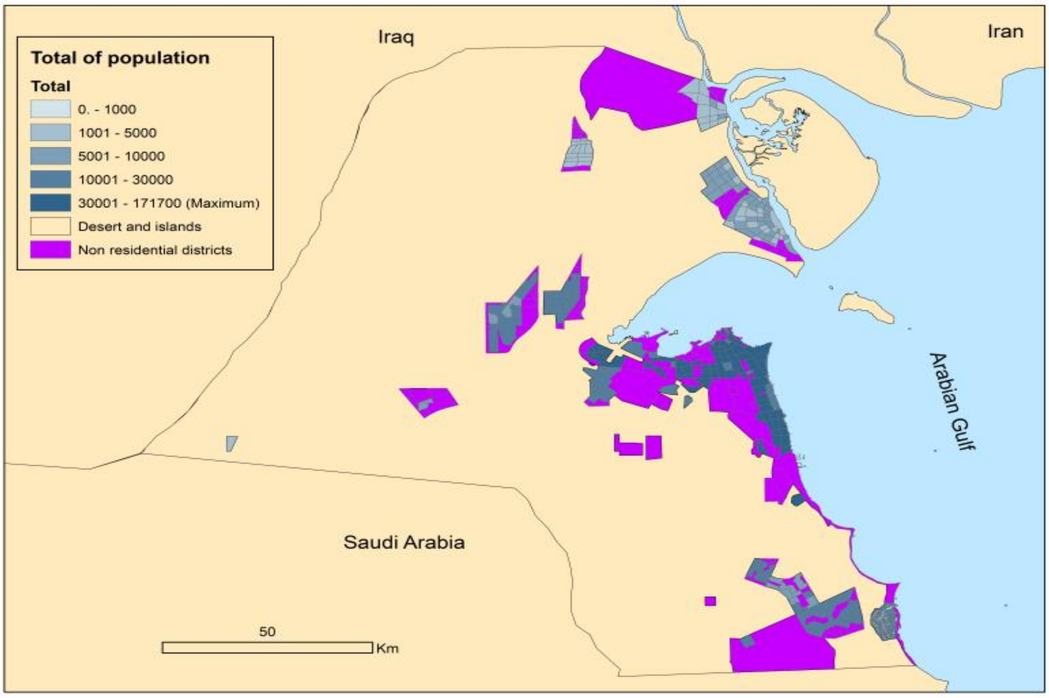

Figure 6-8: 1st scenario population distribution

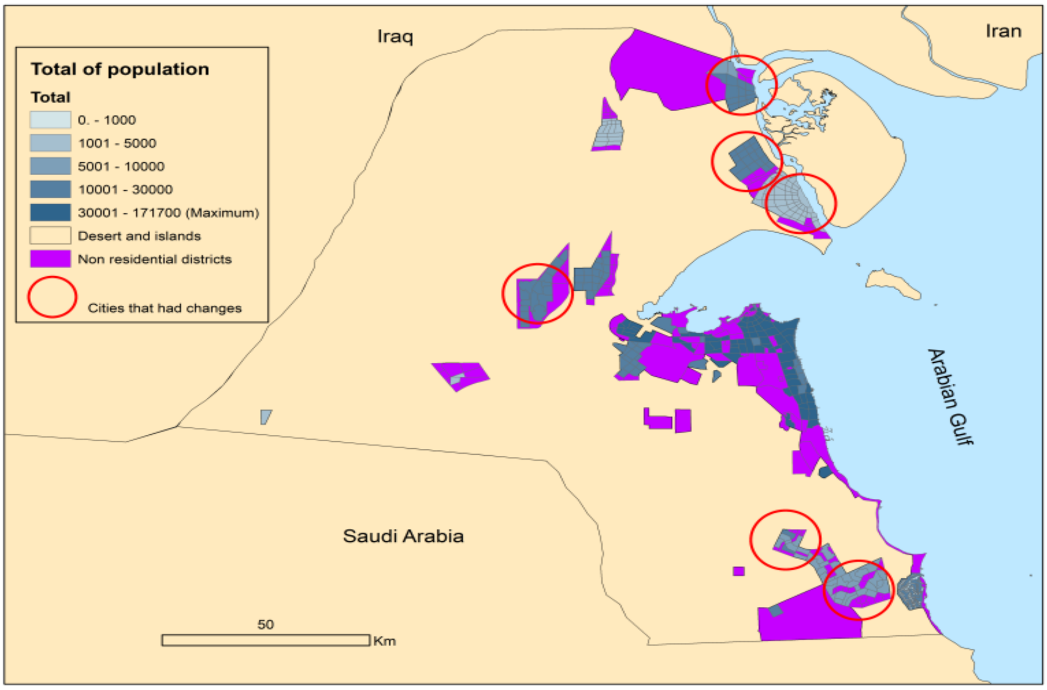

Figure 6-9: 2nd and 3rd scenarios population distribution with differences

Table 6-10 shows the order of establishing the new cities according to the 3 scenarios.

Table 6-10: Establishing new cities order based on scenarios

City	Region	Establishing year according to scenarios	
		1st scenario	2nd and 3rd scenarios
1	South	2020	2030
2	Middle	2020	2025
3	South	2025	2035
4	Middle	2025	2020
5	South	2030	2035
6	Middle	2030	2025
7	North	2035	2025
8	North	2035	2040
9	North	2040	2040
10	West	2040	2045
11	West	2045	2045
12	North	2045	2030

It can be seen that the order based on citizen responses is different than the master plan proposed order, which highlights the importance of participatory planning.

The diagram in Figure 6-10 shows the nationality segregation ratios for each time step in each scenario simulation (ratio of 1 means no segregation between residents).

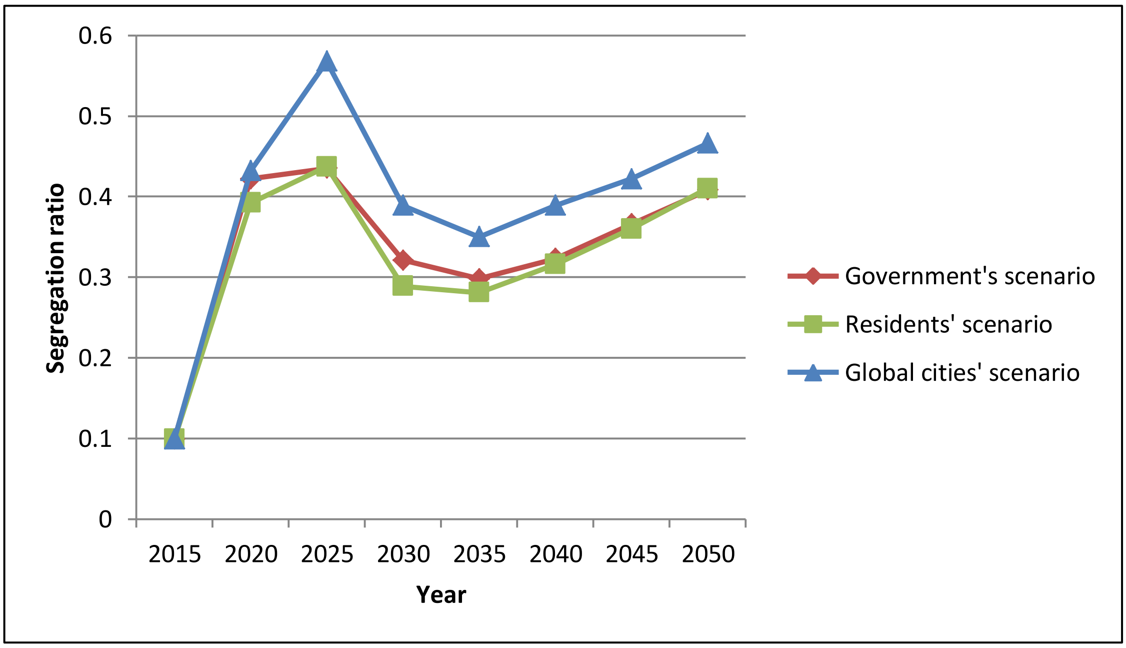

Figure 6-10: Nationality segregation levels in different scenarios

In all scenarios the segregation ratios will be lower compared to the current situation and the Global cities scenario will present the lowest segregation ratio between residents. Figures 6-11 and 6-12 show the nationality segregation ratio maps, with 1 representing equal distribution of Kuwaitis and non-Kuwaitis.

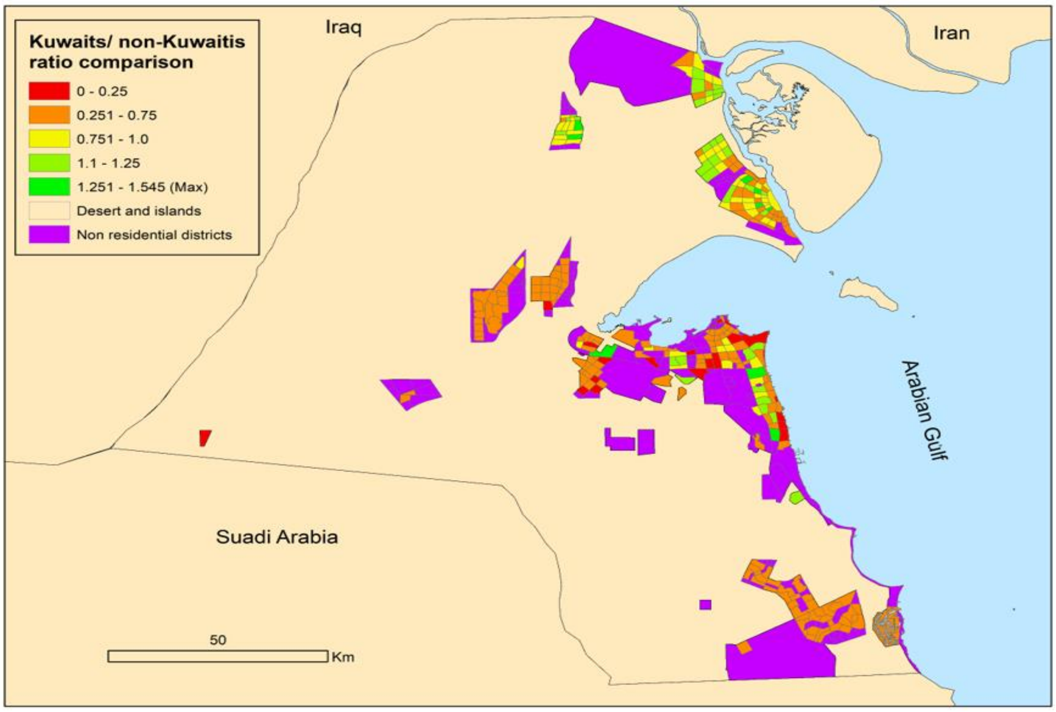

Figure 6-11: 1st scenario segregation outcome map

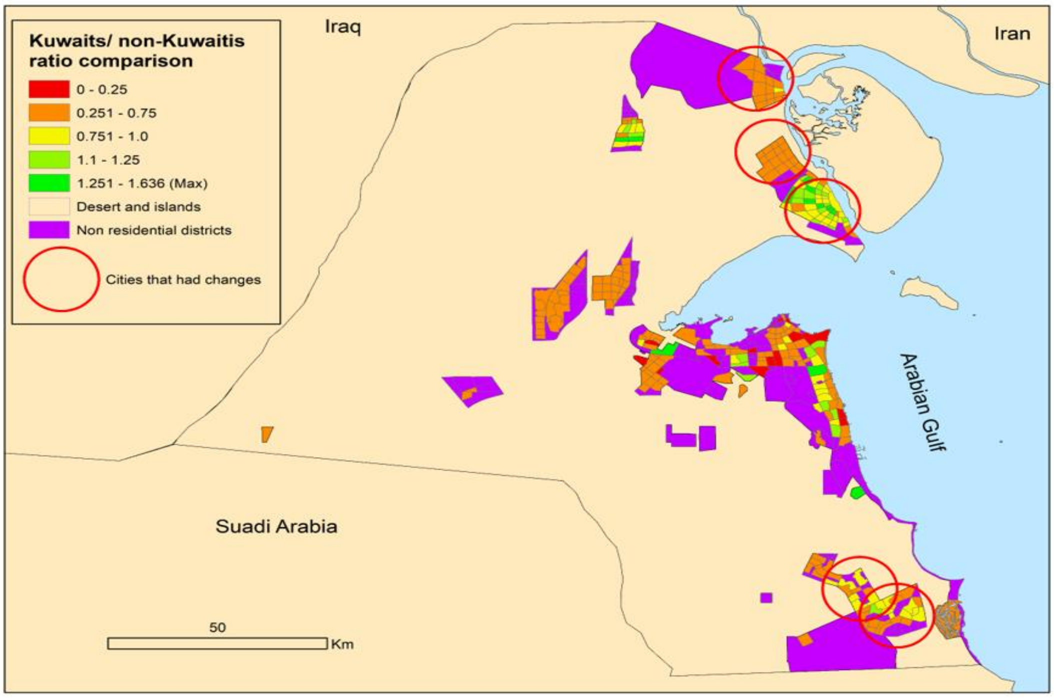

Figure 6-12: 2nd and 3rd scenarios segregation outcome map with differences to 1st scenario

In all scenarios the segregation levels will be lower across all new regions compared to the existing urban area. This trend is mainly due to the allocation of residents being only in the new cities.

5. Discussion and conclusions

Three scenarios were developed and simulated with Agent Based Modelling (ABM) as a purely empirical model, to address a series of research questions in relation to the nationality segregation levels and the desirability of Kuwait's new cities in terms of internal migration by 2050. The simulation outcomes signify the importance of public participation in urban planning. While this is not considered by the government in Kuwait or countries with similar conditions at present, the model of this paper may form a basis for integrating resident opinions in the design and evaluation of construction projects in the future.

Furthermore, the online survey used in this research was a successful approach to involve residents in future planning and simulate migration trends that can help avoid the construction of uninhabited cities. This can be seen in Figure 6-5. Besides, the survey allowed extracting residents' choices, demands, needs and preferences. These were in turn used in the model as inputs and behaviours for the agents. The results showed that the new master plan of Kuwait will most likely not create ghost cities, as there is interest and sufficient number of residents willing to move to the planned new cities.

From the survey it was clear that the main drivers of internal migration were related to housing and new employment opportunities. However, it was also noted that there were some differences between citizens and non-citizens in their needs and preferences. The results of the survey and the outcomes of the model suggested that there were no significant differences in terms of deciding whether to migrate or not. However, the preferred new settlement regions and district types were different between the two groups. In addition, economic and social reasons behind the decision of not moving to the new cities (pull factors at origin) are similar; whereas, the pull factors (at destination) that new cities offer to attract residents are different. All of these meant that it was necessary to split the citizens and non-citizens and treat them as different agents in the model.

It was no surprise that young and middle aged Kuwaitis had the highest desire to migrate to the new cities, as these age groups are the primary recipients of the welfare housing. However, it was surprising that non-Kuwaiti seniors are the keenest on migration. This could be explained because the old non-Kuwaitis are nearing retirement age and they may migrate back to their countries. The new cities may offer new employment opportunities and entice them to stay in Kuwait instead.

Furthermore, this illustrates how the push-pull drivers behind migration are different between citizens and non-citizens in Kuwait. The major pull factor at the destination for Kuwaitis and for non-Kuwaitis is housing, and employment opportunities respectively. Push factors at the origin were found to be similar: high pressure on land and property values and long commuting times in the existing urban area.

The results showed that the nationality segregation levels will be lower in the future compared to 2015 level. In the scenarios based on government's plans and resident preferences segregation is higher by 15% than in the third "Global Cities" scenario. The main reason for this is that citizens prefer to settle in purely residential districts, while non-citizens prefer mixed districts and this preferred settlement trend appears to persist by 2050 in the new cities. Furthermore the government supports this trend, by offering welfare housing only in residential districts. As seen from the Global Cities scenario, which does not include any purely residential districts, but establishes mixed districts with housing, public services and business activities instead, nationality segregation may be drastically reduced. Lower segregation levels will in turn attract more investors and should contribute in transforming Kuwait into a regional trade centre according to the government's new vision for the future.

The model results confirm that the resident responses are mostly aligned to the government's development plans. Importantly, there are a sufficient number of people willing to migrate to the new cities. It can be concluded that establishing new cities is an effective plan as it will mitigate the traffic congestion, solve the housing shortage problems (Alghais & Pullar 2017a) and decrease the nationality segregation levels. Additionally, the new master plan will achieve lower urban density by 2050. The simulations suggest that new cities should be established in the following order: Middle region, South region, North region and finally West region. Moreover, the current urban area should continue gradual expansion by developing new mixed districts for residents who do not want to migrate to the new cities. This recommendation can be generalized and applied to other similar Gulf countries, such as Qatar and the UAE.

A major limitation of this study was that current resident preferences and responses were applied in the model as inputs for all time steps, which assumes that the responses will not change in the future. However, it was beyond the scope of research to predict and model future generation's needs as there is a multitude of non-linear and unpredictable factors that may affect them. Future work can focus on predicting future political, social and economic conditions and integrate them in the ABM for future time steps for enhanced result reliability. In addition, further investigation about the minimum number of cities needed to reduce the negative impacts of urban growth in Kuwait can be carried out through new simulations.

Chapter findings

This chapter incorporates resident behaviours as agent rules in ABM to explore the ways that public participation affects urban growth in Kuwait or similar Arabian Gulf countries.

The simulations confirmed that establishing the new proposed cities according to the master plan is effective in mitigating traffic congestion, solving the housing shortage problem and decreasing the nationality segregation levels. The model incorporated the resident opinions suggesting that the planning authorities in Kuwait must slightly alter the master plan by establishing the new cities in a different order to the initially proposed one: Middle region first, followed by the South and North regions and finally the West region. In addition, the existing urban area should continue to gradually expand with mixed districts for residents who do not want to migrate to the new cities.

Furthermore, the findings of this chapter suggested that creating new cities in Kuwait will most likely not create Ghost cities, as there is sufficient interest from residents willing to move to these cities. Simulating the future urban development with the survey responses also showed that the nationality segregation levels will be lower compared to 2015.

The key differences between Kuwaitis and non-Kuwaitis were the preferences about new settlement regions and district types. However, there was no notable discrepancy in the willingness of the groups to migrate or not. Moreover, economic and social reasons behind the decision of not migrating to the new cities are similar between the two groups. On the other hand the pull factors that new cities offer to attract residents are different between the two groups: economic reasons are more important to non-citizens and social reasons are more important to citizens.

For more details of the algorithms in this model, including the ABM codes and data the reader may refer to Appendix E.

Chapter 7 : Conclusion

This project contributes to the research field of urban systems and urban modelling through addressing issues specific to Kuwait and other Arabian Gulf cities. The overriding theme of the research thesis was that nationality segregation and centralised planning contribute towards negative urban growth impacts in Arabian Gulf societies. With the help of the findings from the models, the conceptual issue of interpreting and predicting urban dynamics, and the practical issues of housing shortages and traffic congestion may be resolved. This reflects on the main research hypothesis, which was to investigate how urban modelling can be integrated in urban planning in Arabian Gulf countries and assist with the design and implementation of alternative expansion approaches that improve the growth impacts. As shown in the results of the simulations, the conceptual and practical contributions of the new models include but are not limited to:

- Urban modelling can be used to extract data useful in monitoring and interpreting the urban dynamics of Arabian Gulf societies.
- Urban modelling can be used to simulate alternative urban growth plans, analyse the impacts of each and assist with decision making.
- Urban modelling can be used to extract data useful for responding to practical issues in Arabian Gulf societies, such as traffic congestion and housing shortages.
- Urban modelling can be used to detect and analyse the underlying conceptual effects of nationality segregation and centralised planning on urban dynamics.

In order to set up the new models, it was first necessary to understand urban systems, urban growth and the associated impacts in the case study city of Kuwait. Via an extensive literature review, direct interviews and surveys it was established that the key decision maker in the past, as well as for the most recent master plans for urban development is the government. In Kuwait, the private sector and the community have little say in planning decisions.

After establishing the key decision makers, it was necessary to understand the key impacts of urban growth as perceived by the government and the local residents. It was found that traffic congestion and housing shortage are the most significant growth impacts of concern in Kuwait. Worryingly, the first simulation for future urban development that follows historical trends of expansion around existing urban areas, shows that traffic congestion and housing shortage will be both aggravated. These simulations, discussed in Chapter 4, were conducted after collecting and spatially collating socio-economic data for Kuwait from 1995 to 2015 in a land use model with automata elements.

As expansion of existing urban area appeared to be ineffective in addressing the urban issues in Kuwait, alternative ways of expansions were considered. The most recent master plan in Kuwait aims to establish new cities at a distance from the single existing urban area. In Chapter 5, a set of interviews with the government decision makers, and survey responses obtained from residents in Kuwait provided insight in assessing the effectiveness of this new master plan. It was shown in the simulations that creating new cities around the country is expected to produce better outcomes than the continuation of existing city expansion in terms of both traffic congestion and housing shortage. This conclusion holds true even if delays will occur in construction projects.

Even though the creation of new cities proposed by the master plan appears to be a step towards the right direction, there are still certain weaknesses in its policies. Most significantly, public participation is non-existent in the master plan, which is a common practice in urban planning in Kuwait's history. Furthermore, the master plan projections are not complemented by urban modelling simulations and it does not consider the important underlying demographics of nationality segregation in Kuwait. In Chapter 6, the simulations in the ABM addressed the aforementioned weaknesses. The third simulation model was developed according to data collected directly from surveying Kuwait residents and applied to the basic elements of the master plan. The data obtained from the resident surveys generated conclusions about the resident desires and expectations from urban development. The results were segmented according to resident nationality between citizen and non-citizen groups. There were notable differences detected in terms of the reasons that may cause each group to consider moving and the locations they would prefer to settle. Specifically, economic factors such as employment opportunities, closeness to workplace and saving on rent are more important to non-citizens. On the other hand, social reasons such as closeness to relatives and friends are the most critical factors influencing the citizens' migration and settlement decisions.

Prince of Kuwait Sabah Al-Ahmad in 2006 stated that: "*Development and planning have the first national priority that must be agreed upon, and work to achieve, for planning and development are life necessity and the bases for building and securing the future of our sons and our future generations. What we aspire to in planning and developments must revolve around the Kuwaiti citizen, their objectives are his welfare and happiness, ...*" (Al-Diwan Al-Amiri 2017). This statement served as a major inspiration for this thesis. The author is confident that its findings indeed can help achieve the Prince's vision for the future of Kuwait. The contribution of the thesis extends beyond simply improving existing State planning and development processes. Instead, improving the wellbeing of residents may be achieved through a process that involves the residents themselves as well. Indeed, the involving of Arabian Gulf residents in the urban projects was recommended by (Schäfer 2013). In the proposed methodology, the resident involvement is carried out via online surveys as these are among the easiest and most direct participation channels.

Reflecting on the significance of this research thesis, we should first highlight the practical applicability of the new automata tools in modelling and assessing different urban growth scenarios, which expands the literature related to automata (Timmermans 2012). Among the most significant reasons that ABM and automata modelling are recommended is their flexibility in analyses of interactions of individuals as agent groups in an urban setting. ABM in this thesis was applied to a series of practical issues instead of just providing new theoretical insights. This in itself, is an innovative application of ABM, which has been already recognised as a valuable tool for research in the field of urban systems (Benenson & Torrens 2004). The urban systems of Kuwait, within which these interactions develop, were not well understood before this project. The simulation results from chapters 4 and 5 are very valuable in that sense, as they allowed a quantitative comparison of the impacts of the master plan (new cities) versus the business as usual (existing city expansion) scenarios. The simulations from the new models have revealed a range of underlying factors that explain the urban dynamics in Arabian Gulf countries with demographics and economic conditions similar to Kuwait. These factors include the differences and similarities in preference of citizens and non-citizens for settling and commuting. More importantly, the survey provided some evidence that the residents in Kuwait are welling to live in a mixed society in the near future (higher rate with non-citizens and lower with citizens); however, it is depend on the future. In turn, the aforementioned findings can be directly used in practice from the state planning authorities or as reference in future studies that aim to expand on the academic knowledge in the field of urban modelling and urban systems.

In addition to assessing the impacts of growth and evaluating the different expansion alternatives with the models, this research concludes that using automata models, such as ABM in the unique context of Arabian Gulf countries is both viable and highly recommended. Data derived by automata modelling may be used in parallel with or in place of conceptual designs based on statistical patterns of past urban growth as is currently the case in Kuwait and other Arabian Gulf countries in their master plans (Madbouly 2009). The proposed models may be easily applied to other similar Arabian Gulf cities with little modification effort, as the nationality segregation, economic conditions, centralised planning and social/institutional structures are shared between several emirates and kingdoms in the region (Khalaf, 2006).

Furthermore, the significance of this research is notable in investigating the integration of resident inputs in the models and comparing the outputs to government plans. These inputs obtained from surveys directed to residents, not only provided the means to acquire valuable urban modelling inputs, but also opened a channel of public participation in urban planning decisions in Kuwait for the first time. The methodology of Chapter 6 described ways that these responses were used to determine weights of model parameters and determine the behaviours and rules of resident agents in the ABM. In fact, the ability to easily integrate such bottom-up data in simulations is a major strength of automata that solidifies the earlier recommendations for using them in urban system modelling. After all, modern cities and their respective systems are increasingly influenced by factors related to quality of life and resident inputs, rather than simply relying on traditional economics and land use models. The model and findings in this thesis are strongly towards this direction, which is especially innovative in the context of Kuwait and Arabian cities. Using online platforms for collecting primary data for government decisions and planning is a relatively new notion; sometimes this is referred to as e-Democracy (Hilbert 2009). While there are still many challenges with the full integration and utilisation of e-Democracy in planning, such as the data integrity and user verification, this research thesis offers a successfully implemented example of surveying residents and extracting useful data.

The interviews with the government and private sector representatives also constitute a novelty in Kuwait. It was possible to comprehend the roles of the key stakeholders in planning and decision making very clearly for the first time, as well as their rationales and concerns. The interviews revealed that there are no alternative options in case the Master Plan is cancelled or delayed and that no predictive modelling of any sort is being used. Furthermore, the government officials confirmed that there is no formal intention of integrating the public opinions to future planning decisions; however, there is interest in reviewing the findings of urban simulations from the model presented in this thesis. Finally, during this research project, it was confirmed that the private sector in Kuwait has the ability, willingness and desire to participate in future planning if the government allows that – this is an important finding that may open new research pathways about how this may be done in terms of urban planning, policy making and finances. The participation of the private sector in local and regional projects has been highly recommended by the Secretariat General of The Cooperation Council for the Arab States of the Gulf (GCC) (GCC Secretariat General, 2011).

Besides the broader contribution to the modelling field, the results of the simulations with the resident inputs confirmed that establishing new cities in Kuwait is a better option than expanding the existing urban area for alleviating the negative impacts of urban growth (traffic congestion, housing shortage and nationality segregation). This expands on the scarce prior research that attempted to assess the effectiveness of master plans in Kuwait (Abu-Ayyash 1980; Abu-Ayyash 1981; Al-Damkhi et al. 2008; Al-Nakib 2014b). It was also shown that there are specific preferences among all residents or particular groups that should have been considered in the master plan. Regardless, another contribution of this thesis to the success of the master plan is the fact that the interest of citizens and non-citizens to move to the new cities is indeed very high. This implies that the Kuwait government, or other state authorities with similar master plans, should attempt to integrate public participation in their future decision making processes. In this project this was achieved through surveying the residents via social media, as the usage of social media in the Arabian Gulf countries has increased significantly since the Arabian spring protests in 2011 and can function as an informal public participation channel (Peterson 2012). This method of data collection is in many ways easier to manage compared to independent research. Furthermore, the advantages of doing so are obvious; firstly, public participation of any kind can help avoid any risks that the government may have omitted in their analysis. Secondly, it was shown that modelling resident responses is easily achieved with ABM, so there is no need to develop any special sophisticated models. Ultimately, it is not in the scope of this research project to comment on the social and political factors related to public participation in Kuwait's urban system decision making. However, the author strongly believes that the planning authorities can only realise benefits if they choose to follow this recommendation in the future and the community will feel more entitled and involved. The inclusion of social and political factors in the model should make the predictions even more realistic and accurate, albeit the parameterisation and data collection processes would become increasingly complex. Regardless, the author is convinced that this constitutes a natural next step for future work.

The model findings also expand our understanding of planning and urban systems in Arabian Gulf cities (not just Kuwait). Firstly, previously known or suggested points were confirmed and enhanced with first hand responses from surveys and interviews: the planning systems are centralised and run exclusively by the government, the private sector's contribution is limited to consultations and there is no plan or willingness from the government side to open planning processes in the near future to either private developers or residents. In addition, new information that highlights the unique context of Arabian cities was revealed during the analysis in this thesis. For instance, we can now ascertain that citizens and non-citizens have clearly different goals and desires in terms of housing and mobility with urban areas. This is particularly important for further research, as first-hand information about both groups and how they perceive urban development and issues was scarce before this thesis. The contribution of this thesis may expand beyond the field of urban systems and/or urban planning, as it was implied through the private sector interviews and public surveys that there is a clear discrepancy between what the government plans are (closed and centralised planning) versus what the residents desire (more open participation channels and private sector involvement). This discrepancy has partially contributed towards unrest in the past with the results seen in Arabian spring movements in 2011, which expressed the dissatisfaction of big parts of population versus various state practices (Peterson 2012).

Considering the above contributions, we believe there is significant novelty value stemming from this research thesis. The outcomes described above contribute to the research field of modelling of urban systems by addressing how population groups defined by nationality have different roles and behaviours to shape urban form. Also, to our knowledge, the use of an ABM to evaluate urban growth issues and to attempt to address these issues with future planning has never been done in the past in cities in Arabian Gulf countries, and specifically Kuwait. In fact, there have been no simulations of future urban growth of any kind in Kuwait in the past at all, and all master plans were based on conceptual designs and assumptions that were never tested. ABMs are well suited to modelling urban dynamics based upon observed patterns and when combined with direct resident group inputs they form powerful tools that can be integrated in future planning decisions.

Furthermore, the design and validation of alternative scenarios via surveys enhanced our understanding and allowed incorporating the residents' preferences, needs and expectations in urban planning for the first time. More importantly, the voice of non-citizens' was considered, which is another novel concept in the reality of Arabian Gulf cities. From an urban geography perspective, the survey results from this thesis improved our understanding of the nationality segregation in Kuwait. Specifically, there was more favourable support for social integration from residents wishing to settle in the new cities.

As urban dynamics change rapidly, the findings related to the conceptual and practical issues and presented in this thesis are not only significant for the provision of data that may be used in planning; instead, the surveys and models themselves may be used with or without modifications in the future to capture any new trends or issues related to urban growth. The demographics, opinions and social contexts may vary significantly and therefore having tools like the models developed in this thesis that can be integrated in urban planning are imperative to monitor and respond to any changes in urban systems in the Arabian Gulf states.

However, that is not to say that this thesis had no challenges. For example, international migration trends were not considered, as this would require extensive data collection from various sources and more complex modelling of future trends. Another limitation is that the next generation's responses may differ from the current ones – so the findings of the study may suggest different outputs if it was conducted in the future. Finally, it was assumed that the macroeconomic conditions remain favourable for Kuwait (or other Arabian Gulf cities). However, as seen in the last few decades, turbulence related to the complicated Middle East geopolitics and oil price fluctuations are anything but uncommon. Hence, future research may focus in investigating how these potential developments may affect urban systems and the local population dynamics.

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Appendices

Appendix A: Ethics approval letter for the interviews and surveys in this research

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Geography Planning and Environmental Management

16 February 2016

TO: Nayef Algais
FROM: Dr Paul Dargusch, GPEM Ethics Officer
CC: Dr David Pullar

RE: Application for Ethics Approval

PROPOSAL TITLE:
Modelling of urban development and future urban growth impacts on congestion and housing shortages in Kuwait [GPEM number 20160203]

In my capacity as the School of GPEM Ethics Officer, I have reviewed the above research proposal for compliance with University and School regulations governing research on human subjects.

The proposed research is not subject to higher level review by the University Behavioural and Social Sciences Ethical Review Committee (BSSERC) for the following reasons: 1) the research does not directly involve human subjects from vulnerable or special populations, 2) the research does not involve any risk above "everyday living", 3) the research is not intrusive, and 4) informed consent will be obtained before data collection, participation is voluntary, and participants may withdraw at any time. The research is thus classified as low risk and ethics approval at School level is appropriate.

The research proposal, as presented, complies with the National Statement on Ethical Conduct in Human Research and the associated university regulations. You may conduct the research subject to the following conditions: 1) the interviews/surveys should be conducted as described in the research protocol; 2) participants should not be personally identifiable in the results without explicit permission of the participant; and 3) the data collected is to be kept in a secure location. Should any of the above conditions change, you must refer the amended research protocol back to the GPEM Ethics officer.

If you have questions about the ethics review process, please contact me.

Dr. Paul Dargusch (p.dargusch@uq.edu.au)
Ethics Officer
School of Geography, Planning, and Environmental Management

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School of Geography, Planning
and Environmental Management

Appendix B1: Participant Information Sheet for the government authorities and developers

CONSENT FORM FOR PARTICIPATION

PROJECT TITLE: Modelling of urban development and future urban growth impacts on congestion and housing shortages in Kuwait

PRINCIPAL INVESTIGATOR: Nayef Alghais

I have been given information about *research title* and discussed the research project with *Nayef Alghais* who is conducting this research as a part of a PhD degree, supervised by *Dr David Pullar* from the school of Geography, Planning and Environmental Management (GPEM) at the University of Queensland, Australia.

I agree to participate in a questionnaire survey related to the title given above that will take approximately 30 minutes. I have read the participant information sheet that gives further information on the questionnaire and I understand the nature of the research and my role in it. Therefore, I hereby agree to be involved in this research project as a participant.

I understand that the data collected from my participation will be stored confidentially and will be used after analysed and summarised for a PhD thesis and for paper publications in relevant journals. I consent for it to be used in that manner. Besides, I understand that I will be provided with a summary of the project outcomes if I opt to.

I have been advised of the potential risks and burdens associated with this research, which include no foreseeable added risk above the risks of everyday living, and have had an opportunity to ask *Nayef Alghais* any questions I may have about the research and my participation.

I understand that my participation in this research is voluntary, and I am free to refuse to participate and to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not impose any direct or indirect penalty to me.

If I have any enquiries about the research, I can contact *Nayef Alghais* (+61 336-58340 n.alghais@uq.edu.au) and/or *Dr David Pullar* (+61 336-56522 d.pullar@uq.edu.au) or if I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, Office of Research, University of Queensland on +61 3365-1594 or email p.dargusch@uq.edu.au.

By signing below I am indicating my consent to be interviewed and answer the researcher's questions based on my knowledge and experiences.

Signed.. Date......./....../......

Name..

Organisation Name and position..

Email (Optional)...

School of Geography, Planning
and Environmental Management

Participant Information Sheet for the government authorities and developers (Arabic version)

اعلان الموافقة على المشاركة

PROJECT TITLE: Modelling of urban development and future urban growth impacts on congestion and housing shortages in Kuwait

عنوان المشروع: نمذجة التوسع الحضري و الاثار المستقبلية للنمو الحضري على الازدحام المروري و المشكلة السكنية في الكويت.

الباحث الرئيسي: *نايف فهد الغيص*

لقد تم اعطائي معلومات عن البحث و تم مناقشة مشروع البحث مع *نايف الغيص* الذي يجري هذا البحث كجزء من دراسته للدكتوراه تحت اشراف *الدكتور ديفيد بولر- David Pullar* من مدرسة الجغرافيا و التخطيط و الادارة البيئية في جامعة كوينزلاند في أستراليا.

أوافق على المشاركة في هذا الاستبيان المتعلق بعنوان البحث المذكورة أعلاه و الذي سيستغرق 30 دقيقة تقريباً. لقد قرأت ورقة معلومات المشاركة التي فيها المزيد من المعلومات عن الاستبيان وأنا أفهم طبيعة هذا البحث ودوري فيه. لذلك، أنا أوافق على أن أشارك في هذا المشروع البحثي.

وأنا على علم أن البيانات الشخصية التي تم سيتم جمعها من مشاركتي سيتم حفظها بسرية، وسيتم استخدامها بعد تحليلها وتلخيصها في اطروحة الدكتوراه و في مقالات في المجلات العلمية ذات الصلة. و أوافق على أن يتم استخدامها في ذلك. و كذلك أنا على علم أنني سوف أحصل على ملخص لنتائج المشروع في حال طلبت ذلك.

لقد تم اعلامي بالمخاطر المحتملة المرتبطة بهذا الاستبيان، و هي عدم وجود أي خطر فوق مخاطر الحياة اليومية، وكان لي الفرصة لطرح أي أسئلة حول البحث ومشاركتي فيه على *نايف الغيص.*

وأنا على دراية أن مشاركتي في هذا البحث هو تطوعي، وأنا حر في رفض المشاركة والانسحاب من الاستبيان في أي وقت. و أن رفضي للمشاركة أو الانسحاب لا يفرض أي عقوبة مباشرة أو غير مباشرة.

إذا كان لدي أي استفسار عن هذا البحث، فإنه يمكنني الاتصال بـ *نايف الغيص* (+61 336-58340، n.alghais@uq.edu.au) أو *الدكتور ديفيد بولر- David Pullar* (+61 336-56522، d.pullar@uq.edu.au). وكذلك إذا كان لدي أي مخاوف أو شكوى بشأن طريقة البحث فإنه يمكنني أن اتصل بمسؤول الاخلاقيات، في لجنة البحوث الإنسانية و الأخلاقيات في مركز البحوث، جامعة كوينزلاند على +61 3365-1594 أو البريد الإلكتروني p.dargusch@uq.edu.au.

من خلال التوقيع أدناه، أنا موافق على إجراء المقابلة والإجابة على أسئلة الباحث بناءً على معرفتي خبرتي.

التوقيع .... التاريخ.........../........../...........

الاسم ....

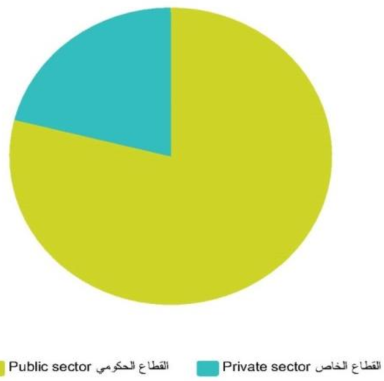
جهة العمل و المسمى الوظيفي...

البريد الالكتروني...

Appendix B2: Completed survey by the government authorities and developers representatives

Q1 Are you working in Public or private sector?هل تعمل في القطاع الحكومي أم الخاص؟

Answered: 19 Skipped: 0

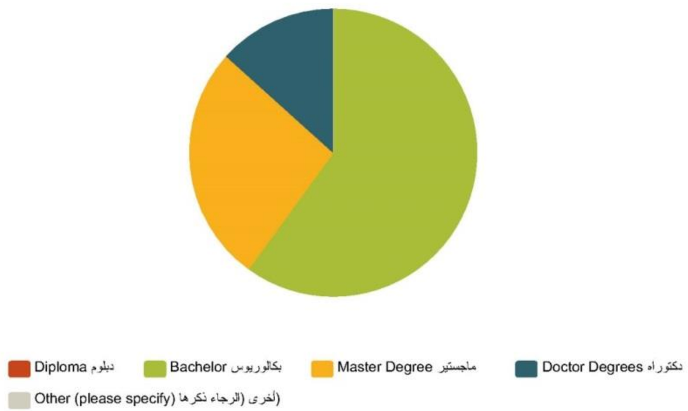


Answer Choices	Responses	
Public sector القطاع الحكومي	78.95%	15
Private sector القطاع الخاص	21.05%	4
Total		19

1 / 127

Q3 Educational background المؤهل العلمي

Answered: 15   Skipped: 4

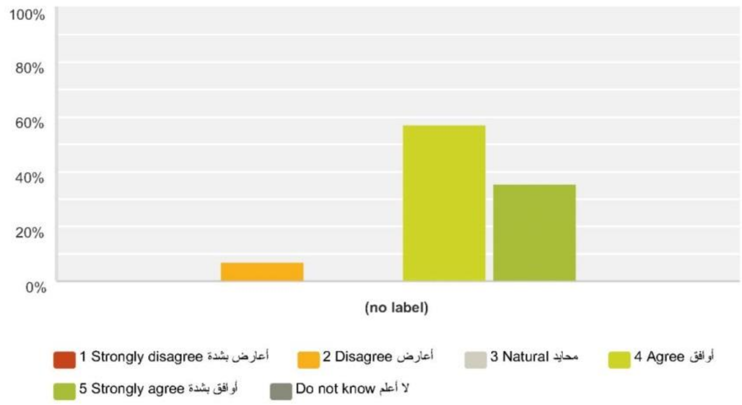


Answer Choices	Responses	
Diploma دبلوم	0.00%	0
Bachelor بكالوريوس	60.00%	9
Master Degree ماجستير	26.67%	4
Doctor Degrees دكتوراه	13.33%	2
Other (please specify) أخرى (الرجاء ذكرها)	0.00%	0
Total		15

#	Other (please specify) أخرى (الرجاء ذكرها)	Date
	There are no responses.	

Q4 Planning approach- Kuwait's Master Plan is the main direction for future development! نظام التخطيط- المخطط الهيكلي هو النظام الرئيسي و السائد في عمليات التخطيط المستقبلية في الكويت !

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	7.14% 1	0.00% 0	57.14% 8	35.71% 5	0.00% 0	14	4.21

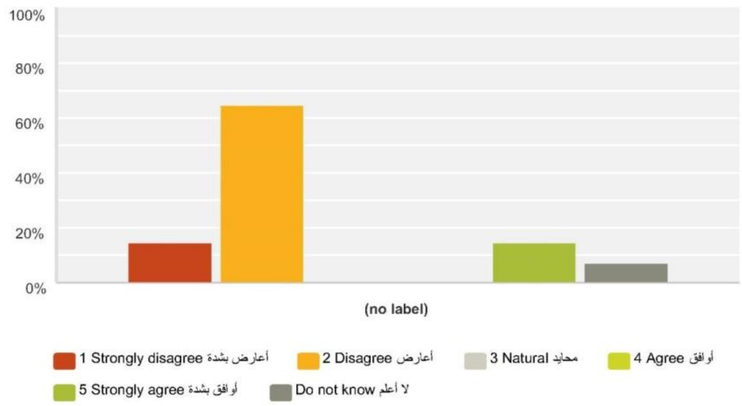
Q5 Planning approach- If the planning approach in Kuwait is not a Master plan, what do you perceive the planning approach to be? (Please write if applicable)نظام التخطيط- إذا كان المخطط الهيكلي ليس هو النظام الرئيسي و السائد في عمليات التخطيط المستقبلية في (الكويت، ما هو النظام المتبع؟ (يرجى الكتابة

Answered: 2 Skipped: 17

#	Responses	Date
1	لا يوجد في الكويت نظام واضح للتخطيط والتخبط هو سيد الموقف في الكويت	4/22/2016 7:48 AM
2	و لكن لا يطبق واقعيا	4/20/2016 7:48 PM

Q6 New plans development- Implementing the new master plan is mainly controlled by one division of government !وضع الخطط الجديدة- تنفيذ المخطط الهيكلي الجديد يتم التحكم به من قبل جهة حكومية واحدة فقط!

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	14.29% 2	64.29% 9	0.00% 0	0.00% 0	14.29% 2	7.14% 1	14	2.31

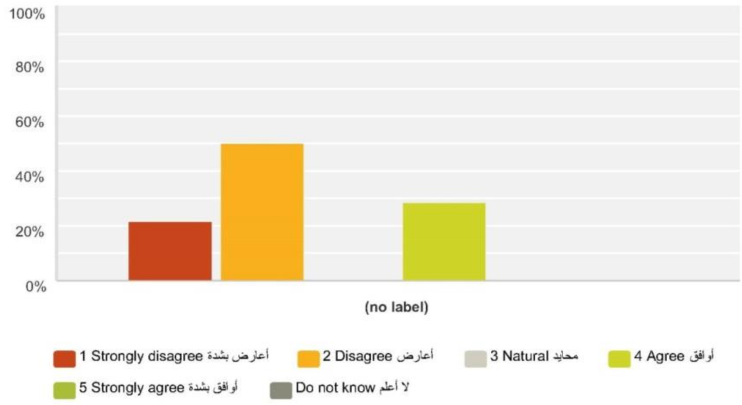
Q7 New plans development- If there are divisions within the government leading to different responsibilities (creating the new plans, overall approval of investment and applying the plans and land use allocations), can you please list them? (Please write if applicable)وضع الخطط الجديدة- إذا كانت هناك انقسامات داخل الحكومة تؤدي إلى مسؤوليات مختلفة مثل (وضع الخطط الجديدة، الموافقة النهائية على الاستثمار ، تطبيق الخطط ، توزيع استخدامات الأراضي) الرجاء تقديم قائمة لهذه الجهات؟ (يرجى الكتابة)

Answered: 12 Skipped: 7

#	Responses	Date
1	بلدية الأشغال مجلس الوزراء مجلس الأمة	4/30/2016 5:17 AM
2	البلدية المرور الإسكان الأشغال	4/28/2016 12:59 AM
3	لجنة عليا للمخطط الهيكلي تبع مجلس الوزراء	4/25/2016 6:21 PM
4	البلدية التخطيط بمرسوم أميري يتحدث كل ٥ سنوات	4/25/2016 5:47 PM
5	بلدية التخطيط مجلس الوزراء	4/24/2016 3:51 AM
6	وزارة التخطيط, بلدية الكويت, الهيئة العامة للرعاية السكنية , وزارة النفط, وزارة المالية, وزارة الكهرباء والماء, وزارة الأشغال	4/22/2016 7:48 AM
7	الامانه الامه للمجلس الاعلى للتخطيط بلديه الكويت المجلس البلدي المجلس الأعلى للتخطيط	4/22/2016 7:36 AM
8	بلديه الكويت الامانه العامة للمجلس الأعلى للتخطيط	4/22/2016 7:11 AM
9	بلدية الكويت وزارة الدفاع المواصلات الإسكان الأشغال النفط	4/21/2016 8:09 PM
10	بلدية و الأشغال و الداخلية و غيرهم	4/20/2016 9:11 PM
11	و لكنها يوجد التزام من الجهات الاخرى المعنيه و عدم وجود رقابه من البلدية البلدية هي الجهة المتحكمة	4/20/2016 7:48 PM
12	البلدية و المرور الأشغال اللجان الخماسيه	4/19/2016 5:28 PM

Q8 New plans development- Kuwait State Audit Bureau has a big role in decision making process in new plans development in Kuwaitوضع الخطط الجديدة- لديوان المحاسبة دور كبير في عملية اتخاذ القرار في التخطيط في دولة الكويت

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	21.43% 3	50.00% 7	0.00% 0	28.57% 4	0.00% 0	0.00% 0	14	2.36

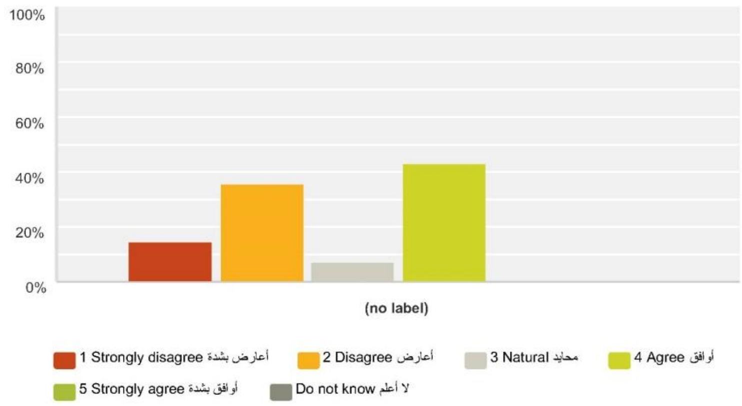
Q9 New plans development- If Kuwait State Audit Bureau has a big role in decision making process in new plans development in Kuwait, what is its role? (please write if applicable)وضع الخطط الجديدة- إذا كان لديوان المحاسبة دور كبير في عملة اتخاذ القرار في التخطيط في دولة الكويت، ما هو دوره؟ (يرجى الكتابة)

Answered: 8 Skipped: 11

#	Responses	Date
1	دوره رقابي على المناقصات و خصوصا اذا كانت المبالغ ضخمة يتم رفضها	4/30/2016 5:17 AM
2	رقابه مالية	4/25/2016 5:47 PM
3	ابداء الرأي رقابة	4/24/2016 3:51 AM
4	الرقابه المالية على الممارسات والمناقصات وعلى الأمور الماليه	4/22/2016 7:36 AM
5	يراقب على الممارسات والمناقصات وحسابات الوزارات	4/22/2016 7:11 AM
6	دورها بمراقبة المناقصات	4/21/2016 8:09 PM
7	الموافقة والرقابة على المناقصات	4/20/2016 9:11 PM
8	مراقبة الحسابات و الميزانيات	4/19/2016 5:28 PM

Q10 New plans development- Kuwait Ministry Of Finance has a big role in decision making process in new plans development in Kuwaitوضع الخطط الجديدة- لوازرة المالية دور كبير في عملية اتخاذ القرار في التخطيط في دولة الكويت

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**14.29%** 2	**35.71%** 5	**7.14%** 1	**42.86%** 6	**0.00%** 0	**0.00%** 0	14	2.79

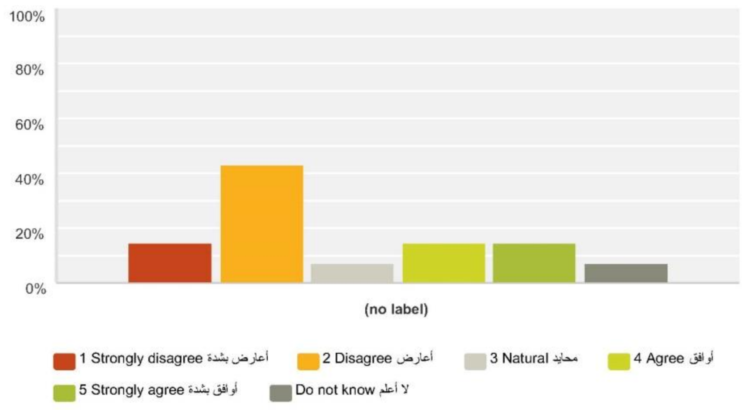
Q11 New plans development- If Kuwait Ministry Of Finance has a big role in decision making process in new plans development in Kuwait, what is its role? (please write if applicable)وضع الخطط الجديدة- إذا كان لوزارة المالية دور كبير في عملة اتخاذ القرار في التخطيط في دولة الكويت، ما هو دورها؟ (يرجى الكتابة)

Answered: 9 Skipped: 10

#	Responses	Date
1	رصد الميزانيات	4/30/2016 5:17 AM
2	ماديا فقط	4/27/2016 10:33 PM
3	إعداد الميزانيه	4/24/2016 3:51 AM
4	صرفه الميزانيات لخطط التنمية وللوزارات	4/22/2016 7:36 AM
5	الموافقه على ميزانيات الوزارات	4/22/2016 7:11 AM
6	الميزانيات	4/21/2016 8:09 PM
7	الموافقة المالية	4/20/2016 9:11 PM
8	يفترض ان تأخذ قراراتها من البلدين و لكن لا يتم ذلك	4/20/2016 7:48 PM
9	ممكن تنظيم عملية توزيع الميزانية لمشاريع الوزارات بعد دراسة اهميتها	4/19/2016 5:28 PM

Q12 Cooperation and coordination- The cooperation and coordination between the government of Kuwait's planning authorities are considered in high level.التعاون والتنسيق- يعتبر التعاون والتنسيق بين الجهات الحكومية المختصة بالتخطيط على مستوى عالي

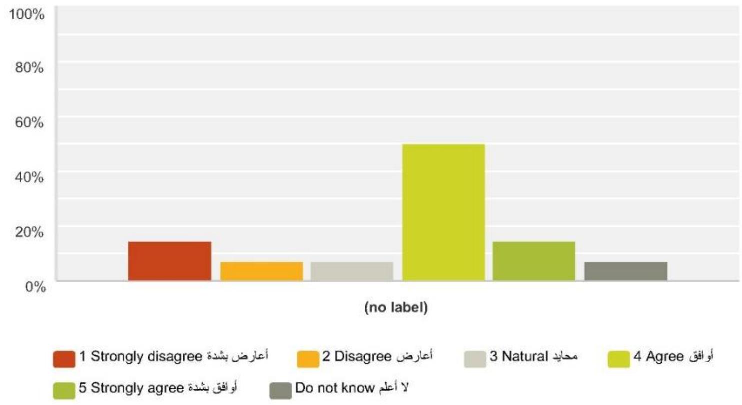
Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	14.29% 2	42.86% 6	7.14% 1	14.29% 2	14.29% 2	7.14% 1	14	2.69

Q13 Urban growth management- The government would like to improve urban growth management in its planning process.ادارة النمو الحضري- ان حكومة الكويت ترغب في تحسين إدارة النمو الحضري من خلال التخطيط في المستقبل

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**14.29%** 2	**7.14%** 1	**7.14%** 1	**50.00%** 7	**14.29%** 2	**7.14%** 1	14	3.46

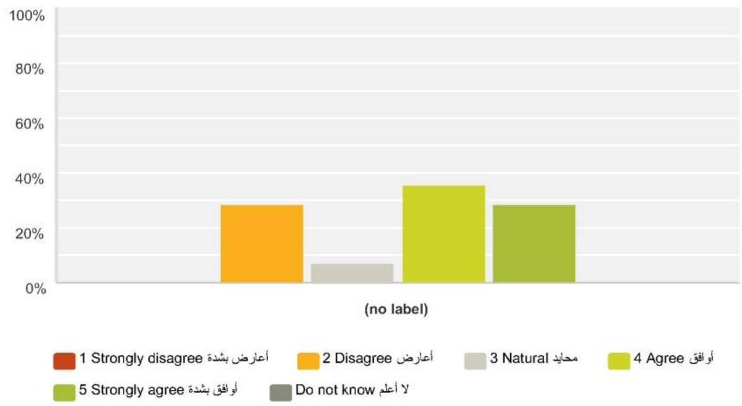
Q14 Consultations- if consultants are international or national, what are other roles of external government involvement in new plans. (Please write if applicable)الاستشارة- اذا كانت الحكومة تستخدم خبراء استشاريين دوليين أو محليين، فما هي الأدوار الأخرى التي تقوم بها الجهات غير الحكومية في الخطط الجديدة؟ (يرجى الكتابة)

Answered: 8 Skipped: 11

#	Responses	Date
1	الإنشاءات من القطاع الخاص	4/30/2016 5:17 AM
2	جامعة الكويت جمعيات النفع العام تقوم بدراسات و لجان	4/28/2016 12:59 AM
3	عن طريق تحديث المخطط	4/25/2016 6:21 PM
4	كل الاستشارات دولية	4/25/2016 5:47 PM
5	الاستشارة ليست على المستوى المطلوب	4/24/2016 3:51 AM
6	لا تقوم بأي شي	4/22/2016 7:48 AM
7	مراجعة المخططات و اعتماداها و التعديل و الموافقة من الجهات الحكومية بناء على ظروف المجتمع و العادات و التقاليد	4/21/2016 8:09 PM
8	المساعدة في الادارة	4/12/2016 8:02 PM

Q15 Decision Making- The government of Kuwait is the final decision maker in initiation of new development plans implementation process.اتخاذ القرار- حكومة الكويت هي صانع القرار النهائي في الشروع في تطبيق الخطط الجديدة

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**28.57%** 4	**7.14%** 1	**35.71%** 5	**28.57%** 4	**0.00%** 0	14	3.64

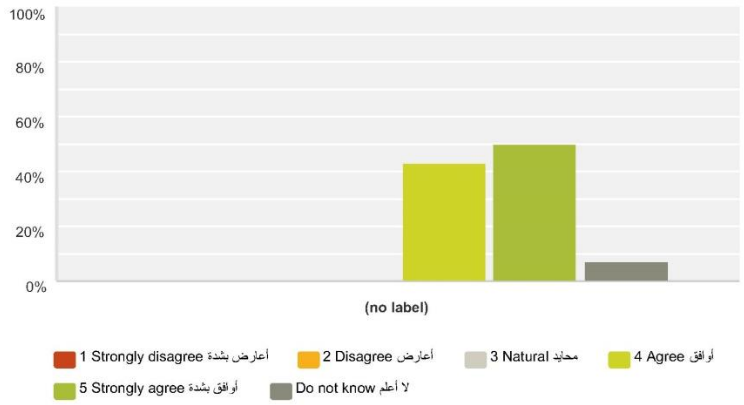
Q16 Decision Making- In your opinion, are there any external decision makers exist in the final outcome of planning in Kuwait? (Please write if applicable)اتخاذ القرار- في رأيك، هل يوجد أي صناع قرار غير الحكومة في عملية التخطيط في الكويت؟ (يرجى الكتابة)

Answered: 11 Skipped: 8

#	Responses	Date
1	مجلس الامة شريك في صنع القرار	4/30/2016 5:17 AM
2	مجلس الامة من خلال التشريع	4/28/2016 12:59 AM
3	المجلس البلدي مجلس الامة	4/25/2016 6:21 PM
4	مجلس الامه و غرفة التجاره	4/25/2016 5:47 PM
5	بسبب عدم قدرتها و ايمانها بالتخطيط	4/24/2016 3:51 AM
6	التجار هم المتحكم في جميع الخطط ويرغبون بتعطيل. الخطط لأطول فترة لضمان عدم نزول اسعار العقارات والايجاراتح	4/22/2016 7:48 AM
7	مجلس الامه	4/22/2016 7:36 AM
8	بعض المتنفذين بالدولة من اصحاب الاستمارات العقاري	4/21/2016 8:09 PM
9	لا	4/20/2016 7:48 PM
10	بعض السلطات العليا في الدوله	4/19/2016 5:28 PM
11	بالتعاون مع مجلس الامه و ليس وحده	4/12/2016 8:02 PM

Q17 Cost responsibility- The Government of Kuwait is solely liable and responsible for the costs of the development and implementation of new plans.-المسؤولية المالية- حكومة الكويت هي المسؤولة الوحيدة عن تكاليف تطوير وتنفيذ الخطط الجديدة

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	42.86% 6	50.00% 7	7.14% 1	14	4.54

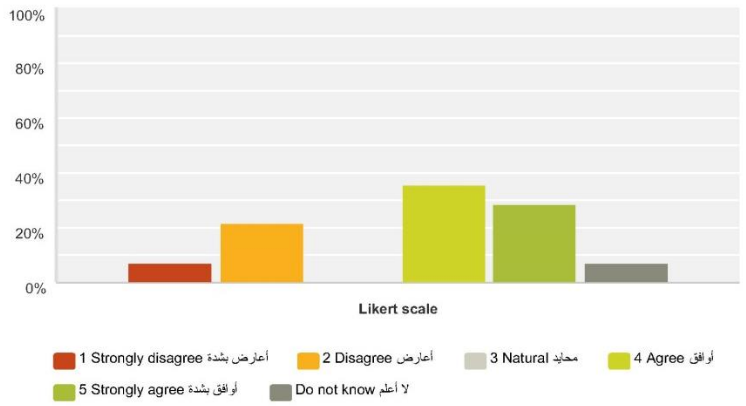
Q18 Cost responsibility- If the government is paying some parts of development plans, which parts are paid for citizens (residential, activities, infrastructures)? (Please write if applicable)المسؤولية المالية- اذا كانت الحكومة تتحمل مسؤولية التكلفة لبعض أجزاء خطط التنمية، ما هي الأجزاء التي تدفع للمواطنين (سكنية ، أنشطة ،بنية تحتية)؟ (يرجى الكتابة)

Answered: 2 Skipped: 17

#	Responses	Date
1	الحكومه تتحمل تكلفه البنية التحتية و الخدمات العامة	4/22/2016 7:48 AM
2	احتياجات المواطن	4/19/2016 5:28 PM

Q19 Cost responsibility- There are differences in payment for residential development between Kuwaitis and non-Kuwaitis.المسؤولية المالية- هناك فرق في التكلفة المخصصة للتنمية السكنية بين المواطنين والوافدين

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
Likert scale	7.14% 1	21.43% 3	0.00% 0	35.71% 5	28.57% 4	7.14% 1	14	3.62

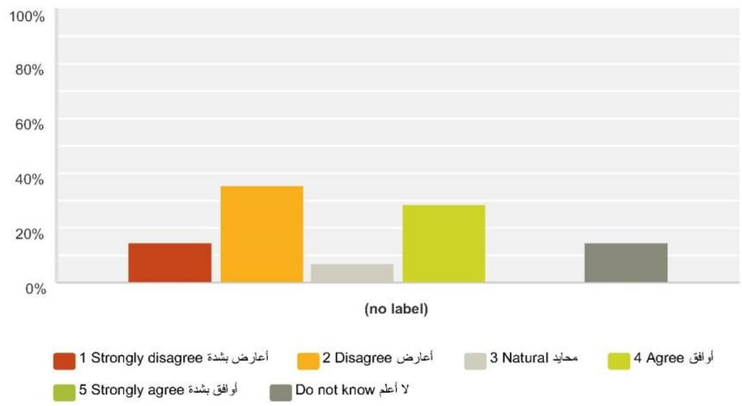
Q20 Cost responsibility- If There are differences in payment for residential development between Kuwaitis and non-Kuwaitis, who is the responsible for paying both residential development (Kuwaitis and non-Kuwaitis)? (Please write if applicable(المسؤولية المالية- إذا كان هناك اختلافات في دفع تكلفة التنمية السكنية بين الكويتيين وغير الكويتيين، من هو المسئول عن دفع كلا التنمية السكنية (الكويتيين وغير الكويتيين)؟ ((يرجى الكتابة

Answered: 8   Skipped: 11

#	Responses	Date
1	الوافدين لا تدفع لهم	4/28/2016 12:59 AM
2	لا علاقة للحكومة بالوافدين	4/25/2016 6:21 PM
3	فقط المواطنين الوافدين للقطاع الاص	4/25/2016 5:47 PM
4	يجب ان يكون هناك فرق و يجب دفع ضريبة من الوافد	4/24/2016 3:51 AM
5	المؤسسه إعلانه للرعاية السكنيه	4/22/2016 7:36 AM
6	دوله الكويت مسؤلة عن توفير سكن لكل مواطن كويتي فقط او إعطاء بدل سكن	4/22/2016 7:11 AM
7	المدن العمالية الجديدة تتبع البلدين للوافدين اما المدن السكنية تتبع الرعاية السكنية للمواطنين	4/21/2016 8:09 PM
8	الكويتين التكلفة على الدولة و بسداد مريح للمواطن أنا الوافدين فالقطاع الخاص الاستثماري	4/12/2016 8:02 PM

Q21 Time - The new master plan will be fully finished and implemented in 2030.الوقت- سيتم الانتهاء بشكل كامل من تنفيذ المخطط الهيكلي الجديد في عام 2030

Answered: 14   Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**14.29%** 2	**35.71%** 5	**7.14%** 1	**28.57%** 4	**0.00%** 0	**14.29%** 2	14	2.58

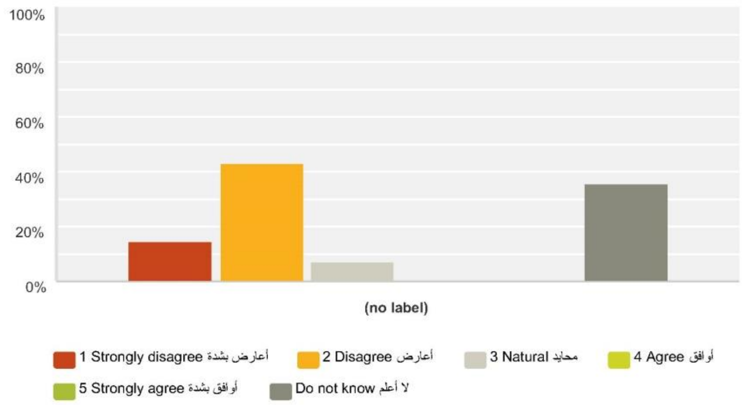
Q22 Time- What decisions affect or delay implementation of the master plan, please list the reasons and consequences (Please write if applicable)الوقت- ما هي القرارات التي قد تؤخر أو تؤثر على تنفيذ المخطط الهيكلي، يرجى ذكر الأسباب والنتائج (يرجى الكتابة)

Answered: 12 Skipped: 7

#	Responses	Date
1	بسبب التكاليف العالية بسبب الفساد الاداري بسبب فساد القطاع الخاص و عدم مقدرتها على إتمام المشاريع	4/30/2016 5:17 AM
2	هناك مشاريع قوانين ممكن ان تسرع ذلك	4/28/2016 12:59 AM
3	تأخر التطبيق من قبل الحكومة	4/27/2016 10:33 PM
4	تعداد السكاني غير دقيق	4/25/2016 5:47 PM
5	عدم وجود جدية من الحكومة	4/24/2016 3:51 AM
6	نشوب حروب عدم توفر ميزانيه لتنفيذ المشاريع	4/22/2016 7:36 AM
7	الدوره المستندية للقرارات مجلس الامه عدم الموافقه على الميزانيه من قبل وزاره المالية	4/22/2016 7:11 AM
8	المتنفذين اقتصاد الدولة	4/21/2016 8:09 PM
9	زيادة سكانية غير متوقعة ميزانية ضعف التنسيق	4/20/2016 9:11 PM
10	٢٠٤٠ القرارات المتسرعة من قبل الحكومة سلبية الجهات الحكومية	4/20/2016 7:48 PM
11	ضعف التخطيط بسبب السلطات المتنفذه ضعف اتخاذ القرار من قبل الحكومة عدم وجود الخبرة الكافيه	4/19/2016 5:28 PM
12	لا يوجد تأخير بالقرارات و ذلك لأنه أتى بمرسوم أميري و لكن الدورة المستندية احد المعوقات الرئيسية	4/12/2016 8:02 PM

Q23 New plan-There is new plans as drafts for the period between 2030 (or the finish time of the existing master plan) to 2050.خطط جديدة- هناك خطط جديدة أو مشاريع مقترحة للفترة بين 2030 (أو وقت الانتهاء من المخطط الهيكلي الجديد الحالي) حتى عام 2050

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	14.29% 2	42.86% 6	7.14% 1	0.00% 0	0.00% 0	35.71% 5	14	1.89

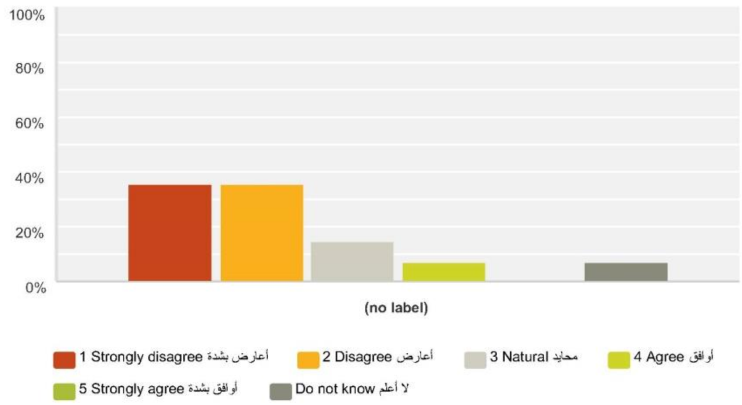
Q24 New plan-If There are new plans as drafts for the period from 2030 (or the finish time of the existing master plan) to 2050, what kind of plan or strategy is it? (Please write if applicable)خطط جديدة-إذا كان هناك خطط جديدة أو مشاريع للفترة بين 2030 (أو وقت الانتهاء من المخطط الهيكلي الجديد الحالي) حتى عام 2050، ما هي نوع هذه الخطط (أو الاستراتيجيات؟ (يرجى الكتابة

Answered: 0 Skipped: 19

#	Responses	Date
	There are no responses.	

Q25 Precaution plan-There is a precaution plan in Kuwait in case of depletion of oil or extremely decline in state's revenues to deal with citizens situation (Kuwaitis and non-Kuwaitis).خطة احتياطية- توجد خطة احتياطية في الكويت في حال نضوب النفط أو في حال انخفاض الإيرادات العامة للدولة بشكل كبير للتعامل مع أوضاع السكان (مواطنين و وافدين)

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**35.71%** 5	**35.71%** 5	**14.29%** 2	**7.14%** 1	**0.00%** 0	**7.14%** 1	14	1.92

Q26 Precaution plan-There is a precaution plan in Kuwait in case of depletion of oil or extremely decline in state's revenues to deal with population situation (Kuwaitis and non-Kuwaitis, what kind of plan or strategy is it? (Please write if applicable). -خطة احتياطية توجد خطة احتياطية في الكويت في حال نضوب النفط أو في حال انخفاض الإيرادات العامة للدولة بشكل كبير للتعامل مع أوضاع السكان (مواطنين و وافدين)، ما نوع هذه الخطة أو الاستراتيجية؟ (يرجى الكتابة))

Answered: 3   Skipped: 16

#	Responses	Date
1	تنويع مصادر الدخل	4/28/2016 12:59 AM
2	لا يوجد خطة	4/22/2016 7:48 AM
3	الميزانية تختلف عن التخطيط و التأثير على الميزانية سيكون سنوي	4/12/2016 8:02 PM

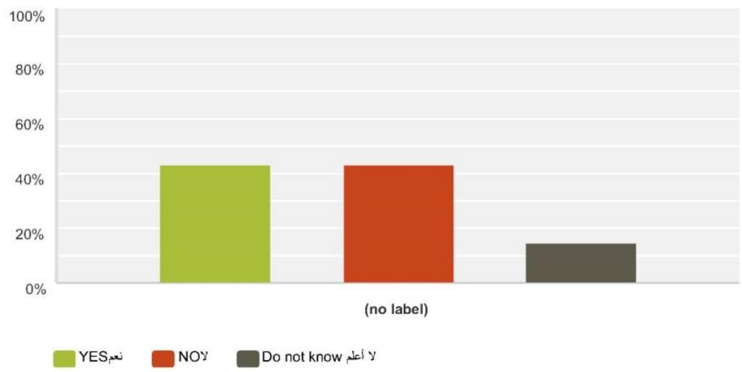
Q27 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 2 Skipped: 17

#	Responses	Date
1	عدم قدرة الحكومة على وضع خطط قابلة للتنفيذ بسبب عدم وجود قيادات مؤهلة بسبب التعيينات على المحسوبية	4/24/2016 3:51 AM
2	س ٢٣ أوافق ان المحاكمه تنتهي ٢٠٣٠ و لكن المخطط سيستمر بالتعديل و التغيير و التوسع خلال هذه الفترة و بعد ذلك	4/12/2016 8:02 PM

Q28 Technologies and tools- Is technology used in the land use planning now such as GIS?التقنيات التكنولوجيا- هل التكنولوجيا الحديثة مستخدمة في تخطيط استخدام الأراضي حالياً مثل نظم المعلومات الجغرافية؟

Answered: 14 Skipped: 5



	YESنعم	NOلا	Do not know لا أعلم	Total	Weighted Average
(no label)	42.86% 6	42.86% 6	14.29% 2	14	3.00

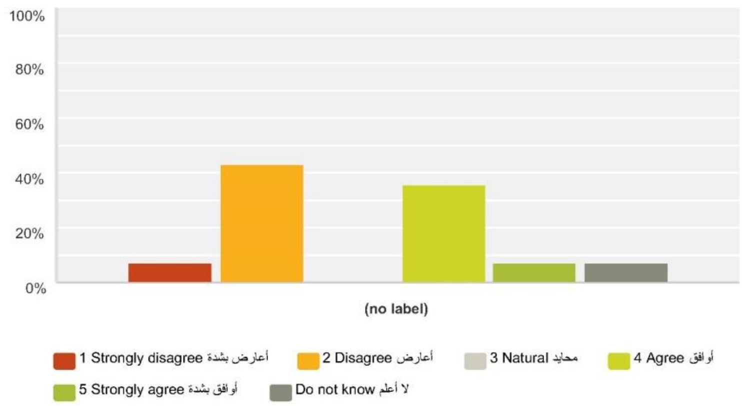
Q29 Technologies and tools- Besides GIS what other technologies or tools are used for land use planning? (Please write if applicable)التقنيات التكنولوجيا- إلى جانب نظم المعلومات الجغرافية ما هي التقنيات أو الأدوات الأخرى المستخدمة حالياً في تخطيط استخدام الأراضي؟ (يرجى الكتابة)

Answered: 5 Skipped: 14

#	Responses	Date
1	لا	4/25/2016 5:50 PM
2	و لكن بشكل بسيط	4/24/2016 3:51 AM
3	اوتوكاد	4/22/2016 7:39 AM
4	اوتو كاد	4/22/2016 7:19 AM
5	حكومة الكترونية كنظام	4/12/2016 8:02 PM

Q30 Alternatives- The development of new plans (such as Master plan) has alternatives, and the government selects the most applicable in Kuwait.البدائل- عند وضع الخطط الجديدة (مثل المخطط الهيكلي) هناك بدائل عديدة، والحكومة تقوم باختيار الأنسب للكويت

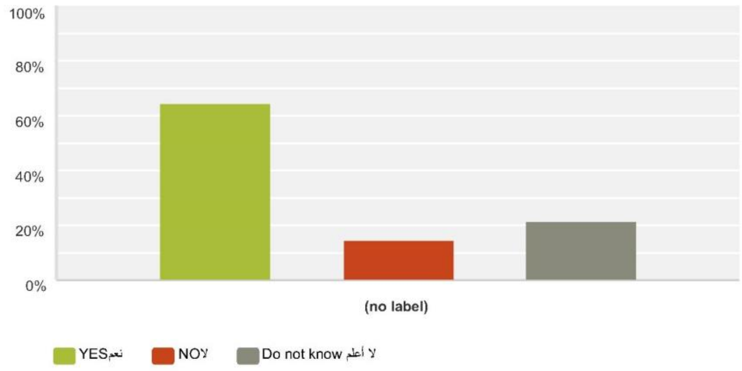
Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.14% 1	42.86% 6	0.00% 0	35.71% 5	7.14% 1	7.14% 1	14	2.92

Q31 Population projections- In the development of new cities/districts projects, your organisation uses population growth projections for the future.توقعات النمو السكاني- عند تطوير مشاريع المدن / المناطق الجديدة، فإن مؤسستك تستخدم توقعات النمو السكاني في المستقبل

Answered: 14 Skipped: 5

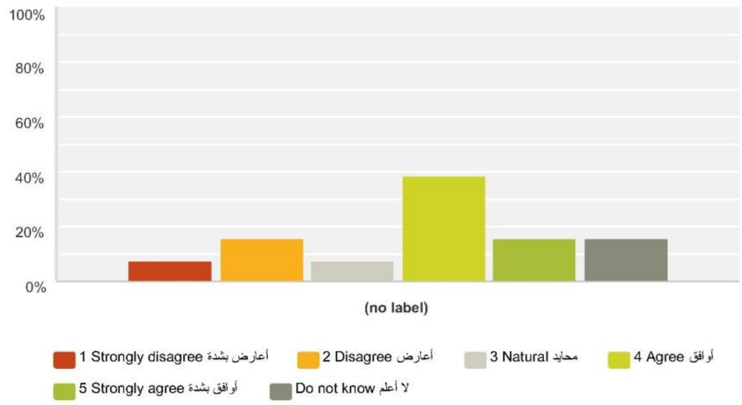


	YESنعم	NOلا	Do not know لا أعلم	Total	Weighted Average
(no label)	64.29% 9	14.29% 2	21.43% 3	14	4.27

33 / 127

Q32 Population projections- The accuracy of population growth projections are adequate for purpose of planning (Please answer if the pervious answer was Yes).توقعات النمو السكاني- دقة توقعات النمو السكاني كافية لأغراض التخطيط (اجب في حال كانت اجابتك السابقة نعم)

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.69% 1	15.38% 2	7.69% 1	38.46% 5	15.38% 2	15.38% 2	13	3.45

Q33 Population projections- If your organisation used population projection for the future, what is the projection calculation method? For example Cohort Component method, Ratio method, others. (Please write if applicable(توقعات النمو السكاني- إذا كانت مؤسستك تستخدم التعداد المتوقع للسكان في المستقبل، فما هي الطريقة المستخدمة لحساب التعداد المتوقع؟ على سبيل المثال طريقة (الأفواج المركبة، طريقة النسبة، أو أخرى. (يرجى الكتابة

Answered: 5 Skipped: 14

#	Responses	Date
1	الأفواج المركبة	4/22/2016 7:39 AM
2	الأفواج المركبة	4/22/2016 7:19 AM
3	طريقة النسب من خلال التعداد السكاني 8.7 تشمل العمالة المنزلية	4/21/2016 8:14 PM
4	الأفواج المركبة	4/20/2016 7:51 PM
5	طريقة النسب	4/19/2016 5:34 PM

Q34 Population projections- If your organisation used population projection for the future, what is that projection reference? For example, UN, KSR, your organisation, other. (Please write if applicable)توقعات النمو السكاني- إذا كانت مؤسستك قد استخدمت تعداد متوقع للسكان في المستقبل، ما هو مرجع هذا التعداد؟ على سبيل المثال، الأمم المتحدة، معهد الكويت للأبحاث العلمية، مؤسستك، أو غيرها. (يرجى الكتابة)

Answered: 7 Skipped: 12

#	Responses	Date
1	الادارة المركزيه للاحصاء	4/22/2016 7:39 AM
2	الادارة المركزيه للاحصاء	4/22/2016 7:19 AM
3	من وزارة التخطيط	4/21/2016 8:14 PM
4	من نفس المؤسسة	4/20/2016 9:14 PM
5	الادارة المركزيه للاحصاء و المعلومات المدنيه	4/20/2016 7:51 PM
6	مركز الكويت للاحصاء	4/19/2016 5:34 PM
7	يتم اخذها من المجلس الأعلى للتخطيط	4/12/2016 8:02 PM

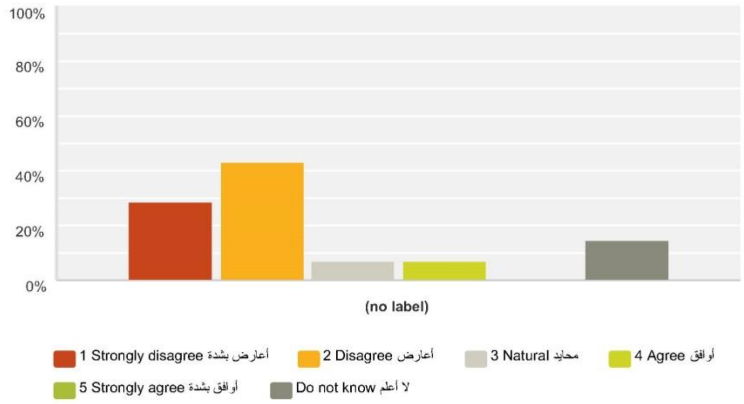
Q35 Population projections- What do believe are the main risks that change future population growth in Kuwait? (Please write if applicable)توقعات النمو السكاني- باعتقادك ما هي المخاطر الرئيسية التي قد تؤدي إلى تغير النمو السكاني في المستقبل في الكويت؟ (يرجى الكتابة)

Answered: 7 Skipped: 12

#	Responses	Date
1	الوضع الاقتصادي	4/25/2016 6:22 PM
2	لا يوجد	4/25/2016 5:50 PM
3	الوضع الأمني الوضع الاقتصادي	4/24/2016 3:51 AM
4	المشاريع الكبرى بحاجة لأيدي عاملة كبيرة	4/20/2016 9:14 PM
5	التجنيس و المشاريع التنموية الكبرى	4/20/2016 7:51 PM
6	تقلص الموارد النفطية عزوف الوافدين عن العمل بالكويت الحروب اكتشاف الغاز يؤدي الى زيادة ديمغرافية السكان	4/19/2016 5:34 PM
7	الحروب و الوضع الاقتصادي و قوانين الدولة المتعلقة بالضرائب و سوء بيئة الاعمال	4/12/2016 8:02 PM

Q36 Urban modelling -The new development plans are evaluated by simulation within urban modelling tools to demonstrate the consequences of the new plans.النمذجة الحضرية- يتم تقييم خطط التنمية الجديدة عن طريق المحاكاة ضمن أدوات النمذجة الحضرية لإظهار الآثار المترتبة عن الخطط الجديدة

Answered: 14 Skipped: 5



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**28.57%** 4	**42.86%** 6	**7.14%** 1	**7.14%** 1	**0.00%** 0	**14.29%** 2	14	1.92

Q37 Urban modelling - If an urban model technique/ tool had been used, what are the simulation techniques/ tools used? (Please write if applicable)النمذجة الحضرية- إذا كان قد تم استخدام تقنية / أداة لنمذجة القطاع الحضري، ما هي تقنية (المحاكاة / الأداة المستخدمة؟ (يرجى الكتابة

Answered: 2 Skipped: 17

#	Responses	Date
1	Ptv. Visum للشوارع من بلدية الكويت	4/27/2016 10:37 PM
2	الدراسات المرورية و الدراسات السكانية	4/21/2016 8:14 PM

Q38 Simulations- If simulation technique/ tool have been used, what is/are the rectification on the future that have been used for evaluation? (Please write if applicable)المحاكاة- إذا استخدمت تقنية / أداة للمحاكاة المستقبلية، ما هي التداعيات التي استخدمت كأدوات لتقييم المستقبل؟ (يرجى الكتابة)

Answered: 0 Skipped: 19

#	Responses	Date
	There are no responses.	

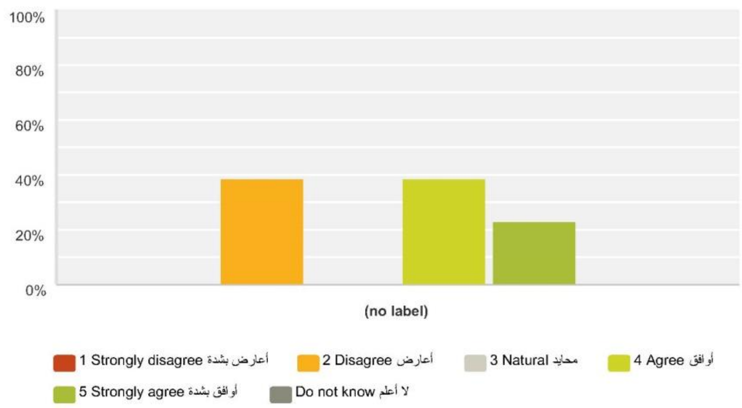
Q39 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 1   Skipped: 18

#	Responses	Date
1	دورنا تشريع و رقابة	4/24/2016 3:51 AM

Q40 Non-citizens- In the new development projects, Non-Kuwaitis have been considered in the process, i.e. Where they will live and work? / How long will they stay? / Their estimated population number in the future?الوافدين- في مشاريع التنمية الجديدة، تم اخذ الوافدين بعين الاعتبار في العملية، على سبيل المثال منطقة السكن والعمل؟ / مدة بقاءهم ؟ / عددهم في المستقبل؟

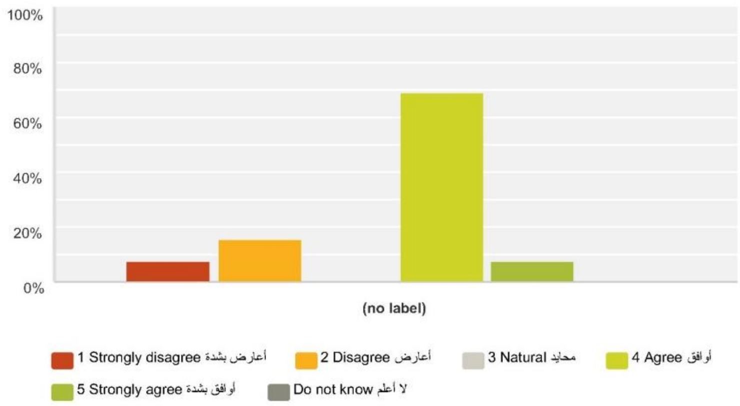
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	38.46% 5	0.00% 0	38.46% 5	23.08% 3	0.00% 0	13	3.46

Q41 Society participation- Kuwait citizens are indirectly engaged in the planning process only through their parliament and municipality council's representations. مشاركة المجتمع- يعتبر المواطنون مشاركين في عملية التخطيط بشكل غير مباشر من خلال تمثيلهم في مجلس الأمة و المجلس البلدي

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**7.69%** 1	**15.38%** 2	**0.00%** 0	**69.23%** 9	**7.69%** 1	**0.00%** 0	13	3.54

43 / 127

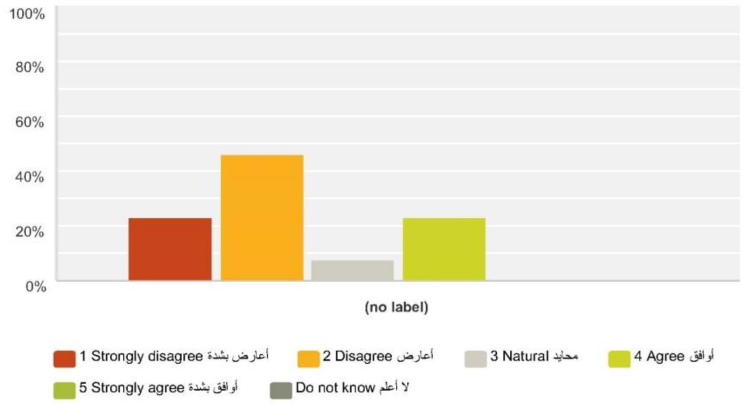
Q42 Society participation- If there are any other forms of Kuwaitis engagement in planning process, what kind of these forms is? (Please write if applicable)مشاركة المجتمع- إذا كان هناك أي أشكال أخرى لمشاركة الكويتيين في عملية التخطيط، ما نوع هذه الأشكال؟ (يرجى الكتابة)

Answered: 7 Skipped: 12

#	Responses	Date
1	حملات اجتماعية تطوعية تطالب بحقوق المواطنين مثل ناطر بيت	4/30/2016 5:20 AM
2	لا يوجد	4/28/2016 1:03 AM
3	الاستبيانات من التخطيط	4/27/2016 10:41 PM
4	ا	4/24/2016 3:51 AM
5	وسائل التواصل الاجتماعي	4/20/2016 9:17 PM
6	النقابات و جمعيات النفع العام	4/19/2016 5:37 PM
7	من خلال المجلس البلدي و المجتمع المدني	4/12/2016 8:02 PM

Q43 Society participation- Kuwait government is interested in greater engagement of Kuwait citizens in the planning process.مشاركة المجتمع- حكومة الكويت مهتمة في زيادة مشاركة المواطنين في عمليات التخطيط الجديدة

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	23.08% 3	46.15% 6	7.69% 1	23.08% 3	0.00% 0	0.00% 0	13	2.31

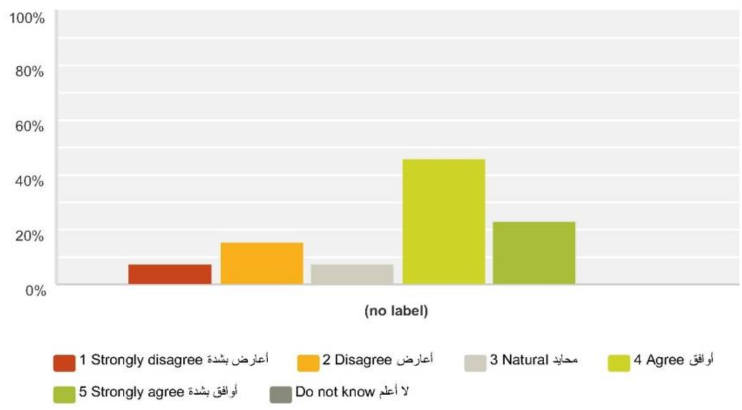
Q44 Society participation- If Kuwait government is interested in greater engagement of Kuwait citizens, how is that can be done? (Please write if applicable)مشاركة المجتمع- إذا كانت حكومة الكويت مهتمة في زيادة مشاركة المواطنين في عمليات التخطيط الجديدة، كيف يمكن القيام بذلك ؟ (يرجى الكتابة)

Answered: 2 Skipped: 17

#	Responses	Date
1	موقع إنترنت يساعد في التشريع و موقع لخر حكومي	4/28/2016 1:03 AM
2	المؤتمرات	4/20/2016 9:17 PM

Q45 Society participation- Non-Kuwait citizens are not engaged in the planning process.مشاركة المجتمع- الوافدين لا يتم اشراكهم في عملية التخطيط

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**7.69%** 1	**15.38%** 2	**7.69%** 1	**46.15%** 6	**23.08%** 3	**0.00%** 0	13	3.62

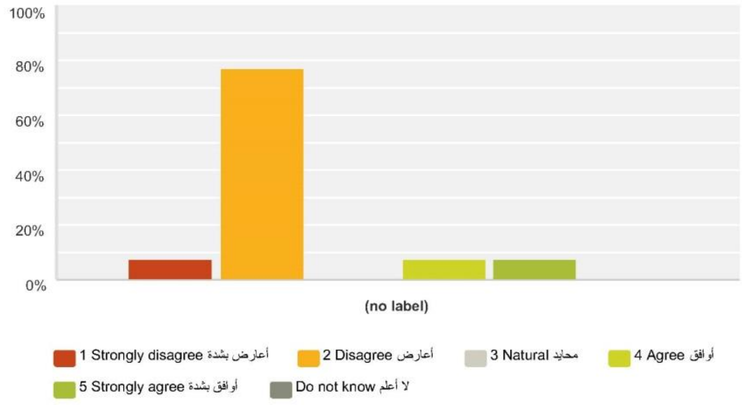
Q46 Society participation- If there are any forms of non-citizens (non-Kuwaitis) engagement in planning process, what kind of these forms is? (Please write if applicable)مشاركة المجتمع- إذا كان هناك أي شكل من أشكال انخراط الوافدين في عملية التخطيط، ما نوع هذه الأشكال؟ ((يرجى الكتابة

Answered: 1 Skipped: 18

#	Responses	Date
1	يتم إشراكهم من خلال الاستشارات و الموظفين و الخ	4/20/2016 7:53 PM

Q47 Society participation- Kuwait government is interested in greater engagement of non-citizens (non-Kuwaitis) in the planning process.مشاركة المجتمع- حكومة الكويت مهتمة في زيادة مشاركة الوافدين في عمليات التخطيط الجديدة

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.69% 1	76.92% 10	0.00% 0	7.69% 1	7.69% 1	0.00% 0	13	2.31

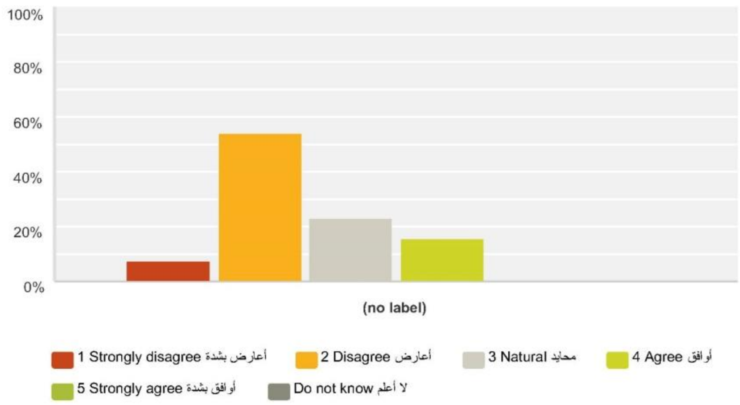
Q48 Society participation- If Kuwait government is interested in greater engagement of non-citizens (non-Kuwaitis), how is that can be done? (Please write if applicable)مشاركة المجتمع- إذا كانت حكومة الكويت مهتمة في زيادة مشاركة الوافدين في عمليات التخطيط الجديدة، كيف يمكن القيام بذلك ؟ (يرجى الكتابة)

Answered: 0 Skipped: 19

#	Responses	Date
	There are no responses.	

Q49 Private sector participation- The private sector has been engaged within the decision-making processes for plan implementation and future developments.مشاركة القطاع الخاص- القطاع الخاص له حق المشاركة في عمليات صنع القرار لتنفيذ الخطط المستقبلية

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.69% 1	53.85% 7	23.08% 3	15.38% 2	0.00% 0	0.00% 0	13	2.46

Q50 Private sector participation- If the private sector has been engage in the planning processes or decision making processes, how did they engage or participate? (Please write if applicable)مشاركة القطاع الخاص- إذا كان القطاع الخاص قد شارك في عمليات التخطيط أو عمليات صنع القرار كيف تم ذلك؟ (يرجى الكتابة)

Answered: 4 Skipped: 15

#	Responses	Date
1	ابداء الرأي فقط	4/28/2016 1:03 AM
2	يجب ان تكون له مشاركة قوية	4/24/2016 3:51 AM
3	عن طريق تنفيع المتنفذين و ذلك بتأخير المشاريع	4/21/2016 8:17 PM
4	من خلال المناقصات لهم سلطة كبيرة في الدولة و اتخاذ القرار	4/19/2016 5:37 PM

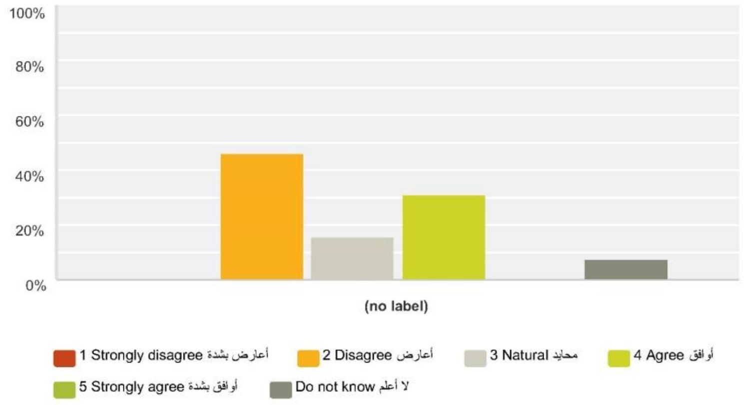
Q51 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 1 Skipped: 18

#	Responses	Date
1	الحكومة لا ترغب بمشاركة المواطنين و لا الوافدين	4/24/2016 3:51 AM

Q52 There is specific number of districts to be developed in specific period of time by law. For example, 5 residential districts each 5 years.هناك عدد محدد من المناطق التي يتم تطويرها في فترة زمنية محددة من خلال القانون. على سبيل المثال، 5 مناطق سكنية لكل 5 سنوات

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	46.15% 6	15.38% 2	30.77% 4	0.00% 0	7.69% 1	13	2.83

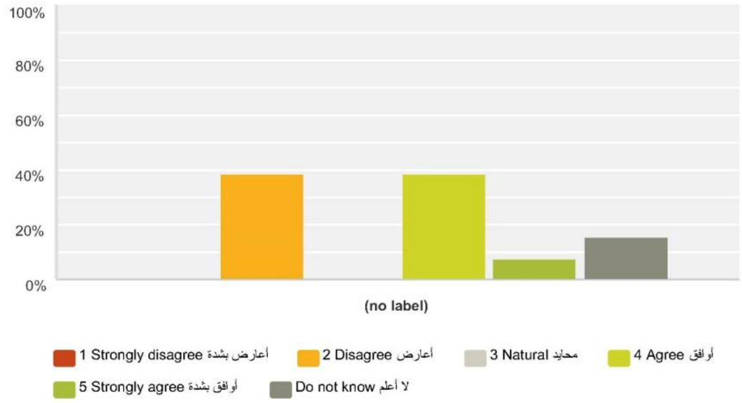
Q53 If there is specific number of districts to be developed in specific period of time by law. What is the number of districts and what is the period of time? (Please write if applicable)اذا كان هناك عدد محدد من المناطق يتم تطويرها في فترة زمنية محددة من خلال القانون، ما هو عدد المناطق وما هي الفترة الزمنية؟ (يرجى الكتابة)

Answered: 5 Skipped: 14

#	Responses	Date
1	لا اعلم	4/30/2016 5:23 AM
2	سنويا ١٢ الف وحدة سكنية	4/28/2016 1:05 AM
3	يوجد خطط غير مفعلة لعدم وجود استراتيجيات للتنفيذ	4/25/2016 6:25 PM
4	لا يوجد ارقام ثابتة	4/25/2016 5:55 PM
5	مثل المدن التابعة مثل الجمهرات و (جابر و سعد(	4/12/2016 8:03 PM

Q54 The government is seeking to increase urban population density for future districts.الحكومة ترغب بزيادة الكثافة السكانية الحضرية للمناطق في المستقبل

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	38.46% 5	0.00% 0	38.46% 5	7.69% 1	15.38% 2	13	3.18

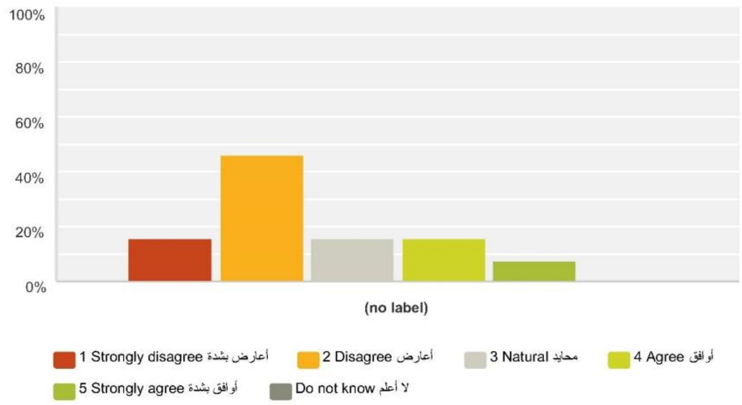
Q55 If there are plans or policies for more dense residential developments, what kinds of plans or policies are considered in planning? (Please write if applicable)إذا كانت هناك خطط أو سياسات لزيادة الكثافة السكنية في المناطق، فما هو نوع هذه الخطط أو السياسات المستخدمة في التخطيط؟ (يرجى الكتابة)

Answered: 6 Skipped: 13

#	Responses	Date
1	التوجه الان عمودي و أفقي	4/28/2016 1:05 AM
2	السكن العمودي	4/25/2016 6:25 PM
3	على شكل سكن خاص	4/25/2016 5:55 PM
4	السكن العمودي	4/21/2016 8:21 PM
5	في المناطق القائمة	4/20/2016 7:55 PM
6	استخدام نسبة محددة من المدينة بشكل تراكمي بالزيادة لتكون سكن عمودي	4/12/2016 8:03 PM

Q56 Private sector can pressure on government to build new districts (mixed districts) such as (Salmiya, Hawalli or Khaitan).القطاع الخاص يستطيع أن يضغط على الحكومة لبناء مناطق جديدة (المناطق الاستثمارية/ المختلطة) مثل (السالمية، حولي أو خيطان)

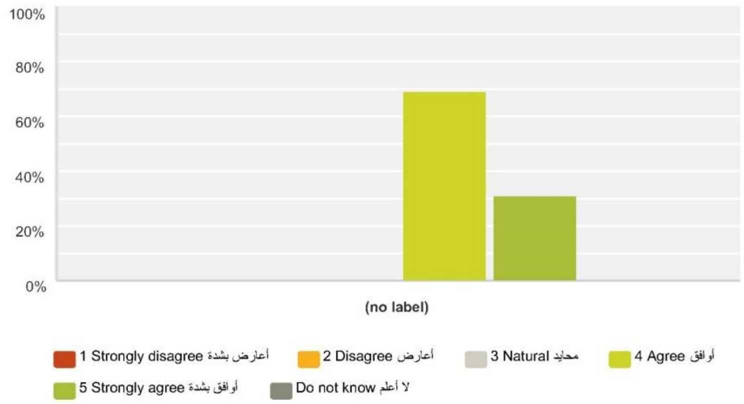
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	15.38% 2	46.15% 6	15.38% 2	15.38% 2	7.69% 1	0.00% 0	13	2.54

Q57 The new residential districts mainly developed for citizens (Kuwaitis).المناطق السكنية الجديدة التي تم تطويرها طورت أساساً للمواطنين الكويتيين

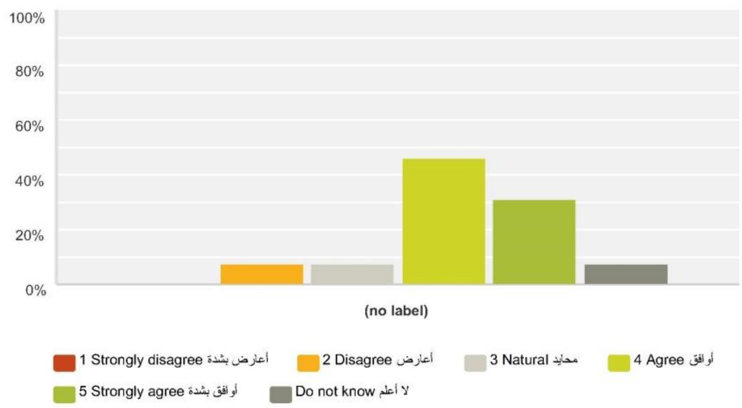
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**0.00%** 0	**0.00%** 0	**69.23%** 9	**30.77%** 4	**0.00%** 0	13	4.31

Q58 In the future there will be new mixed districts developed.في المستقبل سوف يكون هناك مناطق استثمارية/ مختلطة جديدة

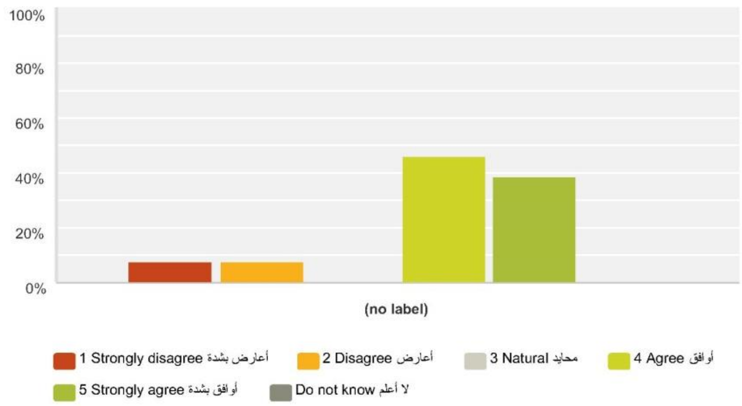
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**7.69%** 1	**7.69%** 1	**46.15%** 6	**30.77%** 4	**7.69%** 1	13	4.08

Q59 It is strictly prohibited to develop new districts within (oil fields, military sites, islands, environmentally sensitive areas).يمنع منعا باتا تطوير مناطق جديدة داخل (حقول النفط، والمواقع العسكرية، والجزر، المناطق الحساسة بيئياً

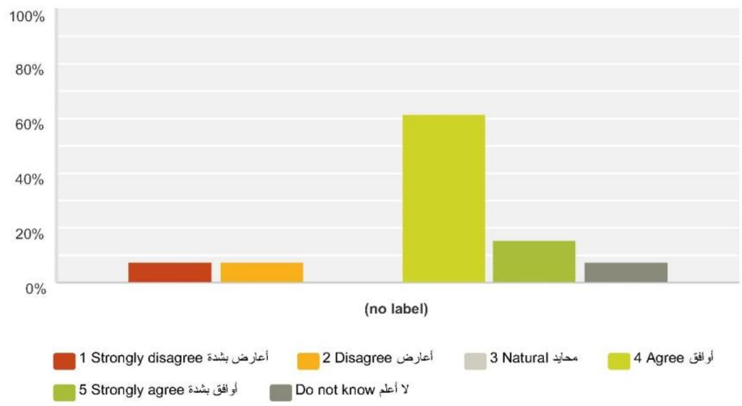
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.69% 1	7.69% 1	0.00% 0	46.15% 6	38.46% 5	0.00% 0	13	4.00

Q60 New centres (large scale cities) are the governments' preferred new headed plans.المدن المتعددة (كبيرة الحجم) هي الخطة الجديدة التي تعيلها و تفضلها الحكومة

Answered: 13 Skipped: 6

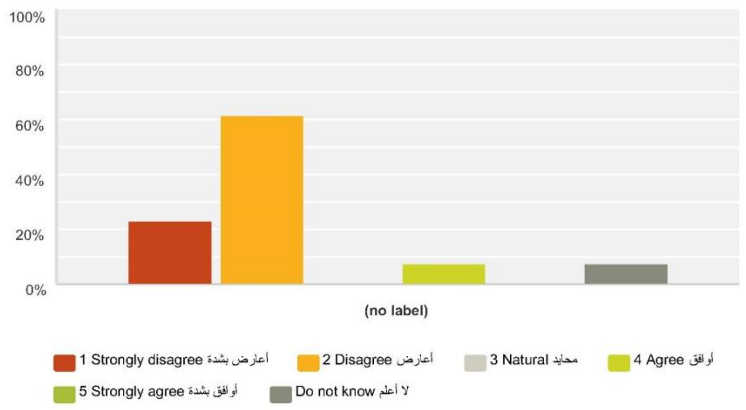


	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.69% 1	7.69% 1	0.00% 0	61.54% 8	15.38% 2	7.69% 1	13	3.75

62 / 127

Q61 New centres (large scale cities) will mainly be for residential.المدن المتعددة (كبيرة الحجم) سوف تكون مناطق سكنية فقط

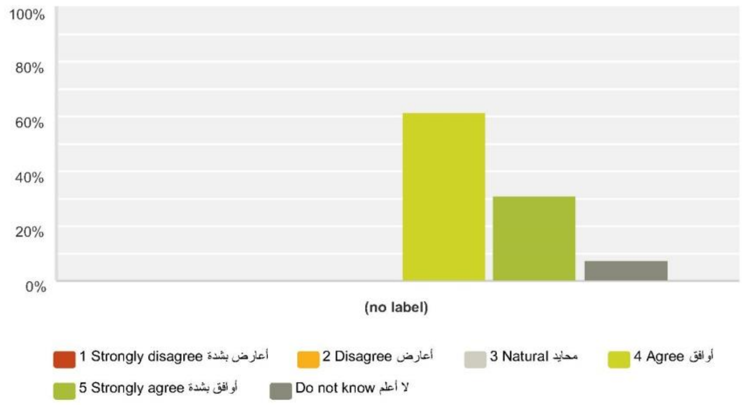
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**23.08%** 3	**61.54%** 8	**0.00%** 0	**7.69%** 1	**0.00%** 0	**7.69%** 1	13	1.92

Q62 New centres (large scale cities) will mainly be for mixed use.(المدن المتعددة (كبيرة الحجم سوف تكون مناطق استثمارية/ مختلطة

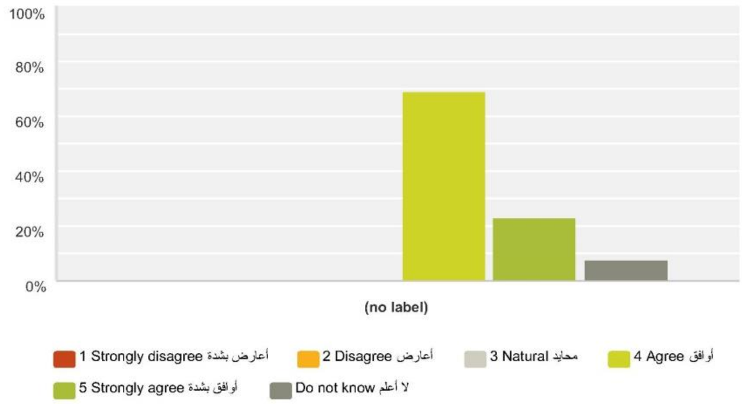
Answered: 13   Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**0.00%** 0	**0.00%** 0	**61.54%** 8	**30.77%** 4	**7.69%** 1	13	4.33

Q63 Multi-cities will dampen and resolve many direct impacts and negative externalities resulted from the existing urban growth pattern such as traffic congestion and housing shortages.المدن المتعددة (كبيرة الحجم) سوف تخفف وتحل الكثير من الآثار السلبية الناجمة عن نمط النمو الحضري الحالي مثل الازدحام المروري و مشكلة السكن

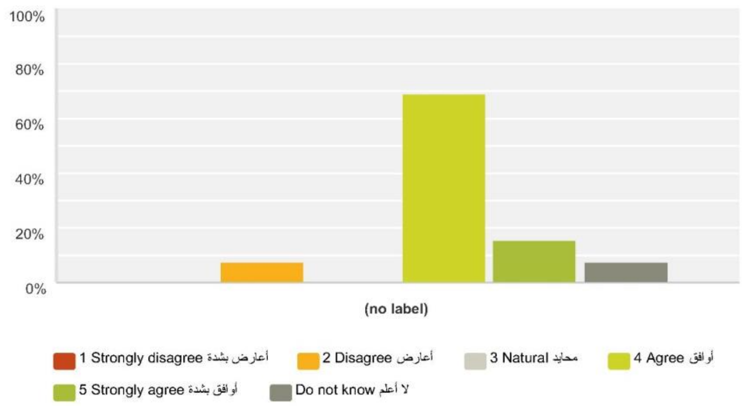
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	69.23% 9	23.08% 3	7.69% 1	13	4.25

Q64 New districts could continue development and expansion while applying the new master plan.المناطق السكنية الجديدة سوف تستمر بالتوسع و التطوير أثناء تطبيق المخطط الهيكلي الجديد

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	7.69% 1	0.00% 0	69.23% 9	15.38% 2	7.69% 1	13	4.00

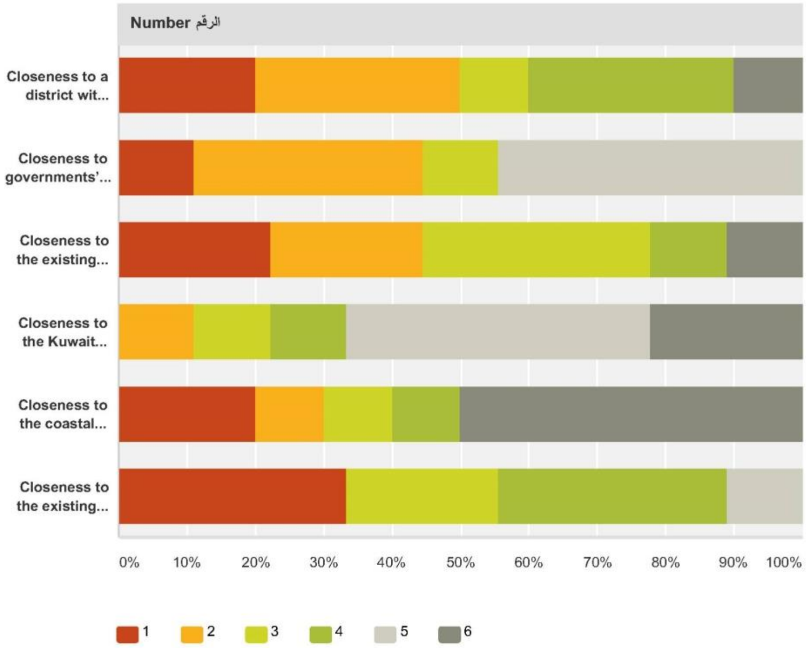
Q65 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 4 Skipped: 15

#	Responses	Date
1	٥٩ بعد تنازل النفط	4/25/2016 5:55 PM
2	عدم جدية الحكومة لحل المشكلات	4/24/2016 3:51 AM
3	٦٠ المتبع هو نظام الاقاليم فيها مدن كبيرة ثم مناطق صغيرة	4/20/2016 9:21 PM
4	السوؤال ٥٨ تعتبر سياسة المدن هي المستقبل السؤال ٥٩ ممكن في حال التنازل	4/12/2016 8:03 PM

Q66 Please order the following elements for where the new residential districts occur (for locating new districts)(From 1= Most important to 6 = Less important)الرجاء ترتيب العناصر التالية حسب الأهمية عند انشاء المناطق الجديدة (لتحديد (موقع المناطق الجديدة)(الأكثر أهمية= 1 الى الأقل أهمية= 6

Answered: 10 Skipped: 9

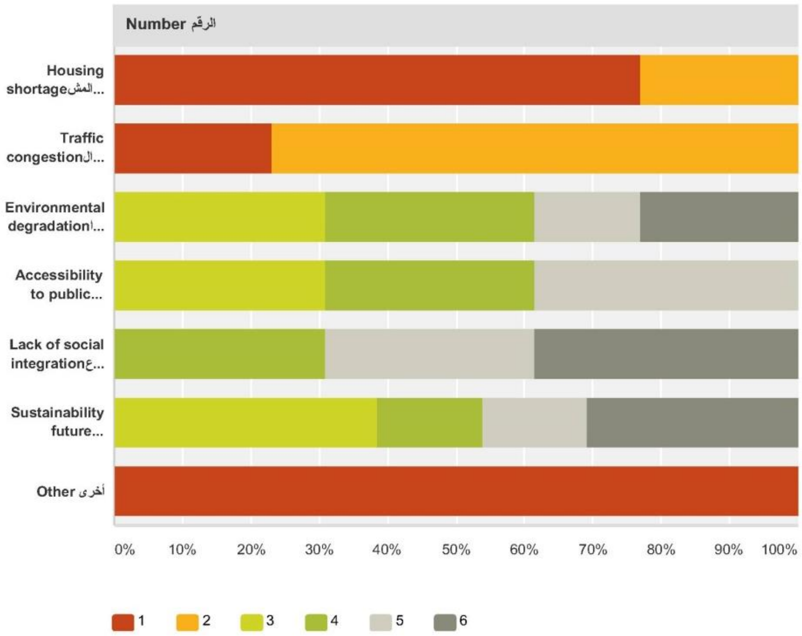


Number الرقم

	1	2	3	4	5	6	Total
Closeness to a district with existing services such as (shopping centers, hospitals and universities).القرب من منطقة فيها خدمات قائمة حالياً مثل (مراكز التسوق و المستشفيات والجامعات)	20.00% 2	30.00% 3	10.00% 1	30.00% 3	0.00% 0	10.00% 1	10
Closeness to governments' offices and ministries such as (Shuwaikh or Ministries district).القرب من المكاتب الحكومية والوزارات مثل (الشويخ أو منطقة الوزارات	11.11% 1	33.33% 3	11.11% 1	0.00% 0	44.44% 4	0.00% 0	9
Closeness to the existing street networks.القرب من شبكات الطرق الحالية	22.22% 2	22.22% 2	33.33% 3	11.11% 1	0.00% 0	11.11% 1	9
Closeness to the Kuwait Capital City (CBD).القرب من العاصمة/ مدينة الكويت	0.00% 0	11.11% 1	11.11% 1	11.11% 1	44.44% 4	22.22% 2	9
Closeness to the coastal line. القرب من الساحل/ البحر	20.00% 2	10.00% 1	10.00% 1	10.00% 1	0.00% 0	50.00% 5	10
Closeness to the existing urban area (Kuwait cities and its environs).القرب من المنطقة الحضرية الحالية (مدينة الكويت وضواحيها	33.33% 3	0.00% 0	22.22% 2	33.33% 3	11.11% 1	0.00% 0	9

Q67 Please order the following urban growth impacts based on your understanding as the most important issues that forms concern to the government (From 1= Most important to 6 (or 7) = Less important)يرجى ترتيب آثار النمو الحضري التالية استناداً إلى فهمك على أنها أهم القضايا التي تشكل مصدر قلق للحكومة (من 1= الأكثر أهمية إلى6 (أو 7)= الأقل أهمية)

Answered: 13   Skipped: 6



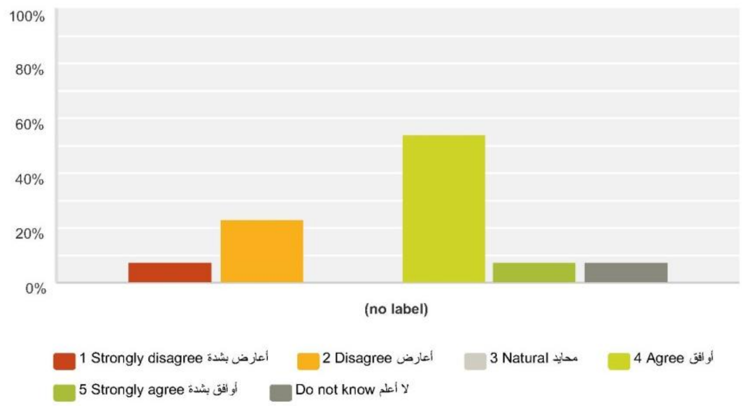
Number الرقم

	1	2	3	4	5	6	Total
Housing shortageالمشكلة السكنية	76.92% 10	23.08% 3	0.00% 0	0.00% 0	0.00% 0	0.00% 0	13
Traffic congestionالازدحام المروري	23.08% 3	76.92% 10	0.00% 0	0.00% 0	0.00% 0	0.00% 0	13
Environmental degradationالتدهور البيئي	0.00% 0	0.00% 0	30.77% 4	30.77% 4	15.38% 2	23.08% 3	13
Accessibility to public servicesالوصول الى الخدمات الحكومية	0.00% 0	0.00% 0	30.77% 4	30.77% 4	38.46% 5	0.00% 0	13
Lack of social integrationعدم الاندماج الاجتماعي بين المواطنين و الوافدين	0.00% 0	0.00% 0	0.00% 0	30.77% 4	30.77% 4	38.46% 5	13
Sustainability future development التنمية المستدامة في التخطيط المستقبلي	0.00% 0	0.00% 0	38.46% 5	15.38% 2	15.38% 2	30.77% 4	13
Other أخرى	100.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	1

#	if other (please specify) (لو أخرى (يرجى الكتابة	Date
1	الوضع السياسي	4/12/2016 8:03 PM

Q68 When planning new districts, traffic congestion is taken into consideration.عند تخطيط المناطق الجديدة يتم أخذ الازدحام المروري بعين الاعتبار

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**7.69%** 1	**23.08%** 3	**0.00%** 0	**53.85%** 7	**7.69%** 1	**7.69%** 1	13	3.33

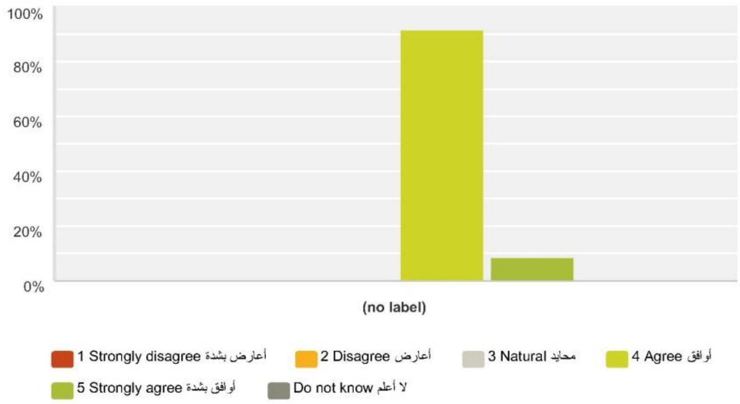
Q69 If traffic congestion is taken into account, how is it measured? For example traffic surveys, Vehicle Kilometres Travelled (VKT) or others. (Please write if applicable)اذا كان الازدحام المروري يؤخذ بعين الاعتبار عند التخطيط، فكيف يتم قياسه أو حسابه؟ على سبيل المثال استبيانات حركة المرور، حساب الكيلومترات المقطوعة بالسيارة (أو غيرها. (يرجى الكتابة

Answered: 5 Skipped: 14

#	Responses	Date
1	Vtv Real time traffic info. Capacity of roads (level of service) for intersections البلدية و الداخلية	4/27/2016 10:53 PM
2	لا يوجد	4/21/2016 9:12 PM
3	الدراسات المرورية	4/21/2016 8:30 PM
4	لا يوجد	4/20/2016 8:08 PM
5	عن طريق استبيانات حركة المرور بوزارة الداخليه	4/19/2016 5:56 PM

Q70 There are new projects to expand the existing roads to reduce the traffic congestion. (from 3 lines to be 4 or 5 lines)توجد مشاريع جديدة لتوسيع الطرق القائمة للحد من الازدحام. (من 3 مسارات لتكون 4 أو 5 مسارات

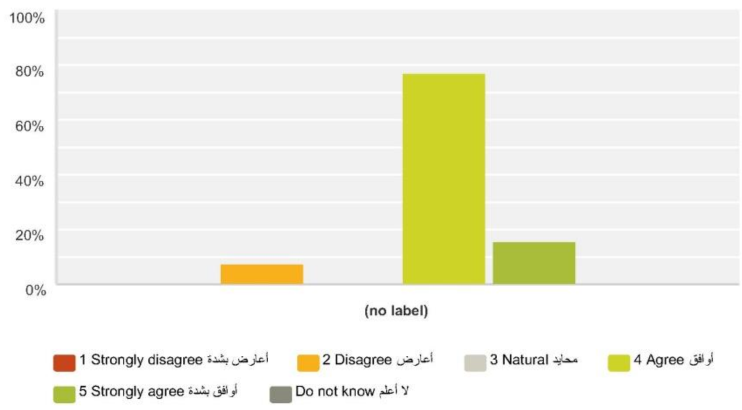
Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	91.67% 11	8.33% 1	0.00% 0	12	4.08

Q71 There are new projects to build new roads to reduce the traffic congestion.يوجد مشاريع جديدة لبناء طرق جديدة للحد من الازدحام

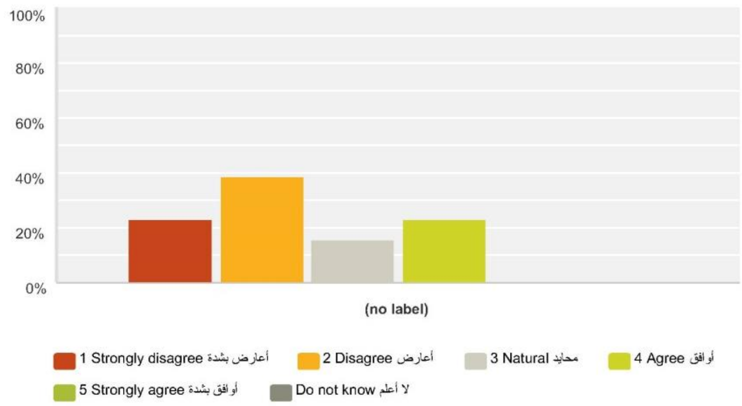
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**7.69%** 1	**0.00%** 0	**76.92%** 10	**15.38%** 2	**0.00%** 0	13	4.00

Q72 There are decentralizing policy government's offices/ companies' offices from the existing urban areas.لا يوجد مركزية في توزيع المكاتب الحكومية و مكاتب الشركات بحيث تكون خارج المناطق الحضرية القائمة

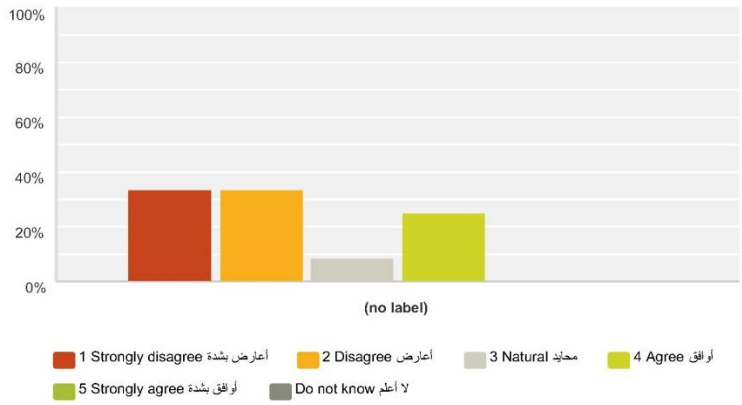
Answered: 13   Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	23.08% 3	38.46% 5	15.38% 2	23.08% 3	0.00% 0	0.00% 0	13	2.38

Q73 There is more attention from the government on the public transportation in the future.يوجد اهتمام متزايد من قبل الحكومة على وسائل النقل العام في المستقبل

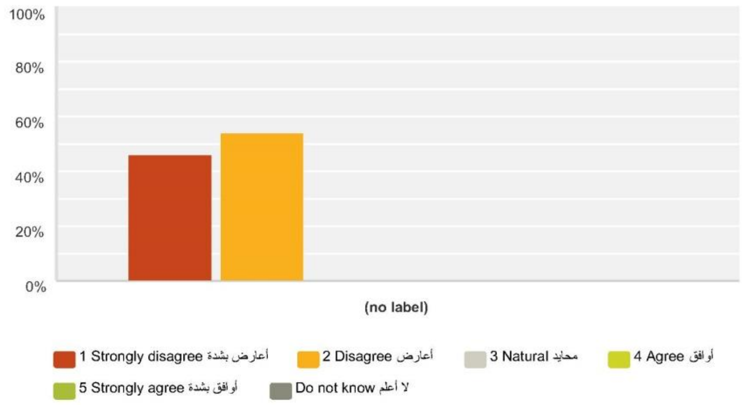
Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**33.33%** 4	**33.33%** 4	**8.33%** 1	**25.00%** 3	**0.00%** 0	**0.00%** 0	12	2.25

Q74 There are separated lines in the roads for the buses.يوجد مسارات منفصلة في الطرق لحافلات النقل العام

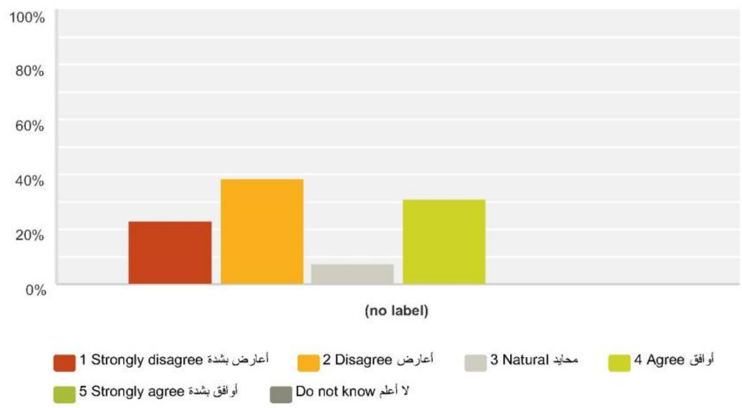
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**46.15%** 6	**53.85%** 7	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	13	1.54

Q75 There are new plans to separate bus lines from car lines.يوجد خطط جديدة لفصل مسارات الحافلات عن مسارات السيارة

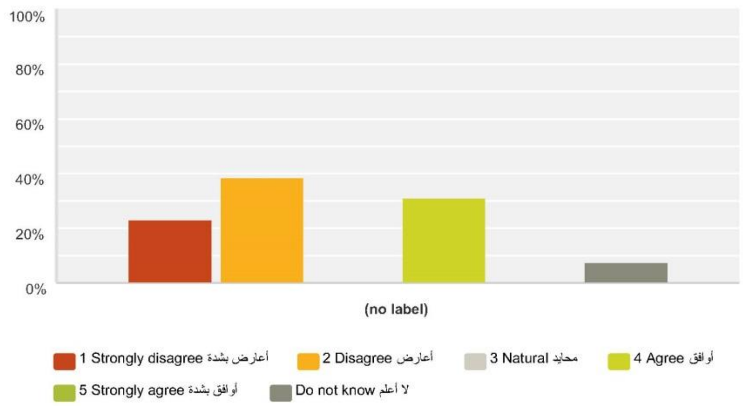
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	23.08% 3	38.46% 5	7.69% 1	30.77% 4	0.00% 0	0.00% 0	13	2.46

Q76 There is coordination between governments' agencies or ministries to adjust the working starting and ending hours to reduce traffic congestion in peak hours. يوجد تنسيق بين الجهات الحكومية أو الوزارات لضبط أوقات بداية و نهاية الدوام الرسمي للحد من الازدحام في ساعات الذروة

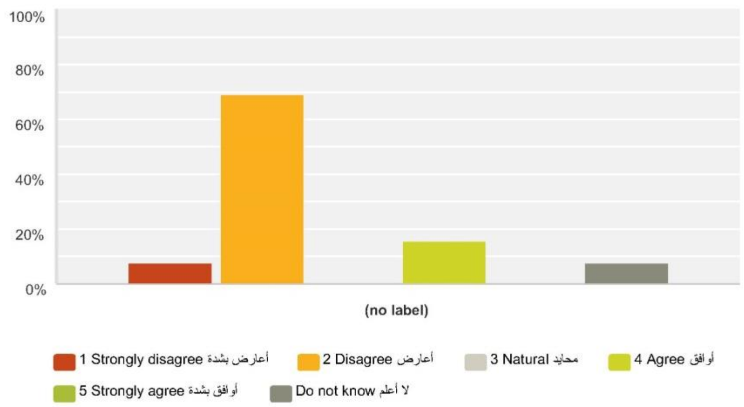
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	23.08% 3	38.46% 5	0.00% 0	30.77% 4	0.00% 0	7.69% 1	13	2.42

Q77 There are new plans on applying taxes/ tolls on driving cars on the roads. For examples peak hours.هناك خطط جديدة لتطبيق ضرائب / رسوم على قيادة السيارات على الطرق في ساعات الذروة

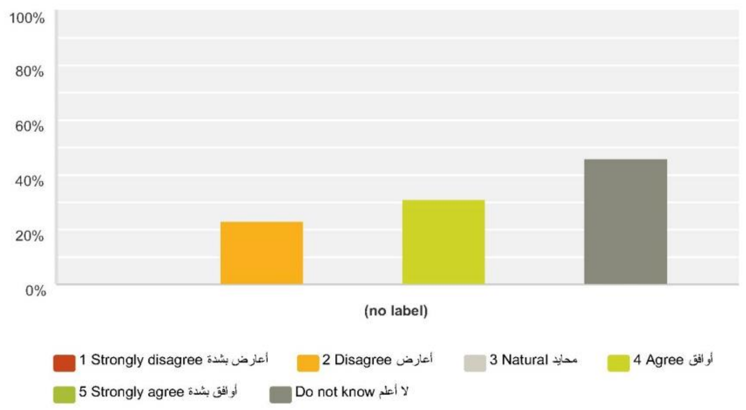
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	7.69% 1	69.23% 9	0.00% 0	15.38% 2	0.00% 0	7.69% 1	13	2.25

Q78 There are new policies to increase the registration fees due to reduce traffic congestion.هناك سياسات جديدة لزيادة رسوم تسجيل المركبات للحد من الازدحام

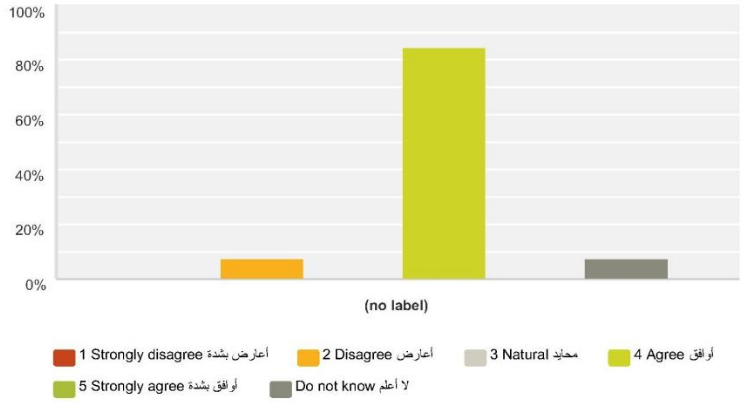
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	23.08% 3	0.00% 0	30.77% 4	0.00% 0	46.15% 6	13	3.14

Q79 Kuwait will apply new rail network in the future to reduce traffic congestion.سيتم تطبيق شبكة سكك حديدية جديدة في المستقبل للحد من الازدحام

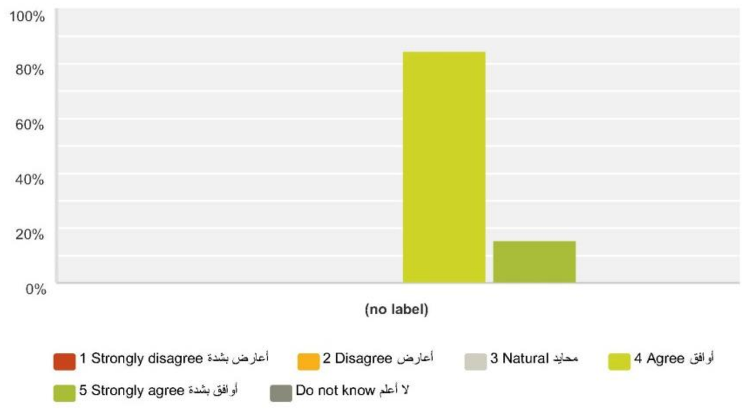
Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**7.69%** 1	**0.00%** 0	**84.62%** 11	**0.00%** 0	**7.69%** 1	13	3.83

Q80 The new master plan (multi-cities) is considered important for reducing traffic congestion.يعتبر المخطط الهيكلي الجديد (المدن المتعددة) مهم للحد من الاختناقات المرورية

Answered: 13 Skipped: 6



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	84.62% 11	15.38% 2	0.00% 0	13	4.15

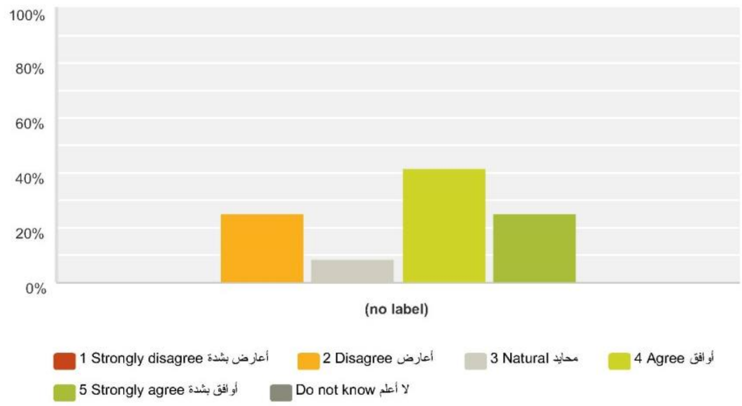
Q81 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 6   Skipped: 13

#	Responses	Date
1	٧٠ حلول و لكنها غير مجدية الاولويات و التنسيق محدود ٧٩ يوجد خطط و لكن لا شيء طبق حتى الان كوني عضو لجنة المترو	4/27/2016 10:53 PM
2	عدم جدية الحكومة في مشروع السكك الحديدية	4/25/2016 6:30 PM
3	عدم قدرة الحكومة على وضع خطط قابلة للتنفيذ بسبب عدم وجود قيادات مؤهلة بسبب التعيينات على المحسوبية	4/24/2016 3:51 AM
4	٧٩ السبب هو نقل البضائع و ليس لحل مشكلة الازدحام	4/20/2016 9:27 PM
5	في حالة تنفيذ المدن المتكاملة المعتمدة سيتم تخفيف الازدحام	4/20/2016 8:08 PM
6	لا علاقة له بالبلدية	4/12/2016 8:03 PM

Q82 When planning new districts, housing shortages (wait list for housing) is taken into account.عند تخطيط المناطق السكنية الجديدة، فإن مشكلة نقص المساكن (قائمة انتظار أصحاب الطلبات الاسكانية) تؤخذ بعين الاعتبار

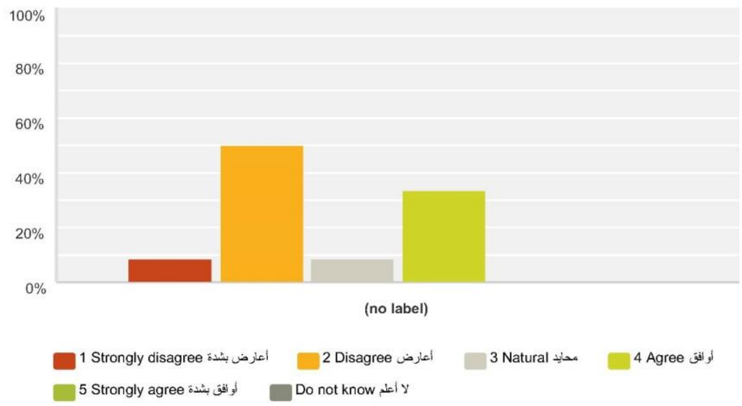
Answered: 12   Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	25.00% 3	8.33% 1	41.67% 5	25.00% 3	0.00% 0	12	3.67

Q83 When building new districts, the amount of expected houses covered the annually demands.عند بناء مناطق سكنية جديدة ، فإنه يتم تغطية عدد المنازل المتوقع في الطلبات سنوياً

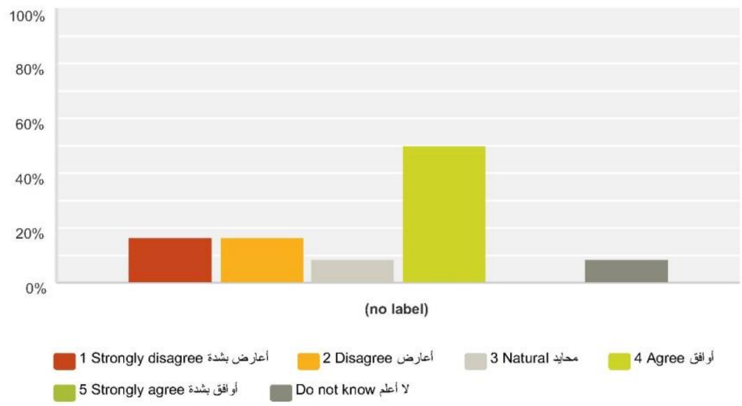
Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**8.33%** 1	**50.00%** 6	**8.33%** 1	**33.33%** 4	**0.00%** 0	**0.00%** 0	12	2.67

Q84 There is a plan to solve the housing shortage in the near future.يوجد خطة لحل أزمة السكن في المستقبل القريب

Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**16.67%** 2	**16.67%** 2	**8.33%** 1	**50.00%** 6	**0.00%** 0	**8.33%** 1	12	3.00

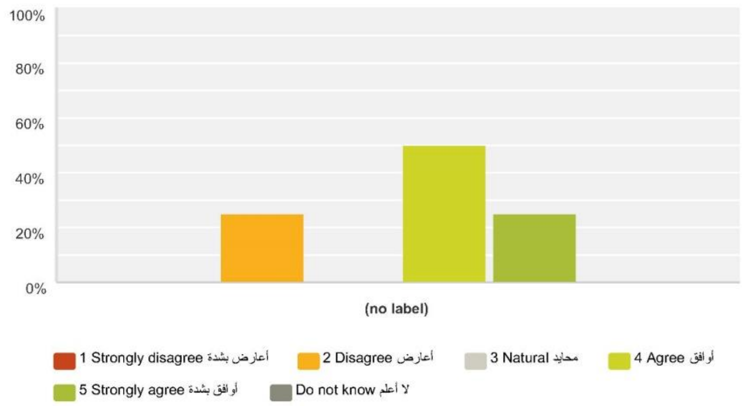
Q85 If there is a plan to solve the housing shortage in the near future, what is this plan? (Please write if applicable)اذا كان يوجد خطة لحل أزمة السكن في المستقبل القريب، فما هو نوع هذه الخطة؟ (يرجى الكتابة)

Answered: 5 Skipped: 14

#	Responses	Date
1	توزيع ١٢ الف وحدة سكنية سنويا	4/30/2016 5:32 AM
2	١٢ الف وحدة سكنية سنويا الاستعانة بمكاتب هندسية عالمية	4/28/2016 1:18 AM
3	٢٦٠ الف وحدة ل١٠٦ طلب اسكاني خلال ١٠ سنوات القادمة	4/25/2016 6:03 PM
4	استعجال انشاء المدن السكنية اكثر من مدينة في فترة زمنية قصيرة من خلال المخطط الهيكلي	4/21/2016 8:36 PM
5	لا اعلم	4/12/2016 8:03 PM

Q86 Kuwait government offer free lands or build houses for the citizens (Kuwaiti families), there is no future plan to stop this policies which is considered expensive to the government.حكومة الكويت تقدم أراضي مجانية أو مساكن مبنية للمواطنين (الأسر الكويتية)، و ليس هناك خطة مستقبلية لوقف هذه السياسة التي تعتبر مكلفة على الدولة

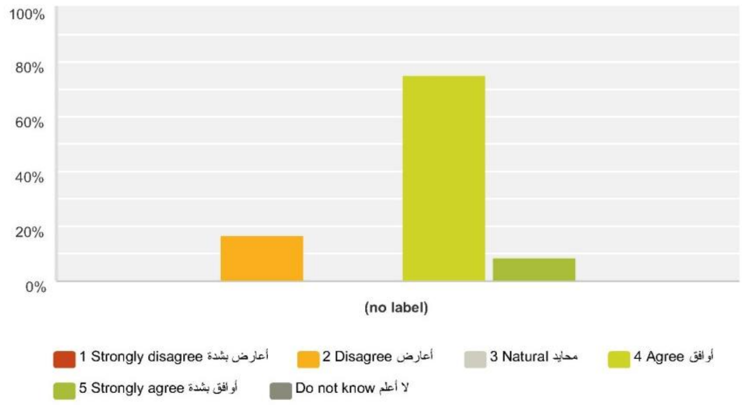
Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**25.00%** 3	**0.00%** 0	**50.00%** 6	**25.00%** 3	**0.00%** 0	12	3.75

Q87 There is new government plans to develop vertical housing (high density districts) offering apartments instead of houses.توجد خطط حكومية جديدة لتطوير السكن العمودي (مناطق عالية الكثافة) وتقدم الشقق بدلا من البيوت

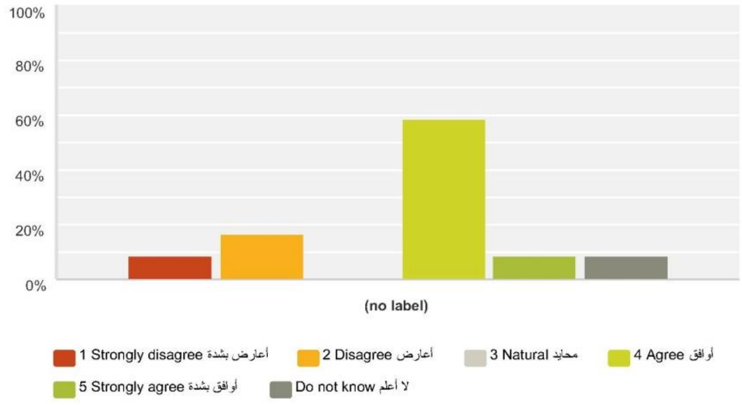
Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	16.67% 2	0.00% 0	75.00% 9	8.33% 1	0.00% 0	12	3.75

Q88 The new master plan (multi-cities) will cover the 100,000 demand applications.المخطط الهيكلي الجديد (المدن المتعددة) سوف يغطي الطلبات الاسكانية الحالية التي تجاوزت 100 ألف طلب

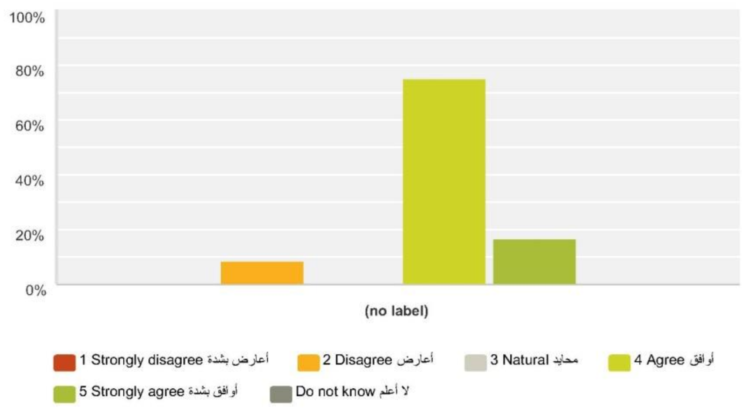
Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**8.33%** 1	**16.67%** 2	**0.00%** 0	**58.33%** 7	**8.33%** 1	**8.33%** 1	12	3.45

Q89 The new master plan (multi-cities) is considered important for reducing the housing shortages and will solve problem.يعتبر المخطط الهيكلي الجديد (المدن المتعددة) مهم للحد من نقص المساكن، وسوف يحل المشكلة

Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**8.33%** 1	**0.00%** 0	**75.00%** 9	**16.67%** 2	**0.00%** 0	12	4.00

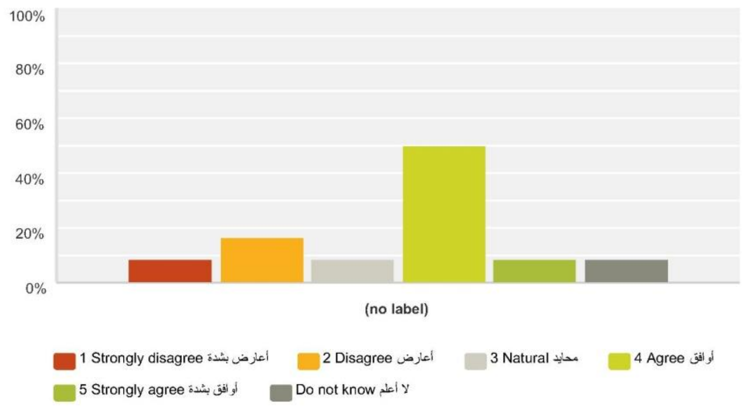
Q90 If the new master plan (multi-cities) will solve the housing shortages problem, how if the application is not stopping from increased due to population growth. (Please write if applicable)اذا كان المخطط الهيكلي الجديد (المدن المتعددة) سوف يحل مشكلة نقص المساكن، فكيف يمكن ان يتم ذلك علماً بأن الطلبات الاسكانية لن تتوقف بسبب النمو السكاني. (يرجى الكتابة))

Answered: 8   Skipped: 11

#	Responses	Date
1	من خلال التوزيع بإعداد اكبر من المطلوبة و تحديث البيانات	4/28/2016 1:18 AM
2	من خلال ٢٦٠ وحده	4/25/2016 6:03 PM
3	بشكل بسيط	4/24/2016 3:52 AM
4	من خلال انشاء مدن جديدةالى ان يتم توفير فائض من المساكن بالمستقبل القريب جدا	4/21/2016 8:36 PM
5	في حال التنفيذ السليم	4/20/2016 9:30 PM
6	من خلال السكن العمودي	4/20/2016 8:09 PM
7	في حال الدراسة الكافيه و التطبيق السليم	4/19/2016 6:01 PM
8	بسرعة الإنجاز	4/12/2016 8:03 PM

Q91 The government is planning to engage the private sector to solve the problem.حكومة الكويت تخطط لإشراك القطاع الخاص في حل المشكلة

Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	8.33% 1	16.67% 2	8.33% 1	50.00% 6	8.33% 1	8.33% 1	12	3.36

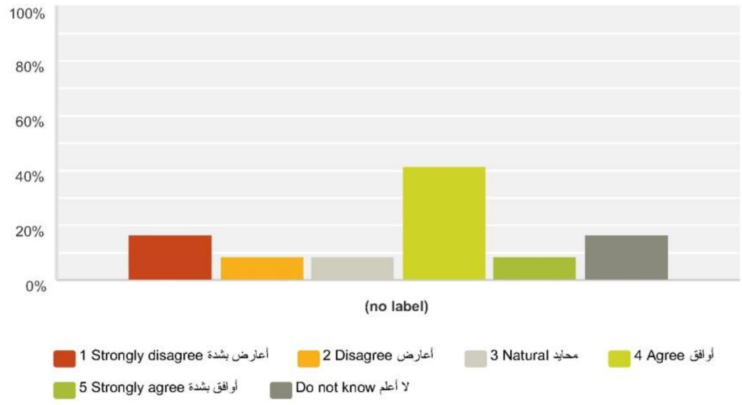
Q92 If the government is planning to engage private sector to solve the problem, how? (Please write if applicable)اذا كانت حكومة الكويت تخطط لإشراك القطاع الخاص في حل المشكلة، فكيف سيتم ذلك؟ (يرجى الكتابة)

Answered: 7 Skipped: 12

#	Responses	Date
1	من خلال بناء البنية التحتية في المدن	4/30/2016 5:32 AM
2	إعطاء القطاع الخاص نسبة معينة لتطوير ها	4/28/2016 1:18 AM
3	لا توجد آلية لذلك	4/25/2016 6:34 PM
4	من خلال تخصيص لجزاء من المشاريع للمطور العقاري	4/21/2016 8:36 PM
5	إلغاء الرقابة المسبقة على المشاريع الإسكانية الاستفادة من خبرات الدول الأجنبية	4/20/2016 9:30 PM
6	تقديم الدراسات و الاستشارات	4/19/2016 6:01 PM
7	باشراك القطاع الخاص من خلال بتنفيذ المشاريعالا	4/12/2016 8:03 PM

Q93 The government is planning to develop new laws or amend the existing rules to solve the problem.حكومة الكويت تخطط لوضع قوانين جديدة أو تعديل القوانين الحالية لحل المشكلة

Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	16.67% 2	8.33% 1	8.33% 1	41.67% 5	8.33% 1	16.67% 2	12	3.20

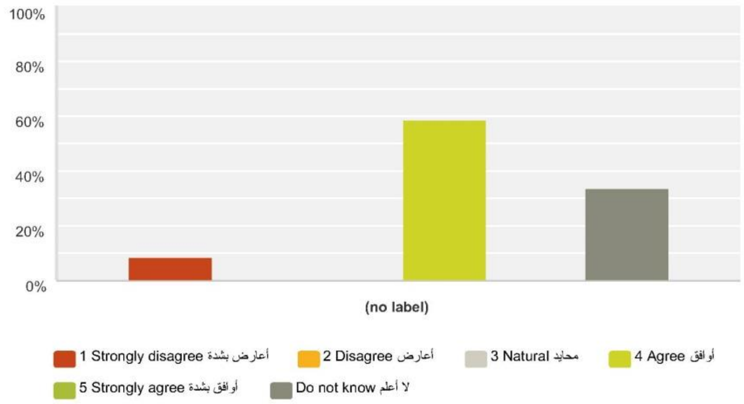
Q94 If The government is planning to develop new laws or amend the existing rules to solve the problem, what are these rules? (Please write if applicable)إذا كانت الحكومة تخطط لوضع قوانين جديدة أو تعديل القوانين القائمة لحل المشكلة، ما هي هذه القوانين؟ (يرجى الكتابة)

Answered: 5 Skipped: 14

#	Responses	Date
1	تعديل القانون و إلغاء الرقابة المسبقة	4/28/2016 1:18 AM
2	تشريع و يشرك القطاع الخاص لذلك	4/25/2016 6:34 PM
3	قوانين سكن المطلقات تقديم ادوار ذوي الاحتياجات الخاصة للسكن	4/22/2016 8:01 AM
4	إلغاء المراقبة المسبقة على المشاريع الإسكانية تم ذلك قبل شهر تقريبا	4/21/2016 8:36 PM
5	استثناء الإسكان من الرقابة السابقة لمدة ٥ سنوات لسرعة الإنجاز	4/12/2016 8:03 PM

Q95 There are predicted PAHW applications numbers for the future (until 2050). For example, an average per year.هناك عدد متوقع لأعداد الطلبات الاسكانية في المستقبل (حتى عام 2050).على سبيل المثال، المتوسط الحسابي السنوي

Answered: 12 Skipped: 7



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	8.33% 1	0.00% 0	0.00% 0	58.33% 7	0.00% 0	33.33% 4	12	3.63

Q96 If there are a predicted PAHW applications numbers for the future (until 2050), what is this number and based on what (i.e. equations)? (Please write if applicable)إذا كان هناك عدد متوقع لأعداد الطلبات الاسكانية في المستقبل (حتى عام 2050)، ما هو هذا العدد وعلى أي أساس تم حسابة (ما هي المعادلات)؟ (يرجى كتابة)

Answered: 3 Skipped: 16

#	Responses	Date
1	لا اعلم	4/30/2016 5:32 AM
2	مدينة الحرير مليونين و ٦٠٠ نسمة	4/25/2016 6:03 PM
3	معدل الزيادة السنوي ٧٠٠٠	4/21/2016 8:36 PM

Q97 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 4   Skipped: 15

#	Responses	Date
1	٨٧ يعتبر لختياري للمواطنين	4/28/2016 1:18 AM
2	لا توجد أي علاقة لي بهذا المجال	4/27/2016 10:54 PM
3	لا يوجد رؤية واضحة لحل المشكلة الإسكانية من قبل الحكومة لحل المشكلة الإسكانية لعدم الاستفادة من مشاركة القطاع الخاص المحلي و الدولي لحل المشكلة	4/24/2016 3:52 AM
4	٨٦ ليست مجانية و لكن بسعر رمزي	4/12/2016 8:03 PM

Q98 ¬ According to your experience, what do you think are the critical success factors that will improve the Kuwait planning processes to control urban growth and decrees its impacts in both traffic congestion and housing shortages?¬ وفقا لخبرتك، ما هي عوامل النجاح الحاسمة التي من شأنها تحسين عمليات التخطيط في الكويت للسيطرة على النمو الحضري والحد من آثاره على كل من الازدحام المروري و المشكلة الإسكانية؟

Answered: 11 Skipped: 8

#	Responses	Date
1	اشراك القطاع الخاص قصر الدورة المستندية التطوير من خلال استخدام طرق حديثة إيجاد تشريعات قانونية تساعد في حل الأزمة	4/28/2016 1:18 AM
2	الازدحام المروري: الانتهاء من المترو و سكك الحديد بأسرع وقت تغيير سلوك قائدي المركبات من لآل تطبيق القوانين الصارمة حل مشكلة مواقف السيارات من خلال المواقف الذكية و استثمار القطاع الخاص وضع المكاتب الحكومية و مراكز العمل خارج الأثمة و قريبة من المناطق الجديدة المشكلة السكنية: تشجيع القطاع الخاص لبناء المساكن تصغير المساحات و لكن بجاذبية لكبر للسمان بشكل عام تحسين أنظمة التخطيط	4/27/2016 11:53 PM
3	مواقف السيارات حل مشكلة بالواقف الذكية و بعدها ننظر الازدحام سرعة الإنجاز و التنفيذ اشراك القطاع الخاص	4/25/2016 6:06 PM
4	يجب ان تؤمن الحكومة بأهمية التخطيط يجب ان توجد وزارة للتخطيط بدل من الامانه العامة للتخطيط يجب تعيين المؤهلين اكاديميا و علميا و الاستفادة من الخبرات يجب جلب الوافدين المتخصصين من الخارج يجب ان يكون هناك مادة تدرس بالمناهج الدراسية تخص التخطيط	4/24/2016 3:52 AM
5	الغاء الدوره المستندية وتفعيل التراسل الاكتروني التعاقد مع شركات اجنبيه لتنفيذ المشاريع بدل من إيجاد وكيل لها بالكويت تنفيذ كافه خطط التنمية	4/22/2016 8:05 AM
6	التنسيق بين وزارات الدولة سرعة الإنجاز بتنفيذ المشاريع	4/21/2016 9:14 PM
7	من خلال تعديل القوانين الابتعاد عن البيروقراطية و الدورة المستندية إقصاء المتنفذين عن تعطيل المشاريع	4/21/2016 8:38 PM
8	تعديل النقل العام و تطوير الطرق توزيع السكان خارج المنطقة الحضرية بشرط ان تكون مدن متكاملة	4/20/2016 9:31 PM
9	توفير مخططين في مجال التخطيط	4/20/2016 8:09 PM
10	عن طريق استخدام التكنولوجيا الحديثة مثل نظم المعلومات و نظم المعلومات الجغرافية و غيرها مواكبة التطور العالمي في حل المشاكل الحضرية	4/19/2016 6:02 PM
11	الالتزام و سرعة الإنجاز و اتباع التخطيط التنموي	4/12/2016 8:03 PM

Q99 General Informationمعلومات عامة

Answered: 4 Skipped: 15

Answer Choices	Responses	
Interviewee Name الاسم	100.00%	4
Company name اسم الشركة	100.00%	4
Position in the Organisation المسمى الوظيفي	100.00%	4
Working experience (Years) (سنوات العمل/ الخبرة (سنوات)	100.00%	4
City/Town	0.00%	0
State/Province	0.00%	0
ZIP/Postal Code	0.00%	0
Country	0.00%	0
Email Address البريد الالكتروني	100.00%	4
Phone Number رقم الهاتف	0.00%	0

#	Interviewee Name الاسم	Date
1	خليفة الفضالة	4/27/2016 10:15 PM
2	محمد العيسى	4/26/2016 8:53 PM
3	محمد الصايغ	4/26/2016 7:58 PM
4	سعود الأيوب	4/26/2016 7:27 PM
#	**Company name اسم الشركة**	**Date**
1	Transmaotion traffic and transportation consultation	4/27/2016 10:15 PM
2	شركة تيكو للمقاولات	4/26/2016 8:53 PM
3	مجموعة الودائع الدولية	4/26/2016 7:58 PM
4	شركة المساكن الدولية للتطوير العقاري	4/26/2016 7:27 PM
#	**Position in the Organisation المسمى الوظيفي**	**Date**
1	General manager	4/27/2016 10:15 PM
2	الرئيس التنفيذي	4/26/2016 8:53 PM
3	الرئيس التنفيذي	4/26/2016 7:58 PM
4	نائب الرئيس	4/26/2016 7:27 PM
#	**Working experience (Years) (سنوات العمل/ الخبرة (سنوات)**	**Date**
1	12	4/27/2016 10:15 PM
2	١٠	4/26/2016 8:53 PM
3	١٩	4/26/2016 7:58 PM
4	١٢	4/26/2016 7:27 PM
#	**City/Town**	**Date**
	There are no responses.	
#	**State/Province**	**Date**
	There are no responses.	
#	**ZIP/Postal Code**	**Date**
	There are no responses.	
#	**Country**	**Date**

	There are no responses.	

#	Email Address البريد الالكتروني	Date
1	@	4/27/2016 10:15 PM
2	@	4/26/2016 8:53 PM
3	*	4/26/2016 7:58 PM
4	=	4/26/2016 7:27 PM

#	Phone Number رقم الهاتف	Date
	There are no responses.	

Q100 Type of company's business نوع النشاط التجاري

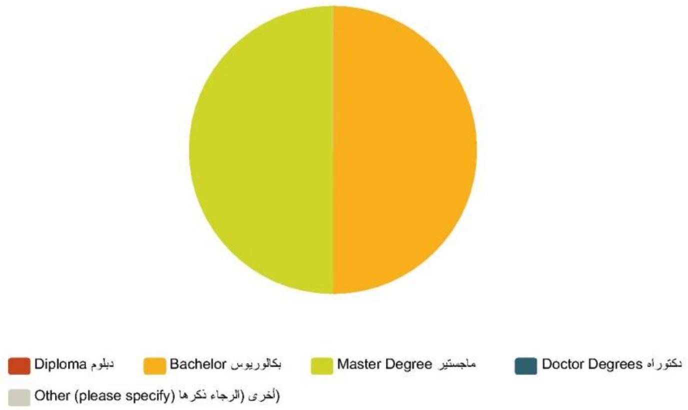
Answered: 4 Skipped: 15

Answer Choices	Responses	
Residential سكني	25.00%	1
Constructions انشاءات	25.00%	1
Real estate عقارات	0.00%	0
Other (please specify) (أخرى (الرجاء ذكرها	50.00%	2
Total		**4**

#	Other (please specify) (أخرى (الرجاء ذكرها	Date
1	استشاري هندسي مروري	4/27/2016 10:15 PM
2	عقاري إنشاءات و اخرى	4/26/2016 7:58 PM

Q101 Educational backgroundالمؤهل العلمي

Answered: 4   Skipped: 15

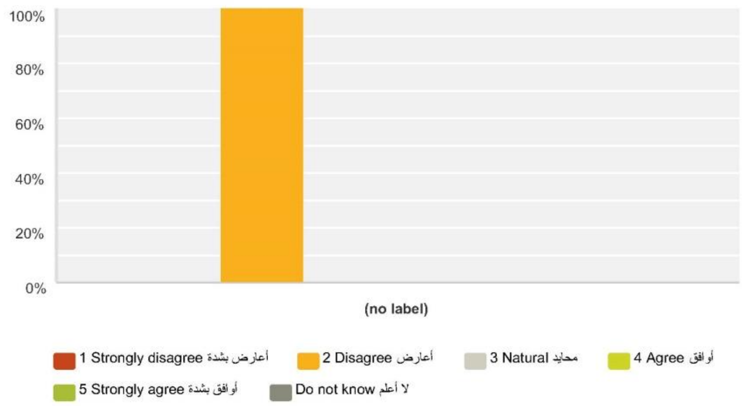


Answer Choices	Responses	
Diploma دبلوم	0.00%	0
Bachelor بكالوريوس	50.00%	2
Master Degree ماجستير	50.00%	2
Doctor Degrees دكتوراه	0.00%	0
Other (please specify) (أخرى (الرجاء ذكرها	0.00%	0
Total		**4**

#	Other (please specify) (أخرى (الرجاء ذكرها	Date
	There are no responses.	

Q102 The Private sector can pressure and lobby the government to build new districts. For example, Mixed districts (Salmiya, Hawalli or Khaitan).القطاع الخاص يستطيع أن يضغط على الحكومة لبناء مناطق جديدة. على سبيل المثال، المناطق (الاستثمارية/ المختلطة (السالمية، حولي أو خيطان

Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	100.00% 4	0.00% 0	0.00% 0	0.00% 0	0.00% 0	4	2.00

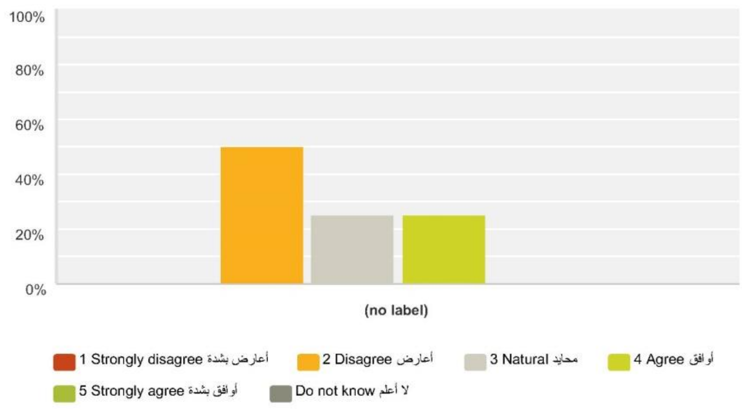
Q103 If the private sector can exhort pressure government to build new districts, how this can be done? (Please write if applicable)اذا كان القطاع الخاص يستطيع أن يضغط على الحكومة لبناء مناطق جديدة، فكيف يتم ذلك؟ (يرجى الكتابة)

Answered: 0 Skipped: 19

#	Responses	Date
	There are no responses.	

Q104 The private sector is the responsible for developing new districts. For example infrastructure, housing, street network.القطاع الخاص هو المسؤول عن تطوير المناطق الجديدة. على سبيل المثال البنية التحتية للمساكن وشبكة الشوارع

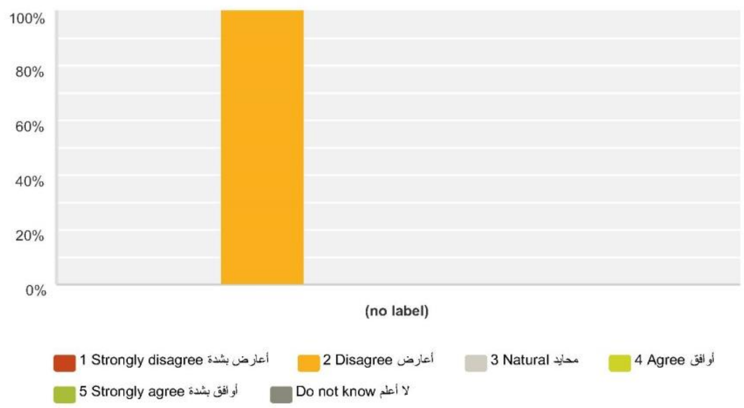
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	50.00% 2	25.00% 1	25.00% 1	0.00% 0	0.00% 0	4	2.75

Q105 The private sector is the responsible of developing new districts cost.القطاع الخاص هو المسؤول عن تكلفة تطوير المناطق الجديدة

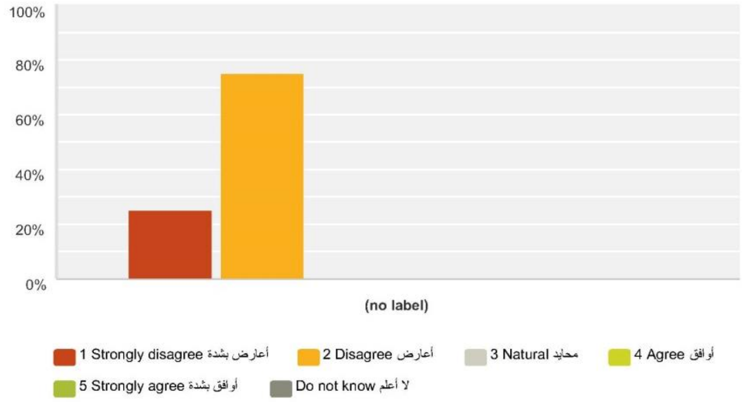
Answered: 4   Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**100.00%** 4	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	4	2.00

Q106 The private sector is a partner with the government in the development new districts. (in cost and developing)القطاع الخاص يعتبر شريك مع الحكومة في تطوير المناطق الجديدة. (في التكاليف و البناء)

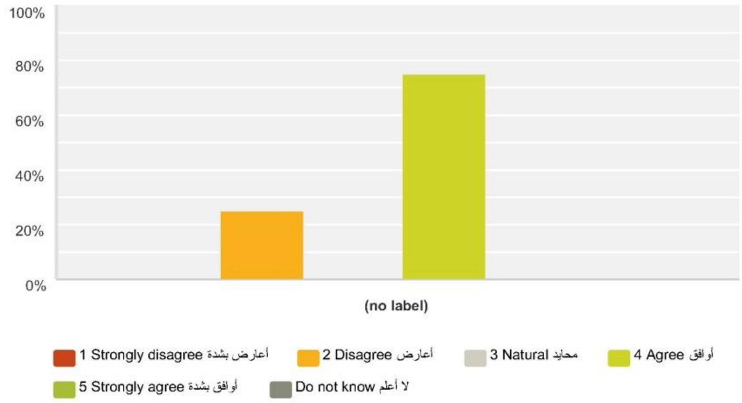
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**25.00%** 1	**75.00%** 3	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	4	1.75

Q107 The private sector is considered as facilitator for developing new districts. (In developing without cost)يعتبر القطاع الخاص وسيط (لتطوير مناطق جديدة. (في البناء دون تكلفة

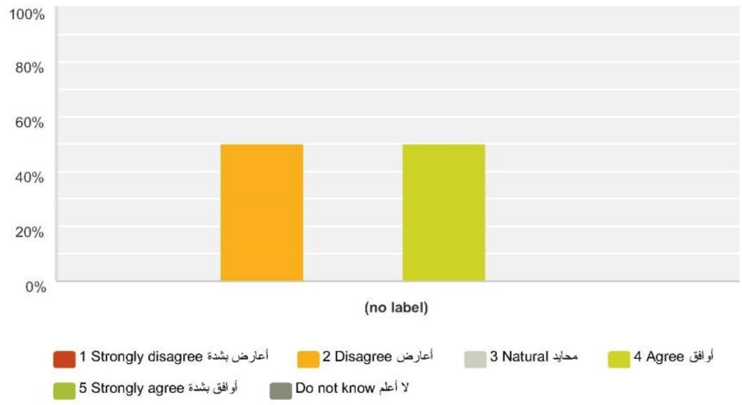
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**25.00%** 1	**0.00%** 0	**75.00%** 3	**0.00%** 0	**0.00%** 0	4	3.50

Q108 The private sector can develop new city with its all needed infrastructure with government approval.يمكن للقطاع الخاص أن يطور مدينة جديدة مع كل ما يلزمها من البنية التحتية بشرط موافقة الحكومة

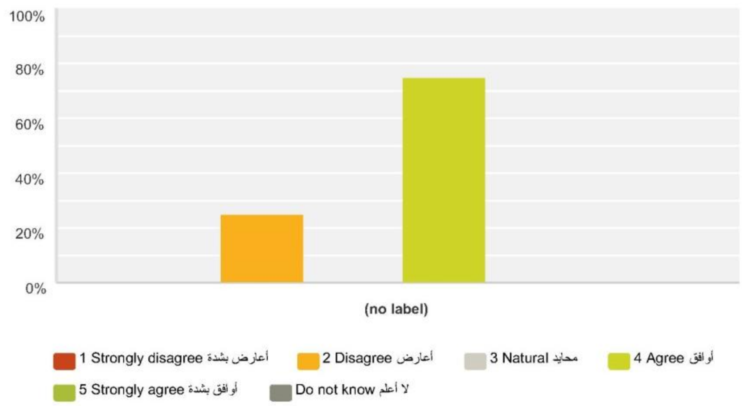
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	50.00% 2	0.00% 0	50.00% 2	0.00% 0	0.00% 0	4	3.00

Q109 The private sector can suggest to the government some new projects.القطاع الخاص يمكن أن يقترح على الحكومة بعض المشاريع الجديدة

Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**25.00%** 1	**0.00%** 0	**75.00%** 3	**0.00%** 0	**0.00%** 0	4	3.50

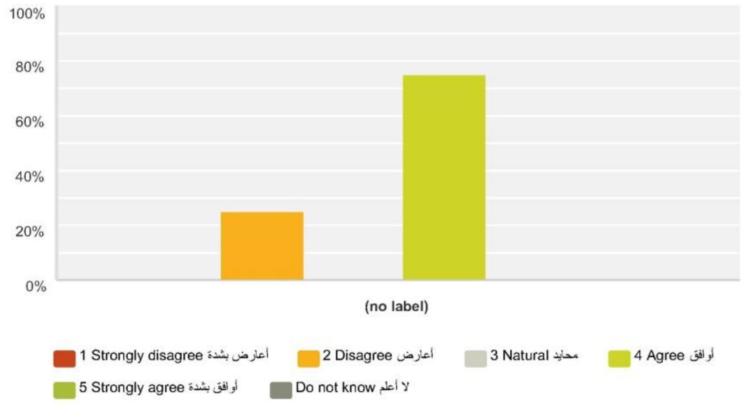
Q110 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 4 Skipped: 15

#	Responses	Date
1	مدينة لؤلؤة الخيران يعتبر استثناء و مشروع المنطقة منخفضة التكاليف غير منفذ ١٢ مثال مدينة الحرير	4/27/2016 10:18 PM
2	٧ جهة تنفيذباشراف حكومي الاراضي ملك الدولة و هي اعلم بتوزيعهاحسب خططها	4/26/2016 8:55 PM
3	الحكومة يجب ان تكون بدور المراقب و المشرف القطاع الخاص يحبان يكون المشغلين و لكن الحكومة تفرض كل شي كي تكون مهيمنة و تقتل روح السؤال يجب الفصل بين بين الادارة و الاشراف الواقع عبارة عن مجاملة من القطاع الخاص للحكومة الاقتراح دون التنفيذ	4/26/2016 8:03 PM
4	من غير دفع ٧ ١٠ يعبر القطاع الخاص مقاول فقط	4/26/2016 7:31 PM

Q111 The private sector can build new houses in the new districts or cities with government approval.يمكن للقطاع الخاص بناء منازل جديدة في المناطق أو المدن الجديدة بشرط موافقة الحكومة

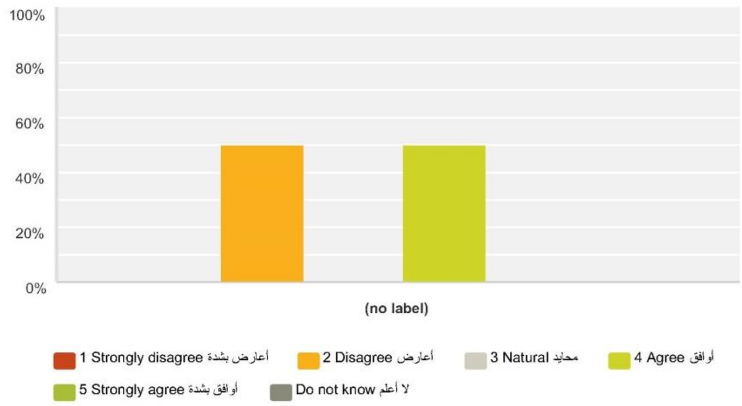
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**25.00%** 1	**0.00%** 0	**75.00%** 3	**0.00%** 0	**0.00%** 0	4	3.50

Q112 The private sector can build residential buildings (vertical) in the residential districts.يمكن للقطاع الخاص بناء العمارات السكنية (العمودية) في المناطق السكنية

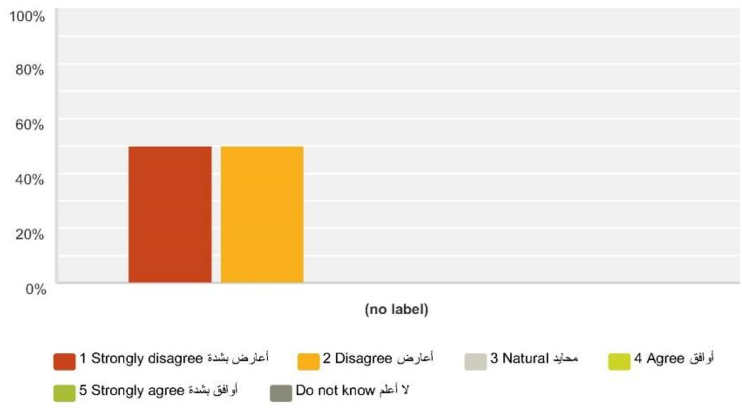
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**50.00%** 2	**0.00%** 0	**50.00%** 2	**0.00%** 0	**0.00%** 0	4	3.00

Q113 The private sector has a role in selecting the new residential districts location.القطاع الخاص له دور في اختيار مواقع المناطق السكنية الجديدة

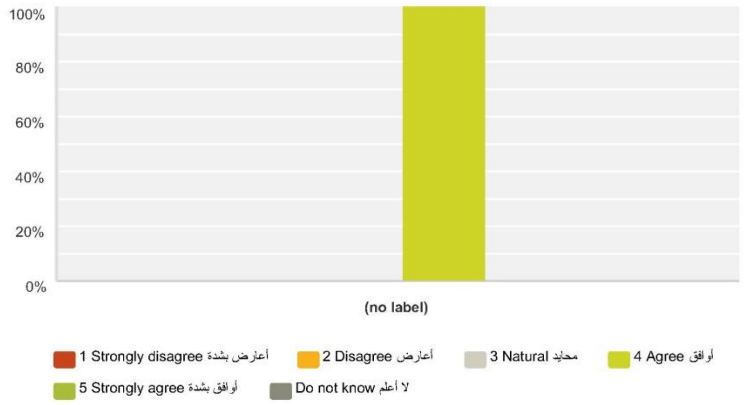
Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**50.00%** 2	**50.00%** 2	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	4	1.50

Q114 The private sector can participate to solve the housing shortages.يمكن للقطاع الخاص المشاركة في حل المشكلة السكنية في الكويت

Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**0.00%** 0	**0.00%** 0	**100.00%** 4	**0.00%** 0	**0.00%** 0	4	4.00

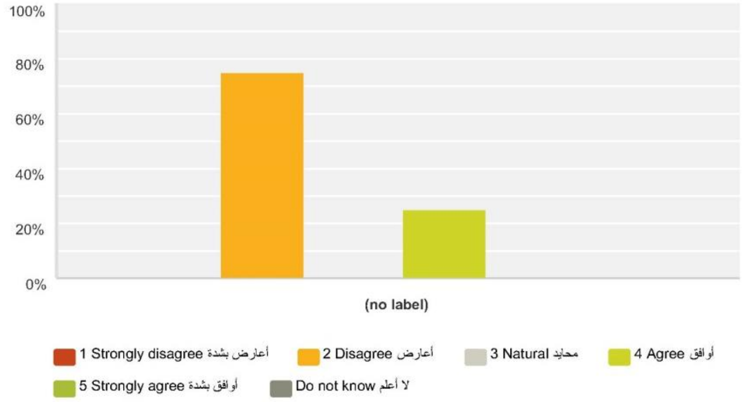
Q115 If Private sector can participate to solve the housing shortages,explain how? (Please write if applicable)اذا كان يمكن للقطاع الخاص المشاركة في حل المشكلة السكنية في الكويت. فكيف يتم ذلك؟ (يرجى كتابة)

Answered: 4 Skipped: 15

#	Responses	Date
1	حلول ذكية و دراسات و يعبر ديناميكي اكثر من الدولة و لكن المشاكل بالحكومة من قوانينها	4/27/2016 10:22 PM
2	عن طريق تقديم اقتراحات للمباني ذات التكلفة البسيطة بناء مصانع داخل الكويت لسرعة الإنجاز و أنظمة بناء حديثة إقناع الحكومة في تذليل المستندات الدورية و البيروقراطية	4/26/2016 8:58 PM
3	لخذ ديمغرافيا الدولة التخطيط و المتطلبات أخذ بيانات مع دقتها يجب تحرير الاراضي بطريقة علمية ثم يتم خلق الحل لمدة زمنية طويلة لأكثر من ١٠ سنوات مع خطة احتياطية و خطة ثانية بعدها التعلب على سوء الادارة عدم إرسال الأوراق و المعاملات الى اكثر من جهة واحدة	4/26/2016 8:11 PM
4	من خلال تسليم الاراضي البيضاء من الحكومة للقطاع الخاص و لكن بشرط التحكم النهائي للأسعار من قبل الحكومة	4/26/2016 7:46 PM

Q116 The private sector that owns residential buildings in the districts prefers to rent it to Kuwaitis.القطاع الخاص الذي يملك المباني السكنية في المناطق يفضل أن يؤجرها للكويتيين

Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	0.00% 0	75.00% 3	0.00% 0	25.00% 1	0.00% 0	0.00% 0	4	2.50

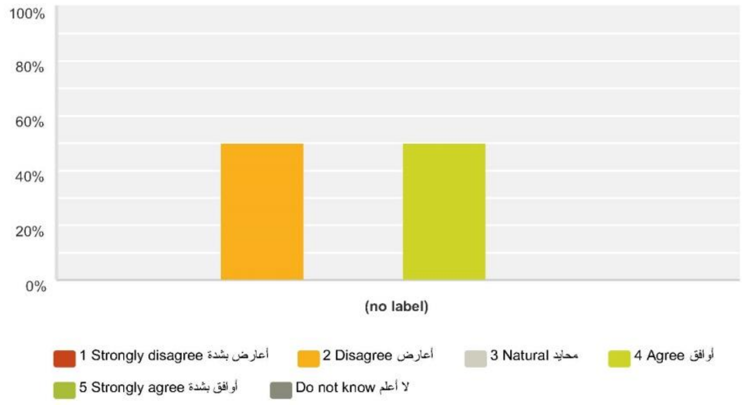
Q117 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 3 Skipped: 16

#	Responses	Date
1	١٥ مثال شمال غرب الصليبيخات	4/27/2016 10:22 PM
2	القانون الكويتي مع الكويتيين و لذلك التفضيل الوافدين ١٩	4/26/2016 8:58 PM
3	الحكومة قاتلة و مدمرة لطاقات الشباب الكويتي و لا تأخذ المواطن بعين الاعتبار لان السوق كويتي و لكن بشرط الانتقاء ١٩	4/26/2016 8:11 PM

Q118 The private sector can build business activities in the residential districts (Fiha, Surra, Audiliya).يمكن للقطاع الخاص بناء الأنشطة التجارية في المناطق السكنية (الفيحاء، السرة، العديلية

Answered: 4 Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**50.00%** 2	**0.00%** 0	**50.00%** 2	**0.00%** 0	**0.00%** 0	4	3.00

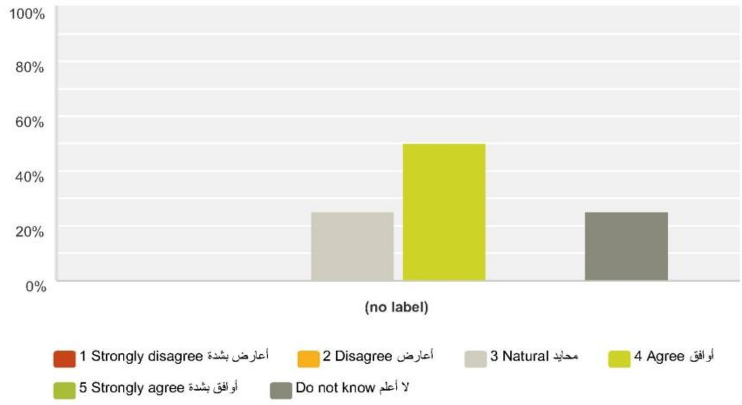
Q119 If the private sector can build business activities in the residential districts, what kind of activities? For example shopping centers, universities, private hospital, etc… (Please write if applicable(إذا كان القطاع الخاص يمكنه بناء الأنشطة التجارية في المناطق السكنية، ما هو نوع هذه الأنشطة؟ على سبيل المثال مراكز التسوق ، الجامعات، المستشفيات الخاصة، الخ ...) يرجى كتابة

Answered: 1 Skipped: 18

#	Responses	Date
1	لقطع الاراضي المخصصة لذلك و لكنها غير كافية	4/26/2016 8:18 PM

Q120 The private sector prefers to build business activities in the mixed districts (Salmiya, Hawalli or Khaitan).يفضل القطاع الخاص بناء الأنشطة التجارية في المناطق الاستثمارية/ المختلطة (السالمية، حولي، خيطان)

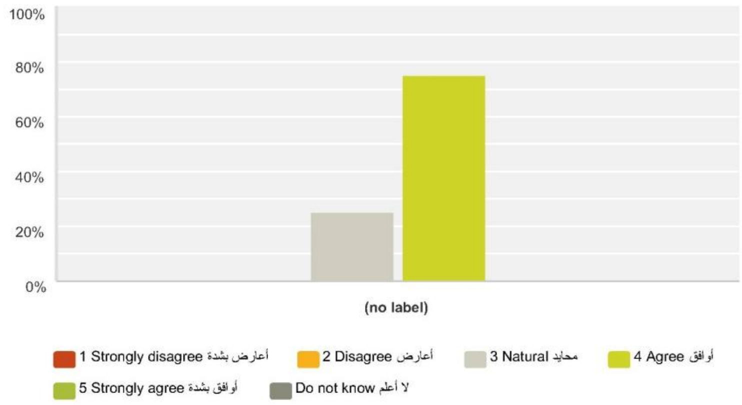
Answered: 4   Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**0.00%** 0	**25.00%** 1	**50.00%** 2	**0.00%** 0	**25.00%** 1	4	3.67

Q121 The private sector prefers new multi-cities rather than residential and mixed districts (current situation).يفضل القطاع الخاص المدن المتعددة الجديدة بدلا من المناطق السكنية والمختلطة (الوضع الحالي)

Answered: 4   Skipped: 15



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Natural محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	Do not know لا أعلم	Total	Weighted Average
(no label)	**0.00%** 0	**0.00%** 0	**25.00%** 1	**75.00%** 3	**0.00%** 0	**0.00%** 0	4	3.75

Q122 Other comments (Please write)تعليقات أخرى (يرجى الكتابة)

Answered: 2 Skipped: 17

#	Responses	Date
1	اللعب في نسب البناء كحل لبعض المشكلات	4/27/2016 10:25 PM
2	الحكومة لا تسمح بالأنشطة في المناطق السكنية بسبب القوانين و على سبيل المثال افتح مجال للمدارس الخاصة و المستشفيات الخاصة في المناطق السكنية مع الرقابة و الإشراف ٢٣ أفضل المناطق وفق التوزيع للاحتياج الديمغرافي و سهولة توصيل و توزيع الخدمات و السلع هناك بعض الأنشطة التجارية يفضّل ان تكون لا سكني و لا استثماري بل يجب ان تكون في منطقة منفصلة حس الحاجة ٢٤ بشرط التنفيذ السليم و توصيل المدن ببعضها	4/26/2016 8:18 PM

Q123 Are there any important issues not covered in this survey that you would like it to be added? If so, please write the questions and answer them kindly in the space provided below.هل هناك أي أسئلة مهمة لم يشملها هذا الاستبيان و ترغب في اضافتها؟إذا كان الأمر كذلك، يرجى كتابة الأسئلة والإجابة عليها في المكان المخصص أدناه

Answered: 8 Skipped: 11

#	Responses	Date
1	سؤال الترتيب لا يوجد له شيء ثابت	4/28/2016 1:18 AM
2	يجب تسليم الاراضي مع البنية التحتية للقطاع الخاص مع إشراف حكومي و التزام القطاع الخاص بمعايير معينة مع مراعاة الالذق العام في التصميم يجب تشديد الرقابة على مشكلة بيع المشاريع بالباطن يجب انشاء شركات تقوم بالإسكان و تطوير المدن و الطرق بشرط ان يملك الشعب ٥٠٪ من اسهمها المشاريع الكبرى يجب يقوم بها تحالف من الشركات مع مستثمر خارجي بشرط إرجاع قيمتها للدولة يجب تشديد الرقابة على لجنة المناقصات مع الشفافية منع بيع المشاريع بين المتقدمين من لأل لجنة تحقيق أو اي آلية اخرى يجب تشجيع الشباب و تعديل القوانين لاستجلاب المستثمر الخارجي	4/26/2016 9:37 PM
3	يرجى النظر الى القطاع بانه جزء لا يتجزا من الدولة و المجتمع و من يعمل به ما هو الا مواطن من المجتمع الكويتي و اغلبهم ينظر الى الصالح العام قبل الصالح الخاص انظر لما يقدمه و يحققه كنجاح للدولة ككل	4/26/2016 8:20 PM
4	طريقة الحكومة في التعامل مع القطاع الخاص القطاع نكرة و محارب من قبل الحكومة هناك تخوف من السكان من القطاع الخاص يجب فتح المجال اكثر من قبل الحكومة للقطاع الخاص	4/26/2016 7:53 PM
5	الطرق في الكويت تم تصميمها ب ٥٪ من مساحة الكويت الجايه و لكن الطاقة الاستيعابية تشكل ٨٪ من مساحة الكويت الشوارع غير كافية لانها مبنية من الخمسينات	4/25/2016 6:36 PM
6	شركة البترول عرضت بناء مدينة كاملة و هي قطاع حكومي يجب تجربة ذلك	4/25/2016 6:07 PM
7	مجلس الامه يعتبر قطاع سياسي و ليس قطاع حكومي و لا خاص	4/24/2016 3:52 AM
8	تحديد المشاريع التنموية الرينسية و منها يتم وضع الخطط التنفيذية لبقية الوزارات في الدلة كل فيما يخصه	4/12/2016 8:03 PM

Appendix C1: Participant Information Sheet for citizens and non-citizens – Electronic

PARTICIPANT INFORMATION SHEET

PROJECT TITLE: Modelling of urban development and future urban growth impacts on congestion and housing shortages in Kuwait

PRINCIPAL INVESTIGATOR: *Nayef Alghais*

School of Geography, Planning and Environmental Management.

+61 336-58340

n.alghais@uq.edu.au

PURPOSE OF THE RESEARCH

This is an invitation to participate in a study conducted by researcher at the University of Queensland. The purpose of the research is to investigate the unique urbanisation traits in modern Kuwait. These traits include an economy almost completely driven by oil exports, non-existent public participation in urban planning and the majority of the population comprising of foreign non-citizen labourers. The study aims to ascertain the impact of urban growth future and analyse its future impacts on housing shortage and traffic congestion.

POSSIBLE RISKS, INCONVENIENCES AND DISCOMFORTS

This questionnaire takes approximately 20 minutes. It will be an online survey and we can foresee no risks for you. Your involvement in the study is voluntary and you may withdraw your participation from the study at any time. Any such withdrawal will result to any data that you have provided to that point being erased. Refusal to participate in the study or withdrawal will not impose any direct or indirect penalty to you. Confidentiality is assured, and you will not be identified in any part of the research.

ETHICS REVIEW AND COMPLAINTS

This study adheres to the guidelines of the ethical review process of The University of Queensland. Whilst you are free to discuss your participation in this study with project staff

(*Nayef Alghais (+61* 336-58340 n.alghais@uq.edu.au*)* and/or *Dr David Pullar* (+61 336-56522 d.pullar@uq.edu.au)), if you would like to speak to an officer of the University not involved in the study, you may contact Dr *Paul Dargusch*, the Ethics Officer on +61 3365 1594; or p.dargusch@uq.edu.au.

DECLARATION OF CONSENT

By clicking on Next (I Agree) button I am indicating my consent to participate in the research. I understand that the data collected from my participation will be stored confidentially and will be used after analysed and summarised for a PhD thesis and for paper publications in relevant journals. I consent for it to be used in that manner. Besides, I understand that I will be provided with a summary of the project outcomes if I opt to.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Geography, Planning and Environmental Management

Participant Information Sheet for citizens and non-citizens – Electronic (Arabic version)

معلومات المشاركة

PROJECT TITLE: Modelling of urban development and future urban growth impacts on congestion and housing shortages in Kuwait

عنوان المشروع: *نمذجة التوسع الحضري و الاثار المستقبلية للنمو الحضري على الازدحام المروري و المشكلة السكنية في الكويت.*

الباحث الرئيسي: *نايف فهد الغيص*

مدرسة الجغرافيا و التخطيط و الادارة البيئية

+61 336-58340

n.alghais@uq.edu.au

الغرض من البحث

هذه عبارة عن دعوة للمشاركة في دراسة يجريها الباحث في جامعة كوينزلاند. والغرض من هذا البحث هو دراسة جوانب التحضر الفريدة من نوعها في الكويت الحديثة. وتشمل هذه الجوانب: الاقتصاد الذي يعتمد بشكل شبه كامل على صادرات النفط، والمشاركة العامة في التخطيط الحضري غير موجودة والغالبية العظمى من السكان تتكون من العمال الأجانب من غير المواطنين. وتهدف الدراسة إلى التحقق من أثر مستقبل النمو الحضري وتحليل آثارها المستقبلية على أزمة السكن والازدحام المروري.

المخاطر المحتملة والمضايقات

هذا الاستبيان سيستغرق 20 دقيقة من وقتك و سيكون عبر الإنترنت، و لا يوجد أي مخاطر عليك. و مشاركتكم في هذه الدراسة هو تطوعي تستطيع أن تنسحب من المشاركة في أي وقت. و انسحابك سيؤدي إلى مسح البيانات التي قدمتها بعد تلك اللحظة. رفضك للمشاركة في الدراسة أو انسحابك لا يفرض عليك أي عقوبة مباشرة أو غير مباشرة. ونؤكد على الحفاظ على سرية بياناتك الشخصية ،حيث أنه لن يتم عرضها في أي جزء من البحث.

استعراض الأخلاق والشكاوي

تلتزم هذه الدراسة بالمبادئ التوجيهية لعملية المراجعة الأخلاقية من جامعة كوينزلاند. حيث أنك حر في مناقشة مشاركتك في هذه الدراسة مع فريق البحث (*نايف الغيص* (336-58340 61+، n.alghais@uq.edu.au) و *الدكتور ديفيد بولر*- ***David Pullar*** (336-56522 61+، d.pullar@uq.edu.au))، و إذا كنت ترغب في التحدث إلى مسؤول الاخلاقيات في الجامعة و الذي لم يشارك في الدراسة، يمكنك الاتصال الدكتور *بول دارغوش*-***Paul Dargusch*** ، على 1594 3365 61+. أو p.dargusch@uq.edu.au.

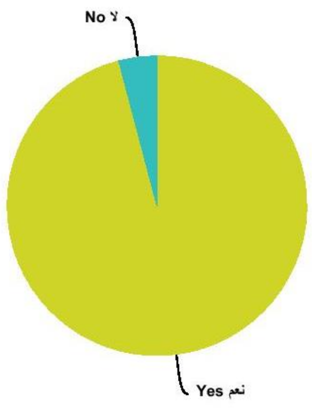
إعلان الموافقة

من خلال النقر على الزر التالي (أنا أوافق) فإنني أصرح على موافقتي على المشاركة في البحث. وأنا على علم أن البيانات التي تم سيتم جمعها من مشاركتي سيتم حفظها بسرية، وسيتم استخدامها بعد تحليلها وتلخيصها في اطروحة الدكتوراه و في مقالات في المجلات العلمية ذات الصلة. و أوافق على أن يتم استخدامها في ذلك. و كذلك أنا على علم أنني سوف أحصل على ملخص لنتائج المشروع في حال طلبت ذلك.

Appendix C2: Completed survey by residents (Kuwaitis and non-Kuwaitis)

Q1 Do you live in Kuwait? هل تعيش في دولة الكويت؟

Answered: 1,340 Skipped: 0

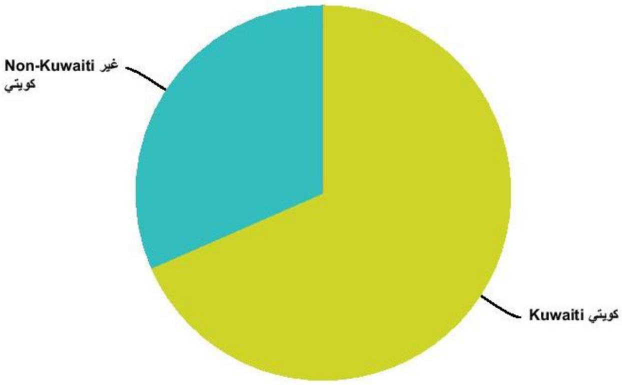


Answer Choices	Responses	
Yes نعم	95.90%	1,285
No لا	4.10%	55
Total		1,340

1 / 76

Q2 Please select your nationality. ما هي جنسيتك؟

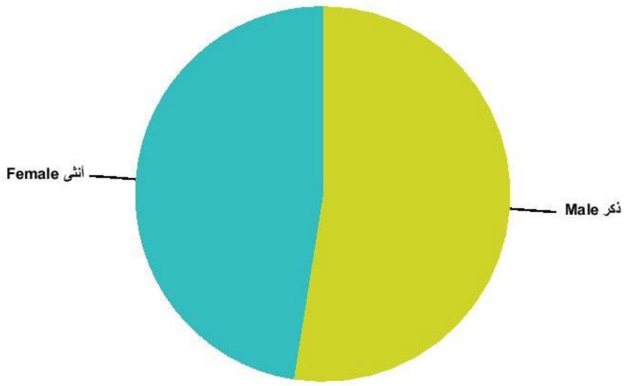
Answered: 1,286   Skipped: 54



Answer Choices	Responses	
Kuwaiti كويتي	68.43%	880
Non-Kuwaiti غير كويتي	31.57%	406
Other (please specify)(أخرى (الرجاء ذكرها)	0.00%	0
Total		1,286

Q4 Gender الجنس

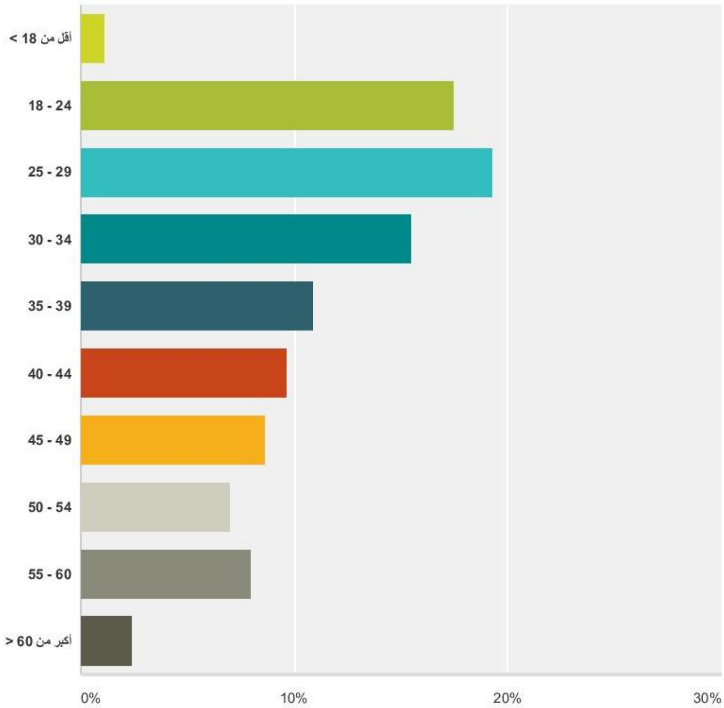
Answered: 880 Skipped: 460



Answer Choices	Responses	
Male ذكر	**52.50%**	462
Female أنثى	**47.50%**	418
Total		**880**

Q5 Age العمر

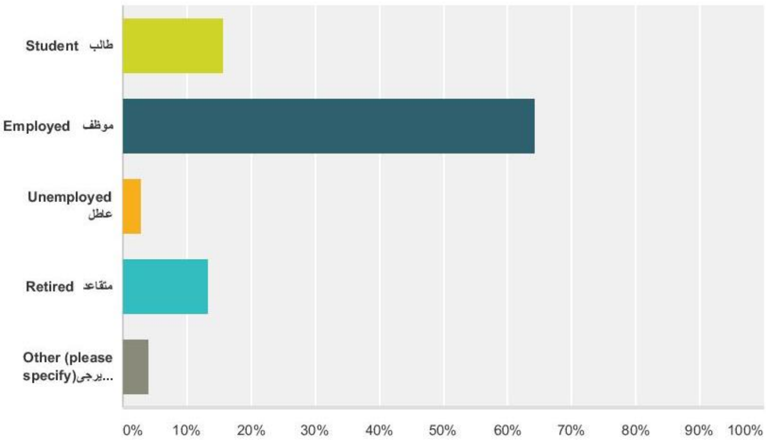
Answered: 880   Skipped: 460



Answer Choices	Responses	
< 18 أقل من	**1.14%**	10
18 - 24	**17.50%**	154
25 - 29	**19.32%**	170
30 - 34	**15.45%**	136
35 - 39	**10.91%**	96
40 - 44	**9.66%**	85
45 - 49	**8.64%**	76
50 - 54	**7.05%**	62
55 - 60	**7.95%**	70
> 60 أكبر من	**2.39%**	21
Total		**880**

Q6 Employment status الحالة الوظيفية

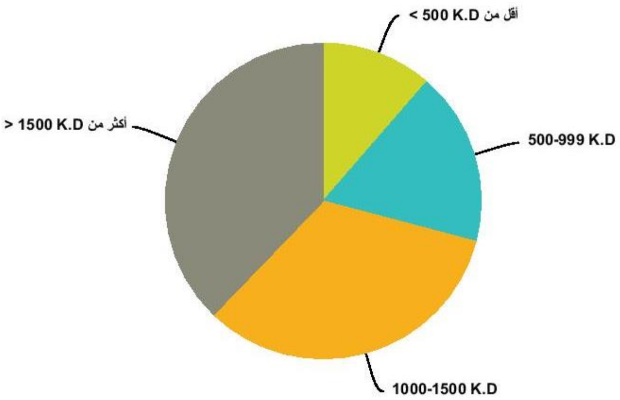
Answered: 880 Skipped: 460



Answer Choices	Responses	
Student طالب	15.57%	137
Employed موظف	64.32%	566
Unemployed عاطل	2.84%	25
Retired متقاعد	13.30%	117
Other (please specify)يرجى الكتابة	3.98%	35
Total		880

Q7 Total monthly income (if applicable) الراتب الشهري (إن وجد)

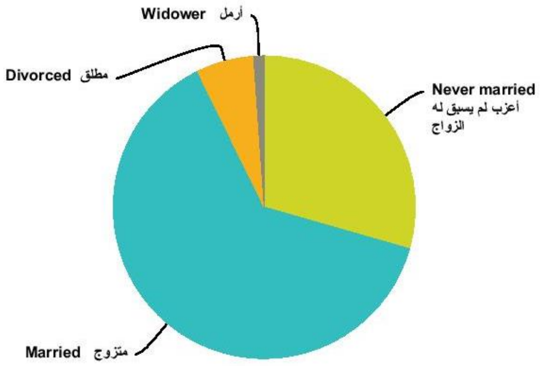
Answered: 783 Skipped: 557



Answer Choices	Responses	
< 500 K.D أقل من	11.37%	89
500-999 K.D	17.75%	139
1000-1500 K.D	33.08%	259
> 1500 K.D أكثر من	37.80%	296
Total		783

Q8 Marital statusالحالة الاجتماعية

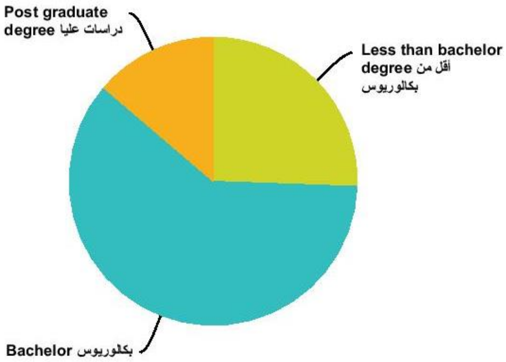
Answered: 880 Skipped: 460



Answer Choices	Responses	
Never married أعزب لم يسبق له الزواج	29.43%	259
Married متزوج	63.30%	557
Divorced مطلق	6.14%	54
Widower أرمل	1.14%	10
Total		880

Q9 Educational backgroundالمؤهل العلمي

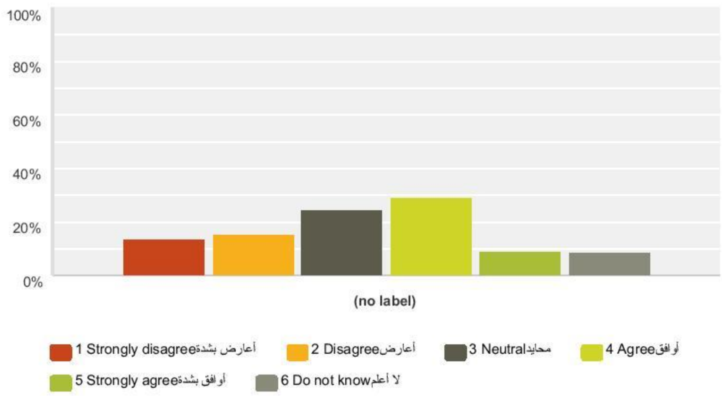
Answered: 880 Skipped: 460



Answer Choices	Responses	
Less than bachelor degree أقل من بكالوريوس	25.57%	225
Bachelor بكالوريوس	60.68%	534
Post graduate degree دراسات عليا	13.75%	121
Total		880

Q10 Kuwait government is planning to develop new cities outside the existing urban area. You considered moving to these new cities in the next 5-10 years. حكومة الكويت تخطط لانشاء مدن جديدة خارج حدود المنطقة الحضرية الحالية. أنت تفكر بالانتقال لهذه المدن خلال الـ5-10 سنوات القادمة.

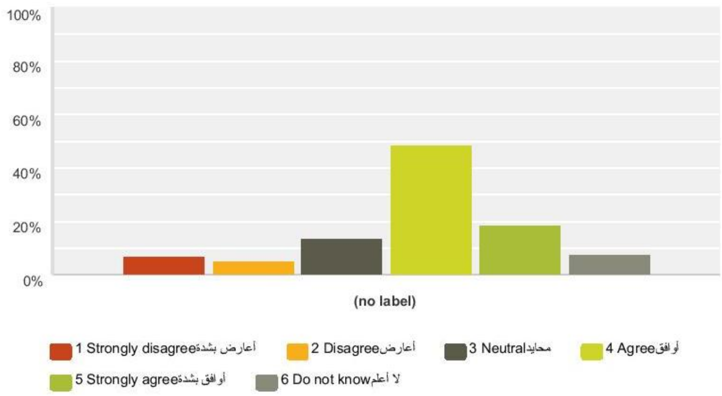
Answered: 859 Skipped: 481



	1 Strongly disagree أعارض بشدة	2 Disagree أعارض	3 Neutral محايد	4 Agree أوافق	5 Strongly agree أوافق بشدة	6 Do not know لا أعلم	Total	Weighted Average
(no label)	**13.50%** 116	**15.37%** 132	**24.68%** 212	**28.99%** 249	**9.08%** 78	**8.38%** 72	859	2.80

Q11 I will move because of economic reasons i.e. less cost or employment opportunities. سوف أنتقل لأسباب اقتصادية مثل: انخفاض أسعار العقارات أو لوجود فرص وظيفية جديدة في المدن الجديدة.

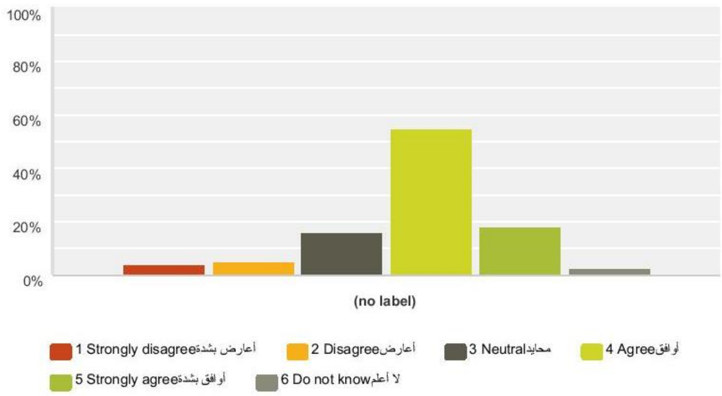
Answered: 316 Skipped: 1,024



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	6.96% 22	5.06% 16	13.61% 43	48.42% 153	18.67% 59	7.28% 23	316	3.45

Q12 I will move because of social or other reasons i.e. to be near to relatives or friends, change of family size or to obtain free dwelling that provided from the government. **سوف أنتقل لأسباب اجتماعية أو لأسباب أخرى مثل: كي أكون قريب من الأهل و الأصدقاء الذين سوف ينتقلون هناك أو بسبب تغير حجم أسرتي أو من أجل الحصول على أرض/بيت من الحكومة هناك .**

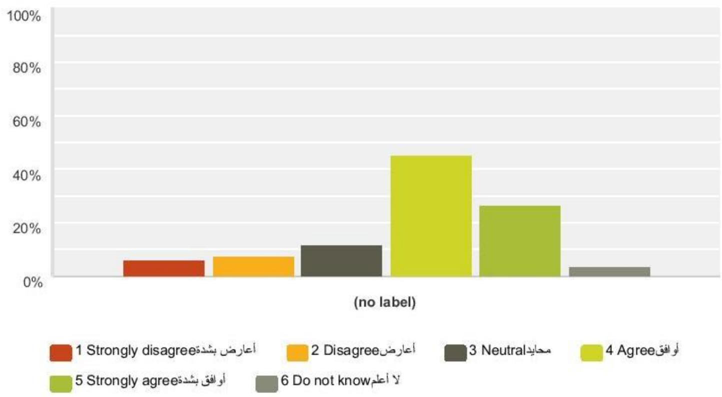
Answered: 316 Skipped: 1,024



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	3.80% 12	5.06% 16	15.82% 50	54.75% 173	18.04% 57	2.53% 8	316	3.71

Q13 I will stay because of economic reasons i.e. living near to work or living cost is reasonable. لن أنتقل لأسباب اقتصادية مثل: أسعار العقارات حيث أسكن مناسبة لي أو كي أكون قريب من مكان عملي.

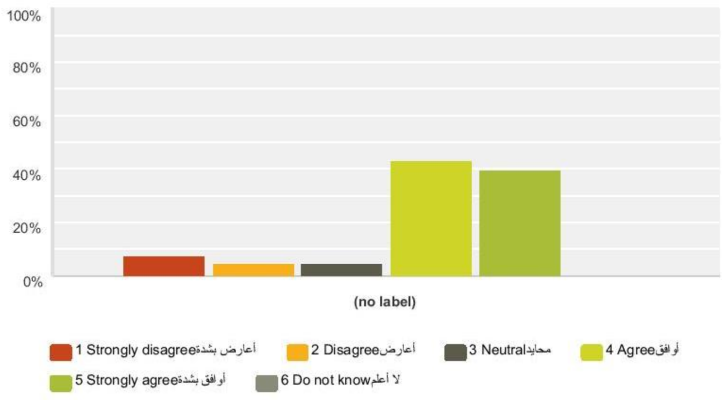
Answered: 237 Skipped: 1,103



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**5.91%** 14	**7.59%** 18	**11.39%** 27	**45.15%** 107	**26.58%** 63	**3.38%** 8	237	3.69

Q14 I will stay because of social or other reasons i.e. to be near to relatives or friends or own a house/ apartment. لن أنتقل لأسباب اجتماعية أو لأسباب أخرى مثل: كي أكون قريب من الأهل و الأصدقاء أو لأنني أملك منزل أو شقة و لا أحتاج للانتقال.

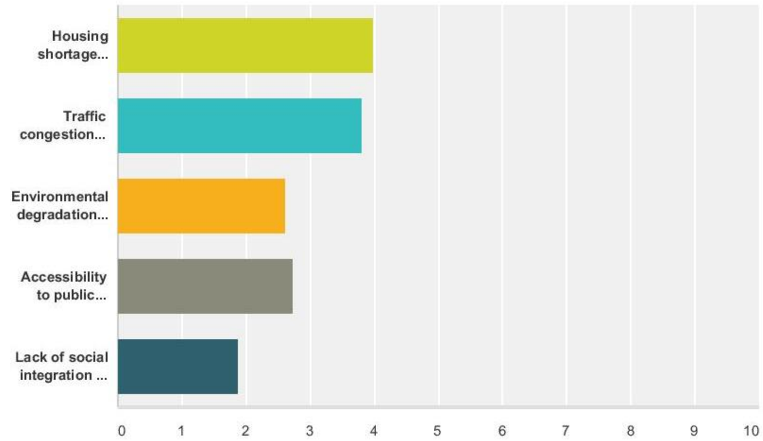
Answered: 237 Skipped: 1,103



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	7.59% 18	4.64% 11	4.64% 11	43.04% 102	39.66% 94	0.42% 1	237	4.01

Q15 Please order the following urban issues (From 1= Most important to 5= Less important) based on your feeling as the most important problems that concern you as a resident in Kuwait يرجى ترتيب المشاكل التالية (من 1= الأكثر أهمية إلى5= الأقل أهمية) استناداً إلى فهمك على أنها أهم القضايا التي تشكل مصدر قلق لك كمواطن في دولة الكويت

Answered: 717 Skipped: 623



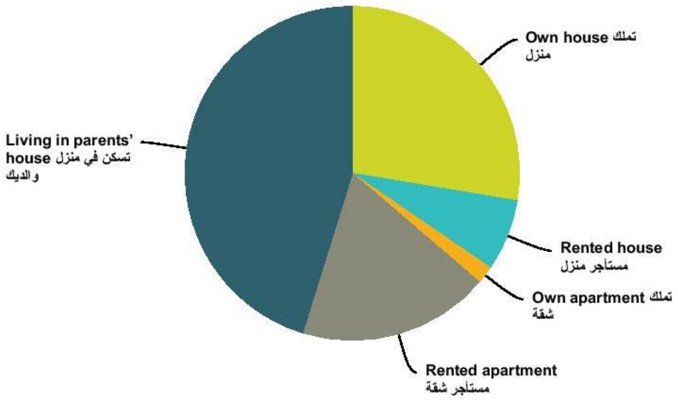
	1	2	3	4	5	Total	Score
Housing shortage المشكلة السكنية	**45.61%** 327	**26.50%** 190	**13.67%** 98	**9.34%** 67	**4.88%** 35	717	3.99
Traffic congestion الازدحام المروري	**31.52%** 226	**35.70%** 256	**18.55%** 133	**9.90%** 71	**4.32%** 31	717	3.80
Environmental degradation التدهور البيئي	**9.62%** 69	**16.32%** 117	**21.20%** 152	**30.26%** 217	**22.59%** 162	717	2.60
Accessibility to public services الوصول للخدمات العامة	**7.39%** 53	**15.62%** 112	**34.73%** 249	**27.34%** 196	**14.92%** 107	717	2.73
Lack of social integration عدم الاندماج الاجتماعي بين المواطنين و الوافدين	**5.86%** 42	**5.86%** 42	**11.85%** 85	**23.15%** 166	**53.28%** 382	717	1.88

Q16 If you think there is another urban problem that is more important that the aforementioned issues, Please specify.إذا كنت تعتقد أن هناك مشكلة حضرية أهم من المشاكل التي وضحت بالأعلى، أرجو كتابتها.

Answered: 189 Skipped: 1,151

Q17 Residential statuesحالة السكن

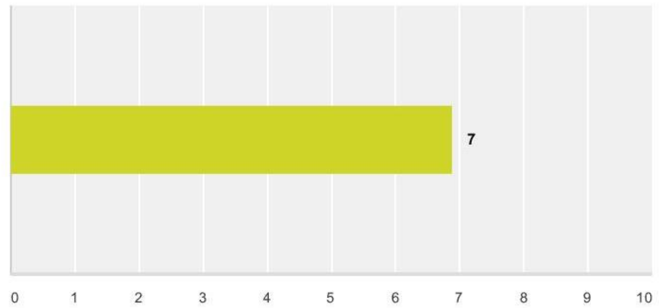
Answered: 706   Skipped: 634



Answer Choices	Responses	
Own house تملك منزل	27.62%	195
Rented house مستأجر منزل	6.94%	49
Own apartment تملك شقة	1.70%	12
Rented apartment مستأجر شقة	18.56%	131
Living in parents' house تسكن في منزل والديك	45.18%	319
Total		706

Q18 Household size: Family membersحجم الأسرة: عدد أفراد الأسرة

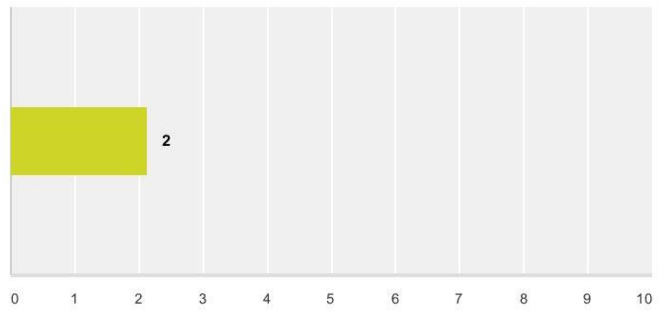
Answered: 706 Skipped: 634



Answer Choices	Average Number	Total Number	Responses
	7	4,861	706
Total Respondents: 706			

Q19 Servants (if applicable)(عدد الخدم (إن وجد

Answered: 657 Skipped: 683



Answer Choices	Average Number	Total Number	Responses
	2	1,405	657
Total Respondents: 657			

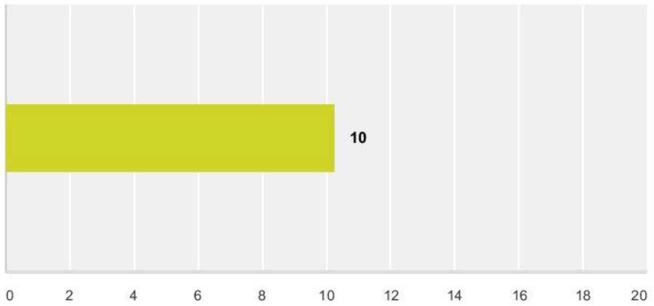
Q20 Application statutes in PAHWوضع الطلب الاسكاني في المؤسسة العامة للرعاية السكنية

Answered: 706   Skipped: 634

Answer Choices	Responses	
Obtained تم الحصول على منزل أو أرض	37.68%	266
Waiting قائمة الانتظار	33.99%	240
Never used لم يتم التقديم بعد	28.33%	200
Total		706

Q21 Waiting years (if applicable)سنوات الانتظار(في حال ذلك))

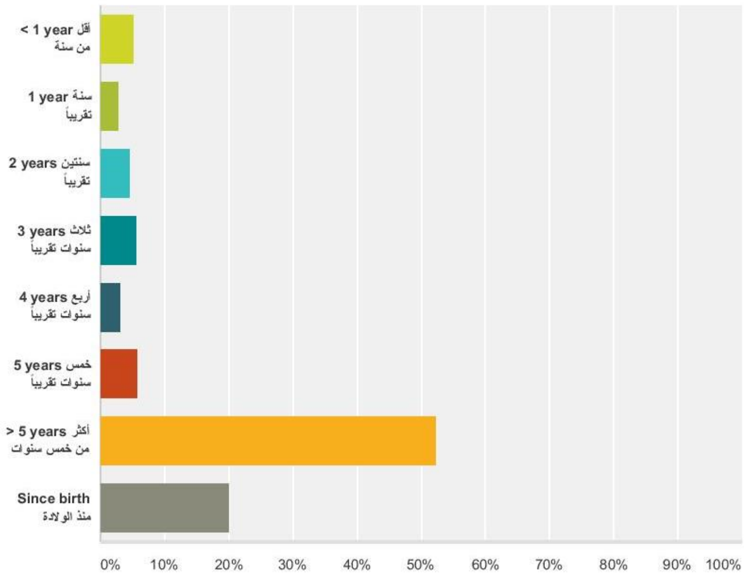
Answered: 499 Skipped: 841



Answer Choices	Average Number	Total Number	Responses
	10	5,130	499
Total Respondents: 499			

Q22 How long have you been live in your current dwelling?منذ متى و انت تسكن في سكنك الحالي؟

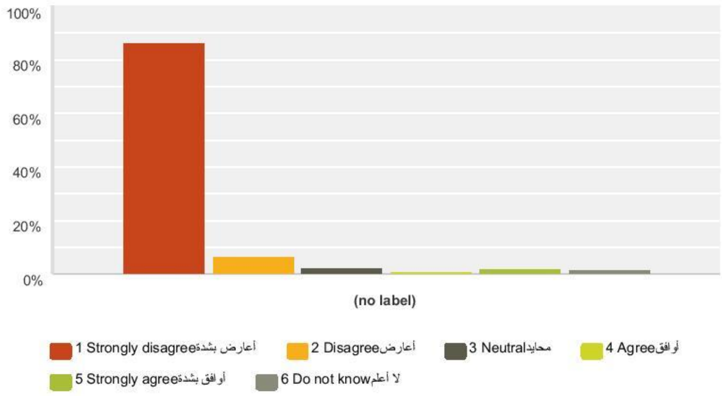
Answered: 706 Skipped: 634



Answer Choices	Responses	
< 1 year أقل من سنة	5.24%	37
1 year سنة تقريباً	2.97%	21
2 years سنتين تقريباً	4.53%	32
3 years ثلاث سنوات تقريباً	5.67%	40
4 years أربع سنوات تقريباً	3.12%	22
5 years خمس سنوات تقريباً	5.95%	42
> 5 years أكثر من خمس سنوات	52.41%	370
Since birth منذ الولادة	20.11%	142
Total		706

Q23 House prices are reasonable, so you can buy new house without using PAHW options. أسعار المساكن معقولة، فأنت يمكنك شراء منزل جديد بدون استخدام خيارات الرعاية السكنية المقدمة من الحكومة.

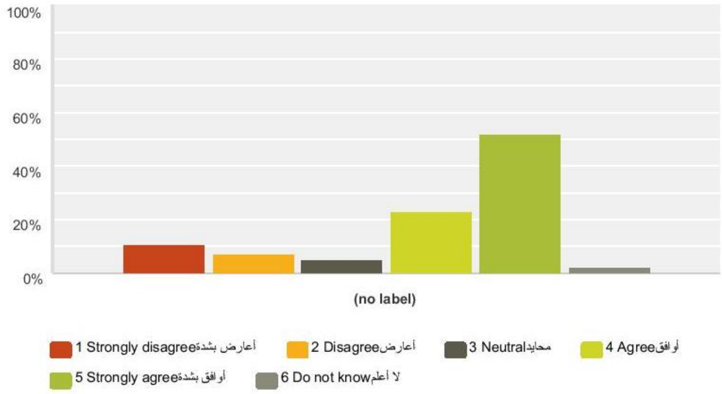
Answered: 691 Skipped: 649



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	86.54% 598	6.51% 45	2.32% 16	1.01% 7	2.17% 15	1.45% 10	691	1.21

Q24 There is a housing shortage problem.
هناك مشكلة نقص في المساكن في الكويت.

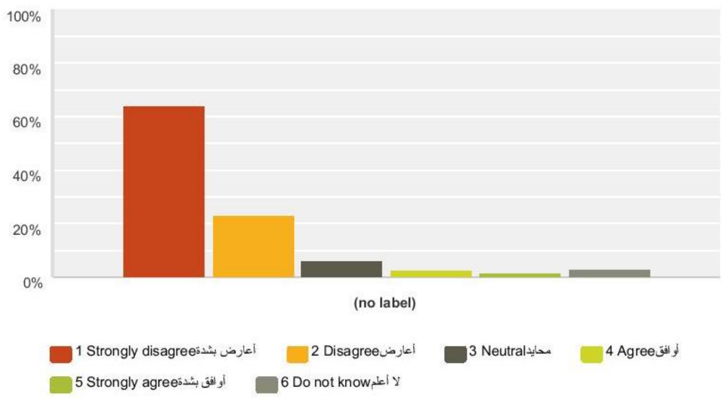
Answered: 691 Skipped: 649



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**10.42%** 72	**7.24%** 50	**5.07%** 35	**23.15%** 160	**52.24%** 361	**1.88%** 13	691	3.94

Q25 The waiting time for PAHW application is reasonable (if applicable). وقت الانتظار للرعاية السكنية المقدمة من الحكومة يعتبر معقول (في حال تم التقديم).

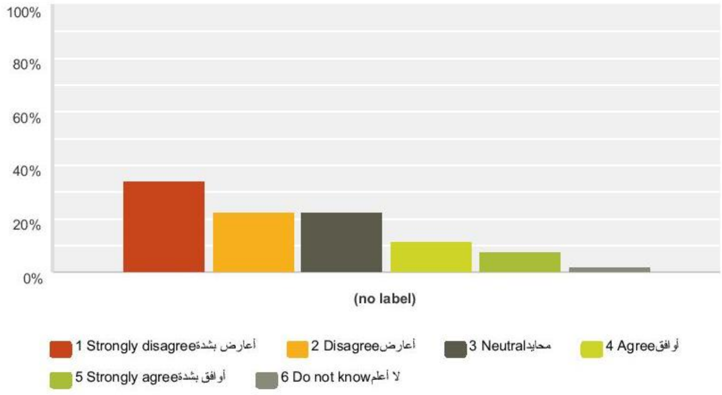
Answered: 691 Skipped: 649



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	63.97% 442	22.87% 158	5.93% 41	2.75% 19	1.45% 10	3.04% 21	691	1.46

Q26 You prefer to live in a district that is less segregated between citizens and non-citizens. أنت تفضل أن تعيش في منطقة لا يوجد فيها فصل بين المواطنين و الوافدين.

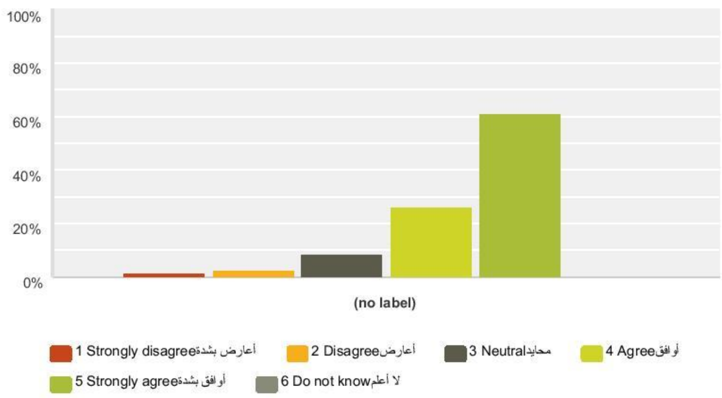
Answered: 691 Skipped: 649



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	33.86% 234	22.72% 157	22.43% 155	11.58% 80	7.53% 52	1.88% 13	691	2.31

Q27 You prefer to live in residential districts (Fiha, Surra or Audiliya) rather than mixed districts (Salmiya, Hawalli or Khaitan). أنت تفضل العيش في المناطق السكنية (الفيحاء، السرة، العديلية) بدلا (من المناطق الاستثمارية/ المختلطة (السالمية، حولي، خيطان.

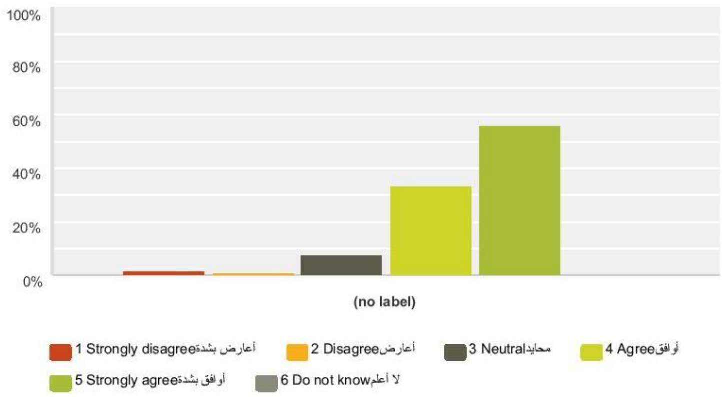
Answered: 691 Skipped: 649



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**1.59%** 11	**2.32%** 16	**8.39%** 58	**25.90%** 179	**61.07%** 422	**0.72%** 5	691	4.40

Q28 Public opinion should be considered for new development and planning decisions. رأي المجتمع يجب أن يؤخذ بعين الاعتبار عند اتخاذ قرارت التخطيط الجديدة.

Answered: 691 Skipped: 649



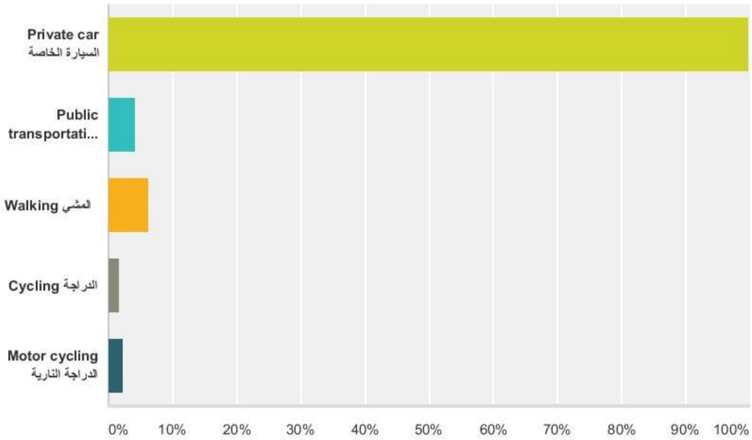
	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**1.30%** 9	**1.16%** 8	**7.67%** 53	**33.29%** 230	**56.15%** 388	**0.43%** 3	691	4.41

Q29 Other comments (Please write) تعليقات أخرى (يرجى الكتابة)

Answered: 80 Skipped: 1,260

Q30 Transportation used type (Multi-answers)نوع وسائل المواصلات المستخدمة (يمكن اختيار أكثر من اجابة)

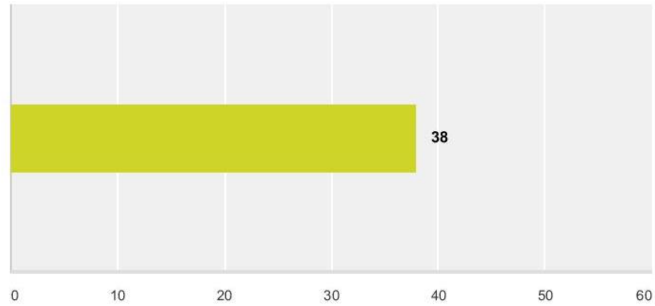
Answered: 684   Skipped: 656



Answer Choices	Responses	
Private car السيارة الخاصة	99.71%	682
Public transportation المواصلات العامة	4.09%	28
Walking المشي	6.29%	43
Cycling الدراجة	1.61%	11
Motor cycling الدراجة النارية	2.19%	15
Total Respondents: 684		

Q31 How long does it usually take from you to reach your work? (in minutes)كم من الوقت (تستغرق عادة للذهاب لعملك أو منزلك؟ (بالدقائق

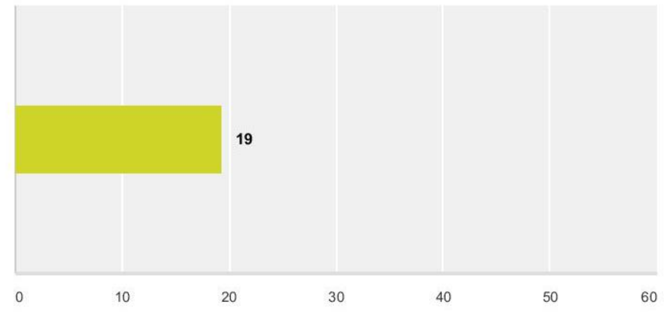
Answered: 684 Skipped: 656



Answer Choices	Average Number	Total Number	Responses
	38	25,955	684
Total Respondents: 684			

Q32 How long does it usually take from you to reach your work without traffic congestion? (in minutes)كم من الوقت تستغرق عادة(للذهاب لعملك أو منزلك في غير أوقات الازدحام؟ (بالدقائق)

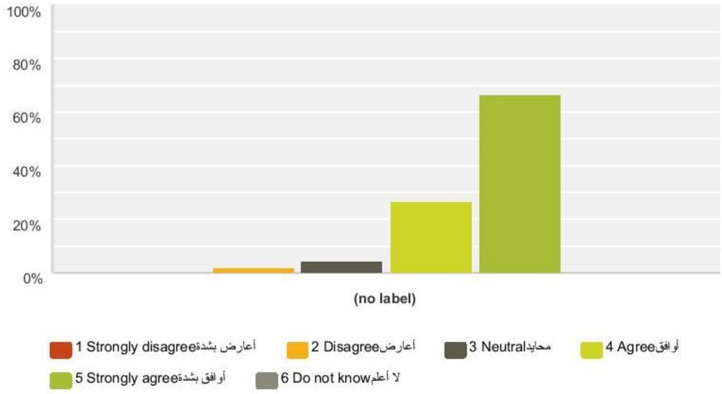
Answered: 684 Skipped: 656



Answer Choices	Average Number	Total Number	Responses
	19	13,171	684
Total Respondents: 684			

Q33 You prefer to use private car rather than public transportation. أنت تفضل استخدام سيارتك الخاصة بدلاً من وسائل النقل العام.

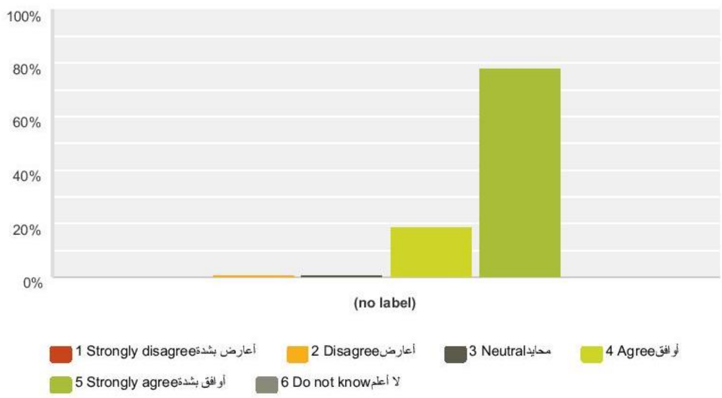
Answered: 676 Skipped: 664



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	0.44% 3	1.78% 12	4.29% 29	26.63% 180	66.72% 451	0.15% 1	676	4.57

Q34 You perceive the traffic congestion as serious problem in Kuwait. ازدحام حركة المرور تعتبر مشكلة جدية و خطيرة في الكويت.

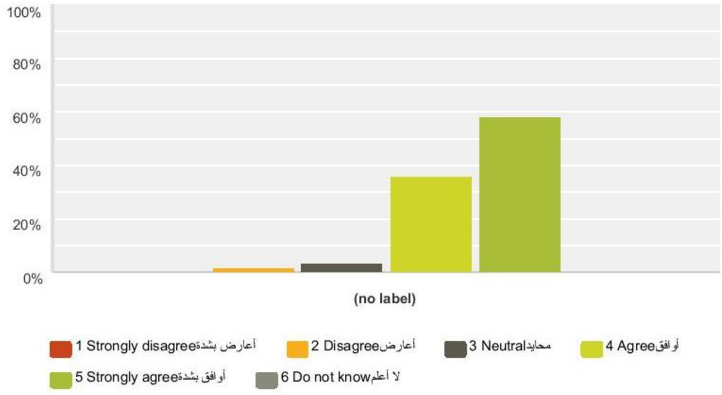
Answered: 676   Skipped: 664



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**0.74%** 5	**1.18%** 8	**1.04%** 7	**19.08%** 129	**77.96%** 527	**0.00%** 0	676	4.72

Q35 There is congestion even if it is not working hours. For example at night. هناك ازدحام مروري حتى خارج أوقات العمل. على سبيل المثال في الليل.

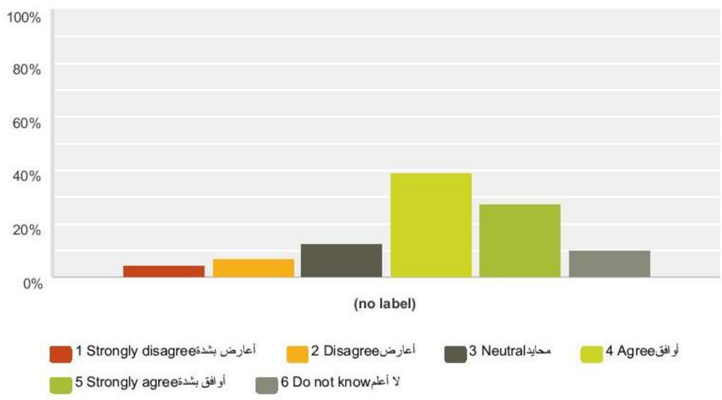
Answered: 676 Skipped: 664



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	0.15% 1	1.63% 11	3.55% 24	36.24% 245	58.14% 393	0.30% 2	676	4.50

Q36 How likely would you be to use a train system in your trips to work and home if it is available? لو كان هناك قطارات في الكويت فهل سوف تستخدمها في رحلاتك للعمل والمنزل؟

Answered: 676 Skipped: 664



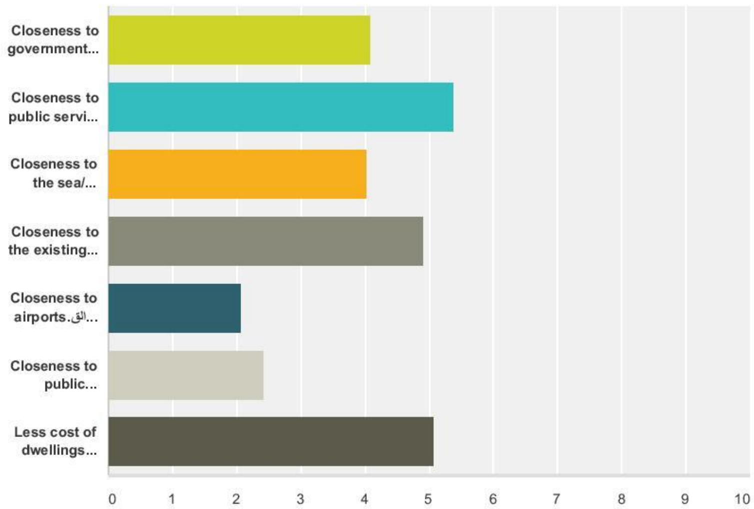
	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	4.44% 30	6.80% 46	12.43% 84	38.76% 262	27.51% 186	10.06% 68	676	3.48

Q37 Other comments (Please write) تعليقات أخرى (يرجى الكتابة)

Answered: 86 Skipped: 1,254

Q38 Please order the following criteria/ elements based on your demands and wishes (From 1= Most important to 7= Less important): الرجاء ترتيب العناصر التالية حسب طلباتك و أمنياتك في المنطقة السكنية التي ترغب السكن فيها (1= الأكثر أهمية الى 7= الأقل أهمية)

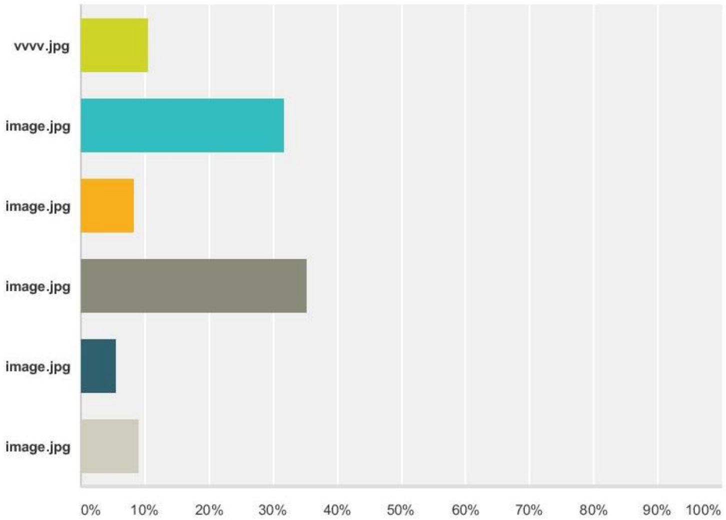
Answered: 634 Skipped: 706



	1	2	3	4	5	6	7	Total	Score
Closeness to government services such as ministries and organisations.القرب من الخدمات الحكومية (وزارات و هيئات).	**4.42%** 28	**16.25%** 103	**20.98%** 133	**21.61%** 137	**22.24%** 141	**9.46%** 60	**5.05%** 32	634	4.10
Closeness to public services such as shopping malls, hospitals, universities and others.القرب من الخدمات العامة مثل مراكز التسوق و المستشفيات و الجامعات و غيرها.	**22.24%** 141	**31.39%** 199	**23.66%** 150	**14.20%** 90	**4.89%** 31	**2.05%** 13	**1.58%** 10	634	5.39
Closeness to the sea/ beaches.القرب من البحر / الشواطئ.	**11.99%** 76	**13.41%** 85	**15.30%** 97	**16.72%** 106	**19.09%** 121	**14.51%** 92	**8.99%** 57	634	4.03
Closeness to the existing urban area.القرب من المنطقة الحضرية الحالية.	**23.66%** 150	**19.40%** 123	**17.82%** 113	**16.56%** 105	**11.04%** 70	**8.36%** 53	**3.15%** 20	634	4.90
Closeness to airports.القرب من المطارات.	**1.58%** 10	**1.10%** 7	**2.37%** 15	**6.31%** 40	**16.56%** 105	**29.81%** 189	**42.27%** 268	634	2.06
Closeness to public transportation (bus or train networks).(القرب من محطات وسائل النقل العام (باصات و قطارات	**1.74%** 11	**3.47%** 22	**5.99%** 38	**9.62%** 61	**16.88%** 107	**28.71%** 182	**33.60%** 213	634	2.43
Less cost of dwellings (purchase or rent).أسعار السكن تكون أقل (شراء أو ايجار).	**34.38%** 218	**14.98%** 95	**13.88%** 88	**14.98%** 95	**9.31%** 59	**7.10%** 45	**5.36%** 34	634	5.07

Q39 Please choose the most preferred strategy to be applied as the new development in Kuwait in this project based on your demands and wishes. يرجى اختيار أكثر. استراتيجية مفضلة لديك ليتم تطبيقها في هذا المشروع بناء على طلباتك ورغباتك الشخصية

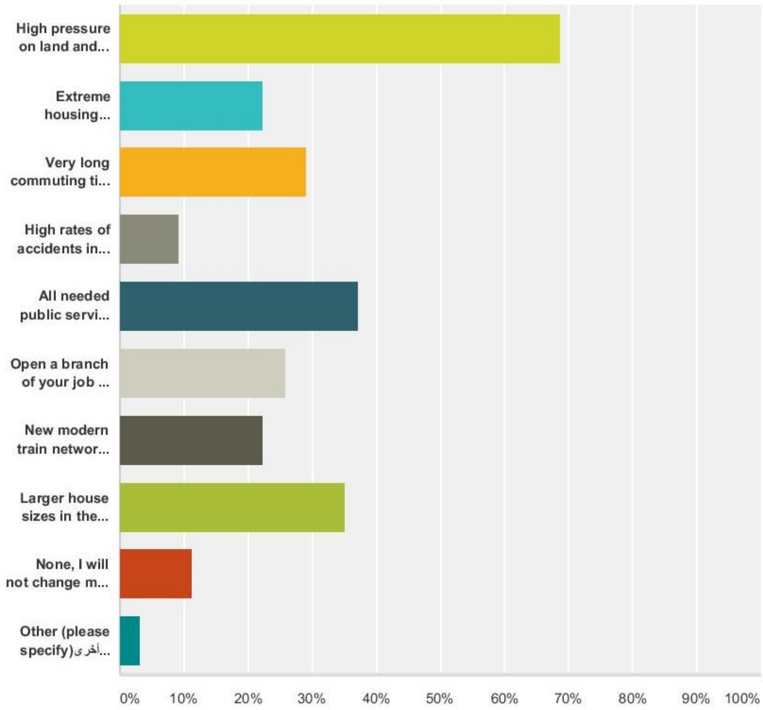
Answered: 625 Skipped: 715



Answer Choices	Responses	
	10.40%	65
	31.68%	198
	8.32%	52
	35.20%	220
	5.44%	34
	8.96%	56
Total		625

Q40 What of these factors could affect your decision of not moving from the existing urban area and make you change your answer to a new city? (Multi answers)أي من هذه العوامل من الممكن أن تؤثر على قرارك بعدم الانتقال لمدينة جديدة و يمكنها أن تجعلك تغير رأيك؟ (يمكن اختيار أكثر من اجابة)

Answered: 259 Skipped: 1,081



Answer Choices	Responses	
High pressure on land and property values in the existing urban area.الارتفاع المبالغ فيه في أسعار العقار في المنطقة الحضرية الحالية.	68.73%	178
Extreme housing shortages in the existing urban area.عدم وجود مساكن كافية في المنطقة الحضرية الحالية.	22.39%	58
Very long commuting times in the existing urban area.وقت طويل جدا للتنقل في المنطقة الحضرية الحالية.	28.96%	75
High rates of accidents in the existing urban area.ارتفاع عدد الحوادث بشكل مبالغ في المنطقة الحضرية الحالية.	9.27%	24
All needed public services provided in the new city.توفر جميع الخدمات العامة في المدينة الجديدة.	37.07%	96
Open a branch of your job in the new city.افتتاح فرع من جهة عملك في المدينة الجديدة.	25.87%	67

New modern train network established. انشاء شبكة قطارات حديثة.	**22.39%**	58
Larger house sizes in the new city. مساحة منازل أكبر في المدينة الجديدة.	**35.14%**	91
None, I will not change my mind. لا يوجد، و لن أغير رأيي.	**11.20%**	29
Other (please specify) (أخرى (الرجاء ذكرها	**3.09%**	8
Total Respondents: 259		

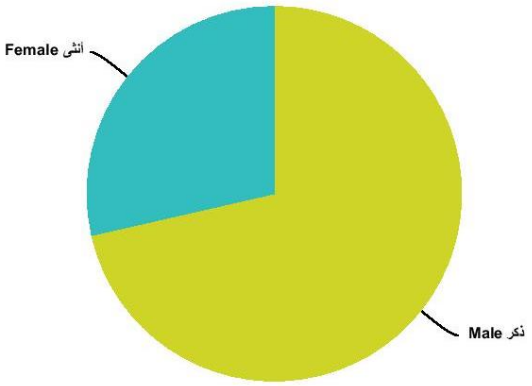
Q41 General Informationمعلومات عامة

Answered: 92   Skipped: 1,248

Answer Choices	Responses	
Contact details, such as email (Optional)(البريد الالكتروني (اختياري)	0.00%	0
Organisation/ Ministry name اسم الوزارة/ الهيئة	0.00%	0
Job title المسمى الوظيفي	0.00%	0
Work experience (Years)(سنوات العمل/ الخبرة (سنوات	0.00%	0
City/Town	0.00%	0
State/Province	0.00%	0
ZIP/Postal Code	0.00%	0
Country	0.00%	0
Email Address (Optional)(البريد الالكتروني (اختياري	100.00%	92
Phone Number (Optional)(رقم الهاتف (اختياري	0.00%	0

Q42 Genderالجنس

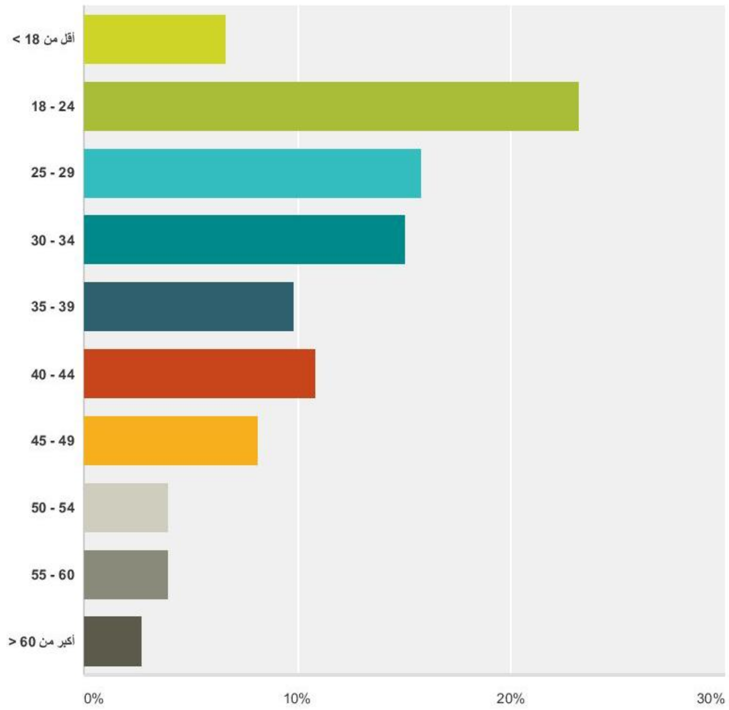
Answered: 406 Skipped: 934



Answer Choices	Responses	
Male ذكر	71.43%	290
Female أنثى	28.57%	116
Total		406

Q43 Age العمر

Answered: 406 Skipped: 934

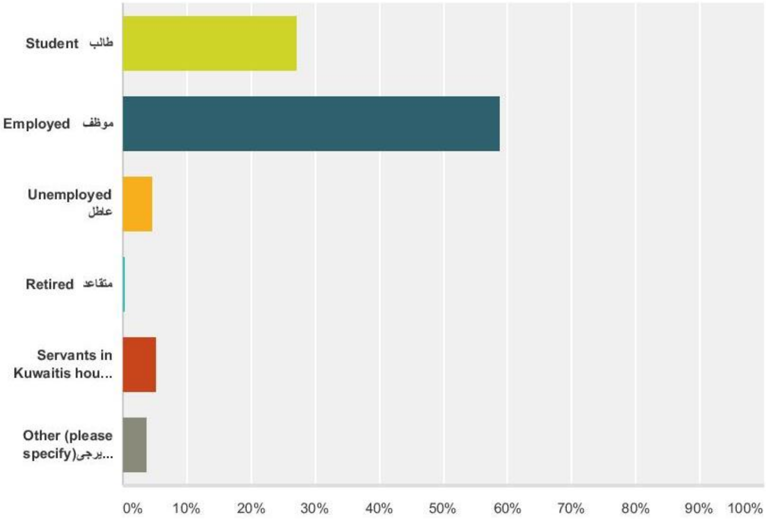


Answer Choices	Responses	
< 18 أقل من	6.65%	27
18 - 24	23.15%	94
25 - 29	15.76%	64
30 - 34	15.02%	61
35 - 39	9.85%	40
40 - 44	10.84%	44
45 - 49	8.13%	33
50 - 54	3.94%	16
55 - 60	3.94%	16
> 60 أكبر من	2.71%	11
Total		**406**

44 / 76

Q44 Employment statusالحالة الوظيفية

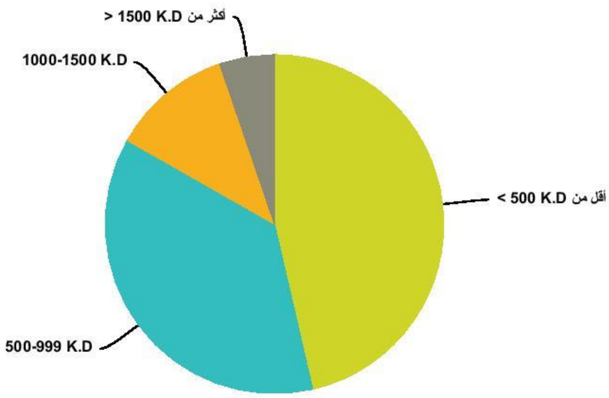
Answered: 406   Skipped: 934



Answer Choices	Responses	
Student طالب	27.09%	110
Employed موظف	58.87%	239
Unemployed عاطل	4.68%	19
Retired متقاعد	0.49%	2
Servants in Kuwaitis house خادم أو سائق في منزل كويتي	5.17%	21
Other (please specify)يرجى الكتابة	3.69%	15
Total		406

Q45 Total monthly income (if applicable)(الراتب الشهري (إن وجد

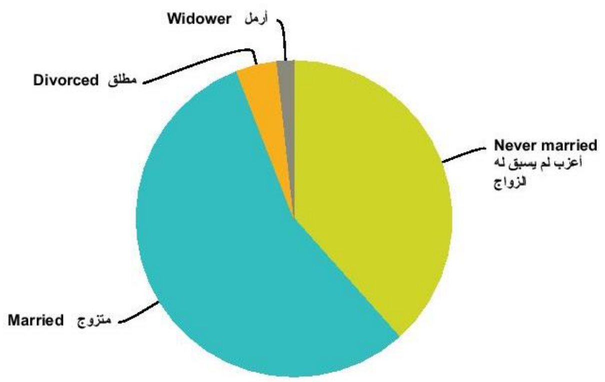
Answered: 304 Skipped: 1,036



Answer Choices	Responses	
< 500 K.D أقل من	46.38%	141
500-999 K.D	36.84%	112
1000-1500 K.D	11.51%	35
> 1500 K.D أكثر من	5.26%	16
Total		304

Q46 Marital statusالحالة الاجتماعية

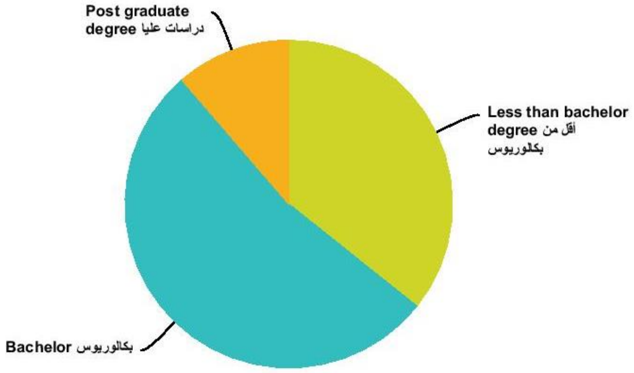
Answered: 406   Skipped: 934



Answer Choices	Responses	
Never married أعزب لم يسبق له الزواج	38.42%	156
Married متزوج	55.67%	226
Divorced مطلق	4.19%	17
Widower أرمل	1.72%	7
Total		406

Q47 Educational backgroundالمؤهل العلمي

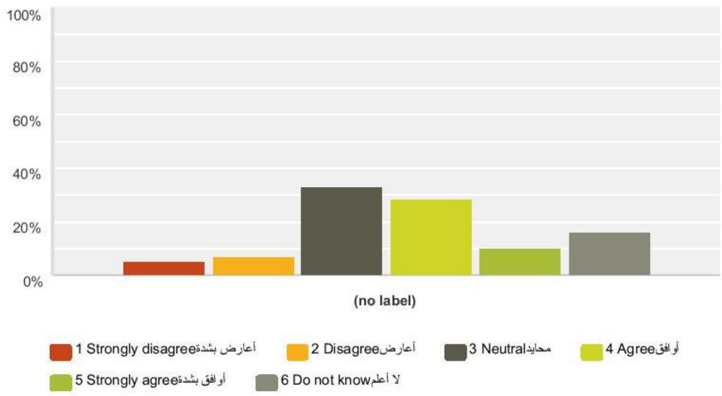
Answered: 406   Skipped: 934



Answer Choices	Responses	
Less than bachelor degree أقل من بكالوريوس	35.71%	145
Bachelor بكالوريوس	52.96%	215
Post graduate degree دراسات عليا	11.33%	46
Total		406

Q48 Kuwait government is planning to develop new cities outside the existing urban area. You considered moving to these new cities in the next 5-10 years. حكومة الكويت تخطط لانشاء مدن جديدة خارج حدود المنطقة الحضرية الحالية. أنت تفكر بالانتقال لهذه المدن خلال الـ5-10 سنوات القادمة.

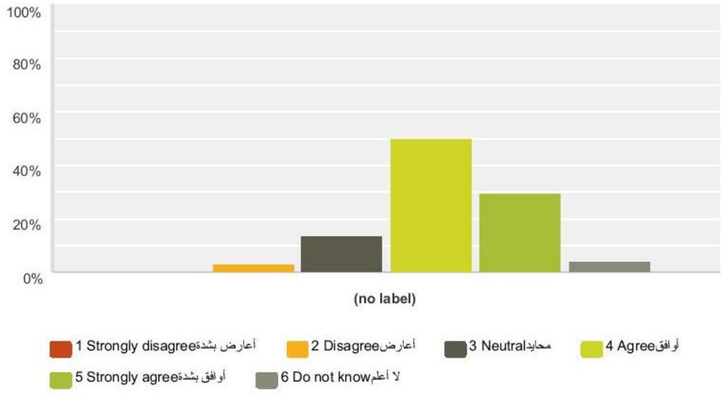
Answered: 376 Skipped: 964



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	5.05% 19	7.18% 27	33.24% 125	28.46% 107	9.84% 37	16.22% 61	376	2.82

Q49 I will move because of economic reasons i.e. less cost or employment opportunities. سوف أنتقل لأسباب اقتصادية مثل: انخفاض أسعار العقارات أو لوجود فرص وظيفية جديدة في المدن الجديدة.

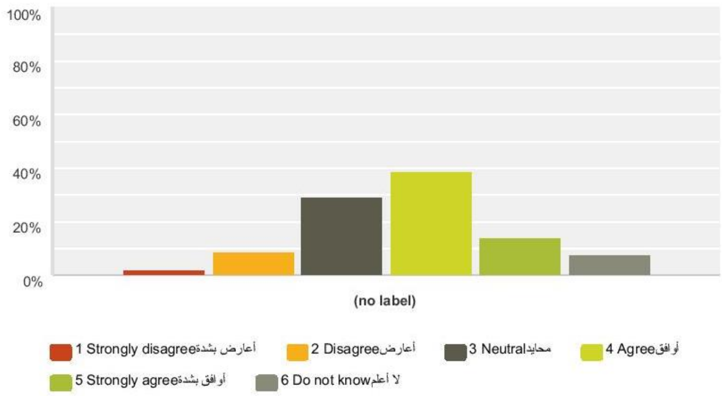
Answered: 142 Skipped: 1,198



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	0.00% 0	2.82% 4	13.38% 19	50.00% 71	29.58% 42	4.23% 6	142	3.94

Q50 I will move because of social or other reasons i.e. to be near to relatives or friends, change of family size or to obtain free dwelling that provided from the government. سوف أنتقل لأسباب اجتماعية أو لأسباب أخرى مثل: كي أكون قريب من الأهل و الأصدقاء الذين سوف ينتقلون هناك أو بسبب تغير حجم أسرتي

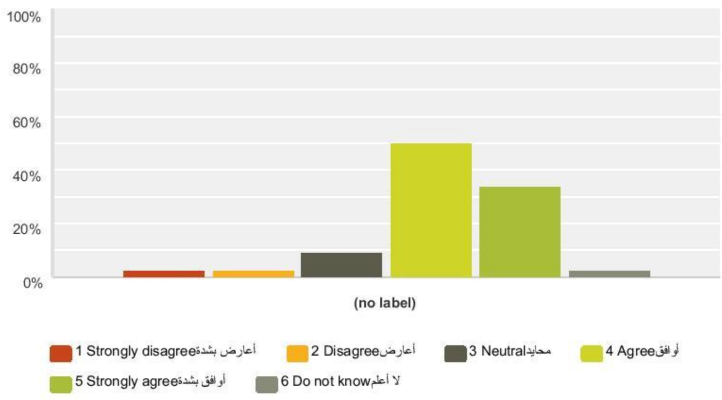
Answered: 142 Skipped: 1,198



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	2.11% 3	8.45% 12	28.87% 41	38.73% 55	14.08% 20	7.75% 11	142	3.31

Q51 I will stay because of economic reasons i.e. living near to work or living cost is reasonable. لن أنتقل لأسباب اقتصادية مثل: أسعار العقارات حيث أسكن مناسبة لي أو كي أكون قريب من مكان عملي.

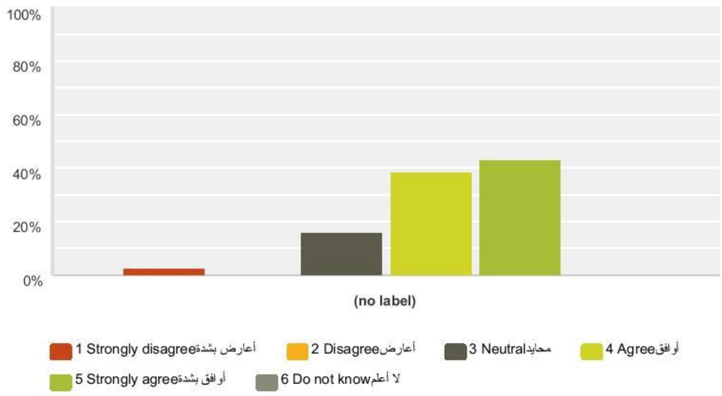
Answered: 44 Skipped: 1,296



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**2.27%** 1	**2.27%** 1	**9.09%** 4	**50.00%** 22	**34.09%** 15	**2.27%** 1	44	4.05

Q52 I will stay because of social or other reasons i.e. to be near to relatives or friends or own a house/ apartment. لن أنتقل لأسباب اجتماعية أو لأسباب أخرى مثل: كي أكون قريب من الأهل و الأصدقاء أو لأنني أملك منزل أو شقة و لا أحتاج للانتقال.

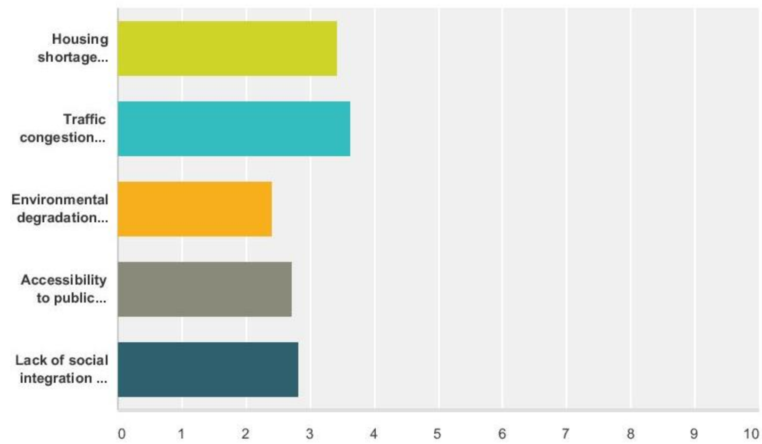
Answered: 44 Skipped: 1,296



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	2.27% 1	0.00% 0	15.91% 7	38.64% 17	43.18% 19	0.00% 0	44	4.20

Q53 Please order the following urban issues (From 1= Most important to 5= Less important) based on your feeling as the most important problems that concern you as a resident in Kuwait يرجى ترتيب المشاكل الحضرية التالية (من 1= الأكثر أهمية إلى 5= الأقل أهمية) استناداً إلى فهمك على أنها أهم القضايا التي تشكل مصدر قلق لك كمقيم في دولة الكويت

Answered: 328 Skipped: 1,012



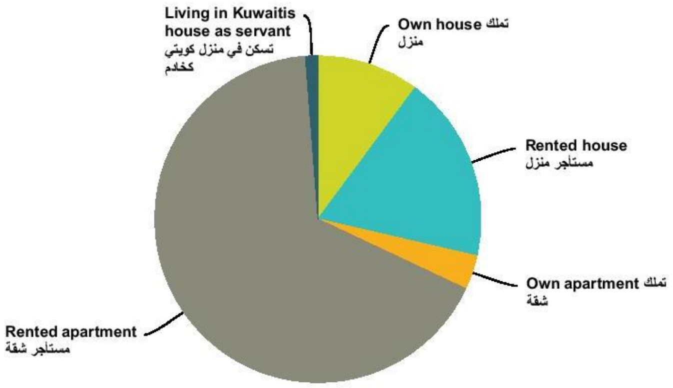
	1	2	3	4	5	Total	Score
Housing shortage المشكلة السكنية	**25.30%** 83	**29.57%** 97	**17.68%** 58	**16.77%** 55	**10.67%** 35	328	3.42
Traffic congestion الازدحام المروري	**33.84%** 111	**28.96%** 95	**16.16%** 53	**9.45%** 31	**11.59%** 38	328	3.64
Environmental degradation التدهور البيئي	**11.28%** 37	**12.80%** 42	**14.94%** 49	**27.74%** 91	**33.23%** 109	328	2.41
Accessibility to public services الوصول للخدمات العامة	**9.15%** 30	**16.77%** 55	**30.79%** 101	**22.56%** 74	**20.73%** 68	328	2.71
Lack of social integration عدم الاندماج الاجتماعي بين المواطنين و الوافدين	**20.43%** 67	**11.89%** 39	**20.43%** 67	**23.48%** 77	**23.78%** 78	328	2.82

Q54 If you think there is another urban problem that is more important that the aforementioned issues, Please specify.إذا كنت تعتقد أن هناك مشكلة حضرية أهم من المشاكل التي وضحت بالأعلى، أرجو كتابتها.

Answered: 51   Skipped: 1,289

Q55 Residential statuesحالة السكن

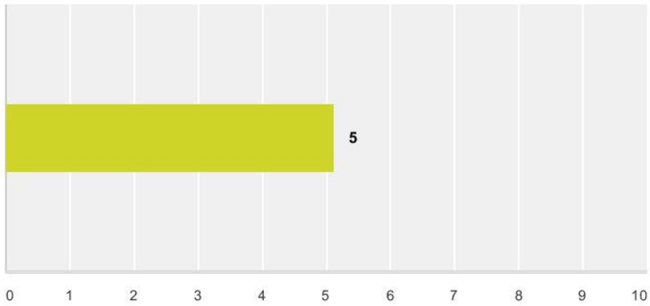
Answered: 325 Skipped: 1,015



Answer Choices	Responses	
Own house تملك منزل	10.15%	33
Rented house مستأجر منزل	18.46%	60
Own apartment تملك شقة	3.38%	11
Rented apartment مستأجر شقة	66.77%	217
Living in Kuwaitis house as servant تسكن في منزل كويتي كخادم	1.23%	4
Total		325

Q56 Household size: Family members or rommates حجم الأسرة: عدد أفراد الأسرة أو شركاء السكن

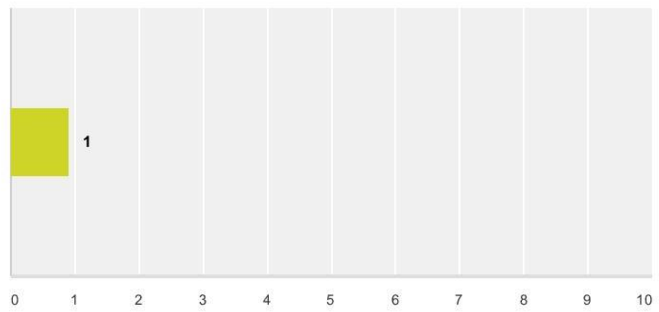
Answered: 325   Skipped: 1,015



Answer Choices	Average Number	Total Number	Responses
	5	1,663	325
Total Respondents: 325			

Q57 Servants (if applicable)(عدد الخدم (إن وجد

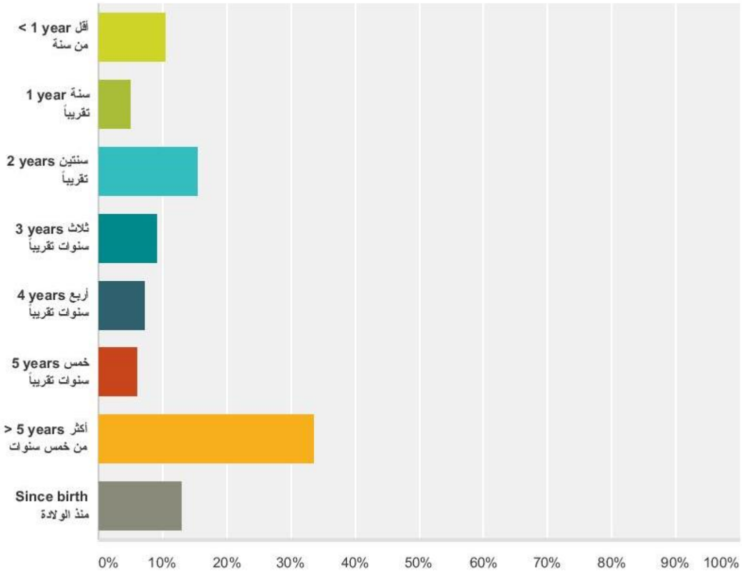
Answered: 201   Skipped: 1,139



Answer Choices	Average Number	Total Number	Responses
	1	180	201
Total Respondents: 201			

Q58 How long have you been live in your current dwelling?منذ متى و انت تسكن في سكنك الحالي؟

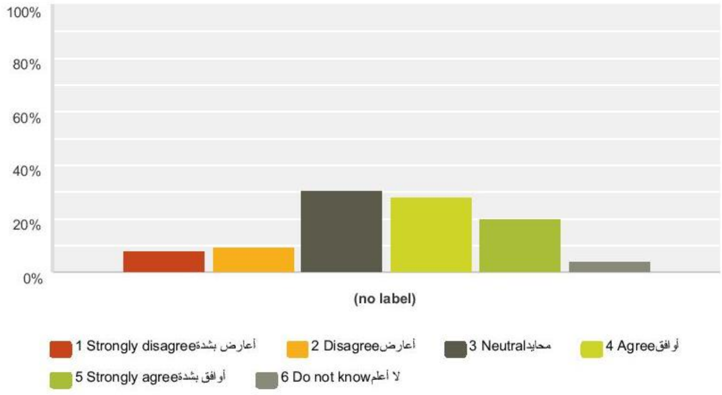
Answered: 325   Skipped: 1,015



Answer Choices	Responses	
< 1 year أقل من سنة	10.46%	34
1 year سنة تقريباً	4.92%	16
2 years سنتين تقريباً	15.38%	50
3 years ثلاث سنوات تقريباً	9.23%	30
4 years أربع سنوات تقريباً	7.38%	24
5 years خمس سنوات تقريباً	6.15%	20
> 5 years أكثر من خمس سنوات	33.54%	109
Since birth منذ الولادة	12.92%	42
Total		325

Q59 You prefer to live in a district that is less segregated between citizens and non-citizens. أنت تفضل أن تعيش في منطقة لا يوجد فيها فصل بين المواطنين و الوافدين.

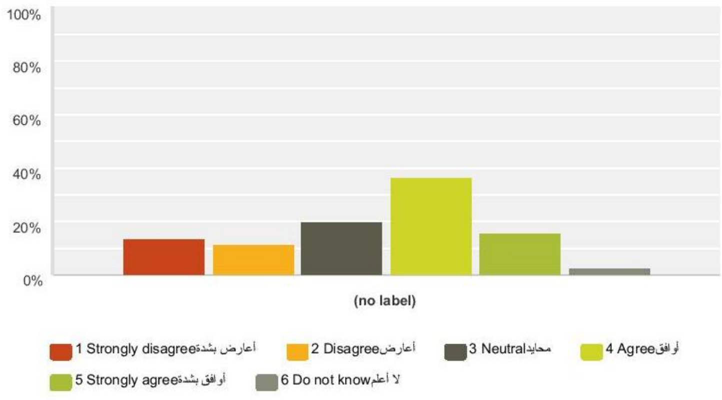
Answered: 319 Skipped: 1,021



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	7.84% 25	9.72% 31	30.72% 98	27.90% 89	20.06% 64	3.76% 12	319	3.31

Q60 You prefer to live in mixed districts (Salmiya, Hawalli or Khaitan) rather than residential districts (Fiha, Surra or Audiliya). /أنت تفضل العيش في المناطق الاستثمارية المختلطة (السالمية، حولي، خيطان) بدلا من المناطق السكنية (الفيحاء، السرة، العديلية)).

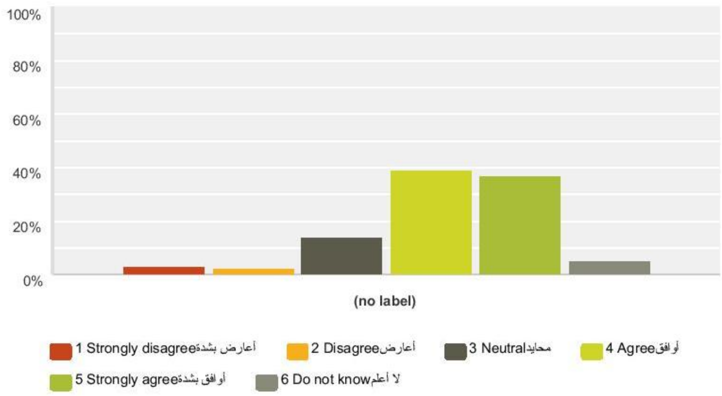
Answered: 319 Skipped: 1,021



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	13.48% 43	11.60% 37	20.06% 64	36.68% 117	15.67% 50	2.51% 8	319	3.22

Q61 Public opinion should be considered for new development and planning decisions. رأي المجتمع يجب أن يؤخذ بعين الاعتبار عند اتخاذ قرارت التخطيط الجديدة.

Answered: 319 Skipped: 1,021



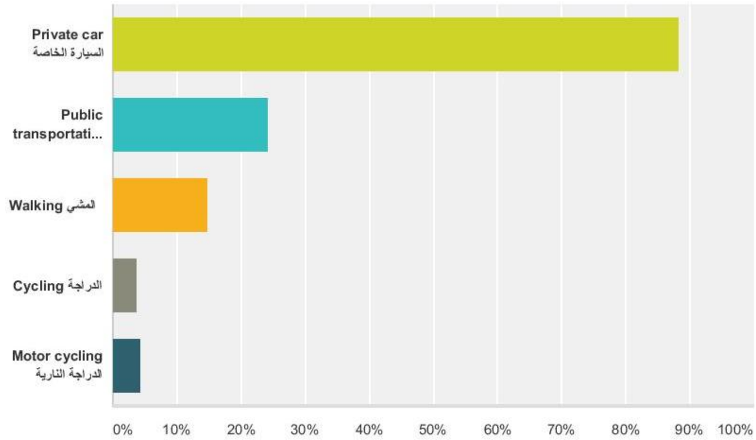
	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**2.82%** 9	**2.51%** 8	**13.79%** 44	**38.87%** 124	**36.99%** 118	**5.02%** 16	319	3.90

Q62 Other comments (Please write) تعليقات أخرى (يرجى الكتابة)

Answered: 25 Skipped: 1,315

Q63 Transportation used type (Multi-answers)نوع وسائل المواصلات المستخدمة (يمكن اختيار أكثر من اجابة)

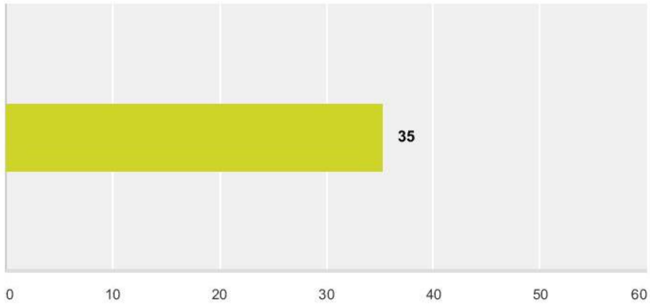
Answered: 318 Skipped: 1,022



Answer Choices	Responses	
Private car السيارة الخاصة	88.36%	281
Public transportation المواصلات العامة	24.21%	77
Walking المشي	14.78%	47
Cycling الدراجة	3.77%	12
Motor cycling الدراجة النارية	4.40%	14
Total Respondents: 318		

Q64 How long does it usually take from you to reach your work? (in minutes)كم من الوقت تستغرق عادة للذهاب لعملك أو منزلك؟ (بالدقائق)

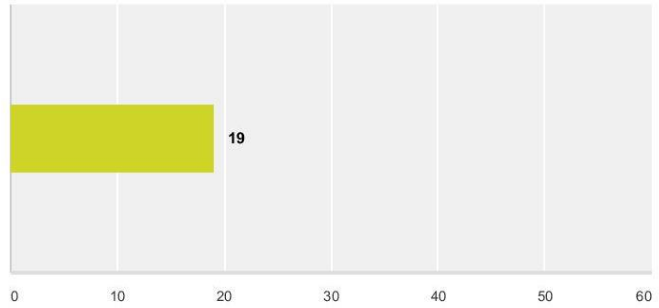
Answered: 318 Skipped: 1,022



Answer Choices	Average Number	Total Number	Responses
	35	11,215	318
Total Respondents: 318			

Q65 How long does it usually take from you to reach your work without traffic congestion? (in minutes)كم من الوقت تستغرق عادة (للذهاب لعملك أو منزلك في غير أوقات الازدحام؟ (بالدقائق

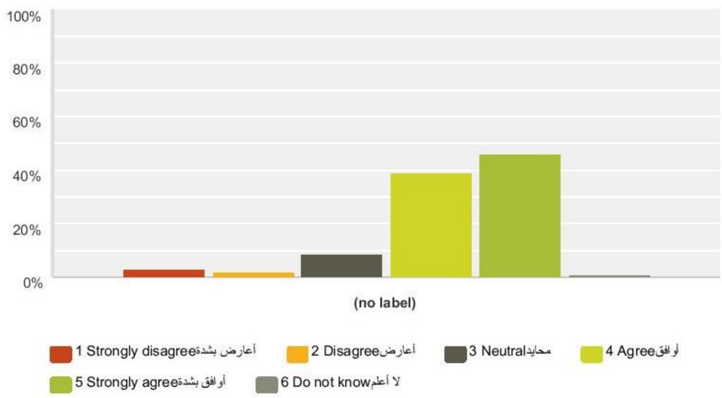
Answered: 318 Skipped: 1,022



Answer Choices	Average Number	Total Number	Responses
	19	6,040	318
Total Respondents: 318			

Q66 You prefer to use private car rather than public transportation. أنت تفضل استخدام سيارتك الخاصة بدلاً من وسائل النقل العام.

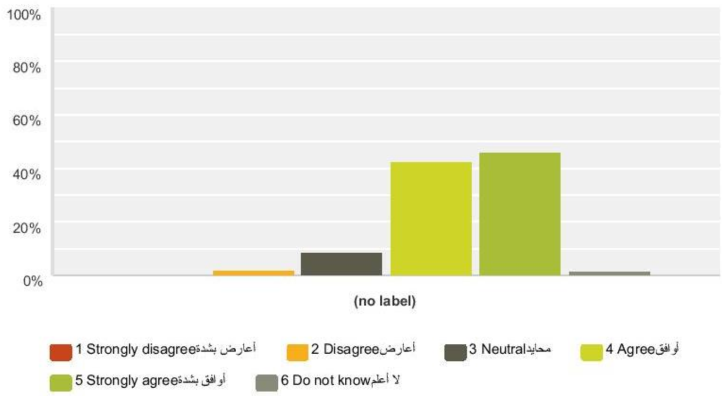
Answered: 314 Skipped: 1,026



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**3.18%** 10	**1.91%** 6	**8.60%** 27	**39.17%** 123	**46.18%** 145	**0.96%** 3	314	4.20

Q67 You perceive the traffic congestion as serious problem in Kuwait. ازدحام حركة المرور تعتبر مشكلة جدية و خطيرة في الكويت.

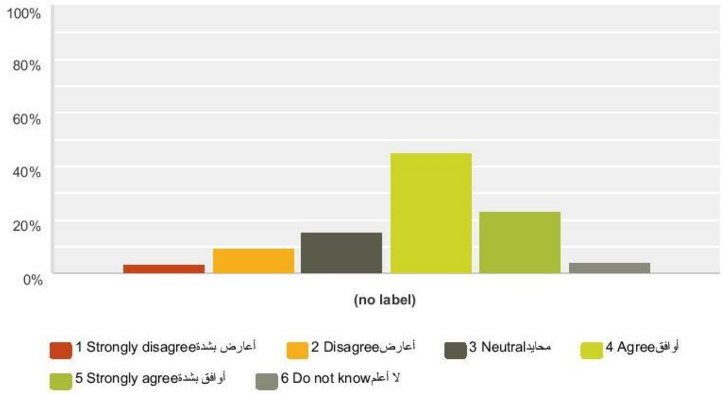
Answered: 314 Skipped: 1,026



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	0.00% 0	2.23% 7	8.28% 26	42.36% 133	45.86% 144	1.27% 4	314	4.28

Q68 There is congestion even if it is not working hours. For example at night. هناك ازدحام مروري حتى خارج أوقات العمل. على سبيل المثال في الليل.

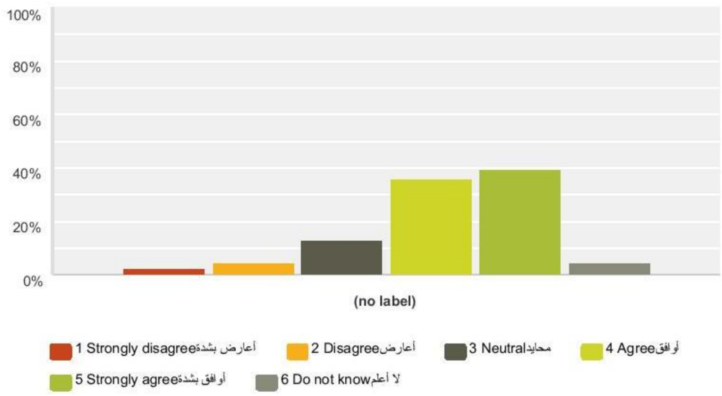
Answered: 314 Skipped: 1,026



	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	**3.50%** 11	**9.55%** 30	**15.29%** 48	**44.90%** 141	**22.93%** 72	**3.82%** 12	314	3.63

Q69 How likely would you be to use a train system in your trips to work and home if it is available? لو كان هناك قطارات في الكويت فهل سوف تستخدمها في رحلاتك للعمل والمنزل؟

Answered: 314 Skipped: 1,026



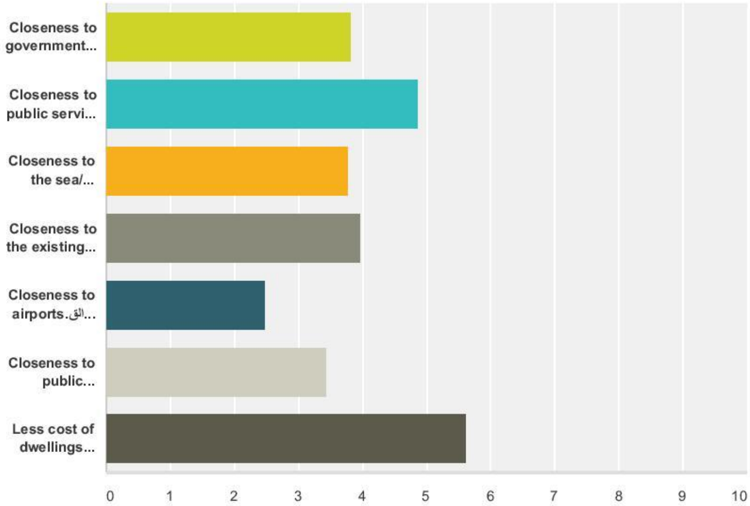
	1 Strongly disagreeأعارض بشدة	2 Disagreeأعارض	3 Neutralمحايد	4 Agreeأوافق	5 Strongly agreeأوافق بشدة	6 Do not knowلا أعلم	Total	Weighted Average
(no label)	2.55% 8	4.46% 14	13.06% 41	35.99% 113	39.49% 124	4.46% 14	314	3.92

Q70 Other comments (Please write) تعليقات أخرى (يرجى الكتابة)

Answered: 22 Skipped: 1,318

Q71 Please order the following criteria/ elements based on your demands and wishes (From 1= Most important to 7= Less important): الرجاء ترتيب العناصر التالية حسب طلباتك و أمنياتك في المنطقة السكنية التي ترغب السكن فيها (1= الأكثر أهمية الى 7= الأقل أهمية)

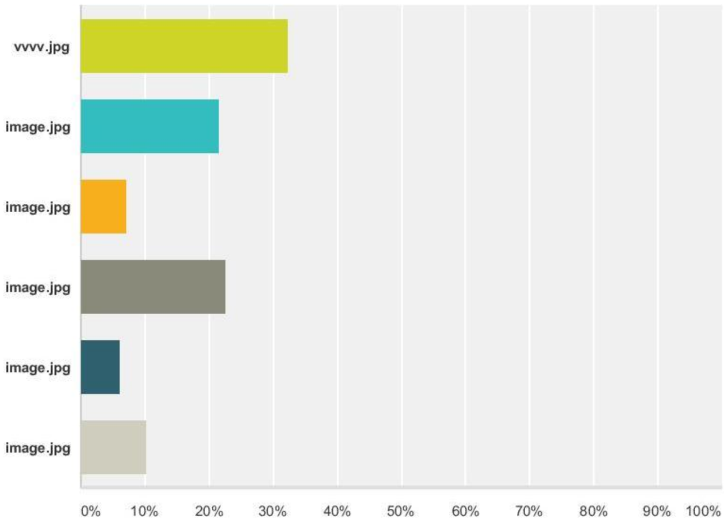
Answered: 298 Skipped: 1,042



	1	2	3	4	5	6	7	Total	Score
Closeness to government services such as ministries and organisations.القرب من الخدمات الحكومية (وزارات و هيئات).	**6.71%** 20	**11.74%** 35	**18.79%** 56	**17.11%** 51	**21.48%** 64	**14.09%** 42	**10.07%** 30	298	3.83
Closeness to public services such as shopping malls, hospitals, universities and others.القرب من الخدمات العامة مثل مراكز التسوق و المستشفيات و الجامعات و غيرها.	**15.77%** 47	**26.85%** 80	**22.15%** 66	**14.09%** 42	**11.07%** 33	**5.37%** 16	**4.70%** 14	298	4.87
Closeness to the sea/ beaches.القرب من البحر / الشواطئ.	**7.72%** 23	**15.77%** 47	**15.77%** 47	**14.09%** 42	**14.43%** 43	**17.79%** 53	**14.43%** 43	298	3.77
Closeness to the existing urban area.القرب من المنطقة الحضرية الحالية.	**10.40%** 31	**13.09%** 39	**14.43%** 43	**21.81%** 65	**15.77%** 47	**14.77%** 44	**9.73%** 29	298	3.97
Closeness to airports.القرب من المطارات.	**3.69%** 11	**4.03%** 12	**7.72%** 23	**9.40%** 28	**11.74%** 35	**23.15%** 69	**40.27%** 120	298	2.48
Closeness to public transportation (bus or train networks).القرب من محطات وسائل النقل العام (باصات و قطارات)	**5.03%** 15	**12.75%** 38	**11.74%** 35	**17.11%** 51	**16.78%** 50	**19.46%** 58	**17.11%** 51	298	3.45
Less cost of dwellings (purchase or rent).أسعار السكن تكون أقل (شراء أو ايجار).	**50.67%** 151	**15.77%** 47	**9.40%** 28	**6.38%** 19	**8.72%** 26	**5.37%** 16	**3.69%** 11	298	5.62

Q72 Please choose the most preferred strategy to be applied as the new development in Kuwait in this project based on your demands and wishes. .يرجى اختيار أكثر استراتيجية مفضلة لديك ليتم تطبيقها في هذا المشروع بناء على طلباتك ورغباتك الشخصية

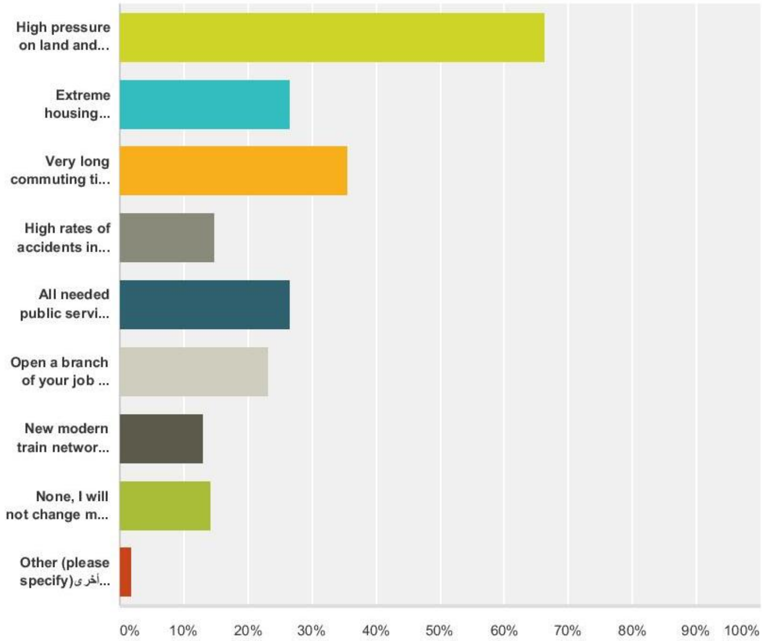
Answered: 293 Skipped: 1,047



Answer Choices	Responses	
	32.42%	95
	21.50%	63
	7.17%	21
	22.53%	66
	6.14%	18
	10.24%	30
Total		293

Q73 What of these factors could affect your decision of not moving from the existing urban area and make you change your answer to a new city? (Multi answers)أي من هذه العوامل من الممكن أن تؤثر على قرارك بعدم الانتقال لمدينة جديدة و يمكنها أن تجعلك تغير رأيك؟ (يمكن اختيار أكثر من اجابة)

Answered: 155 Skipped: 1,185



Answer Choices	Responses	
High pressure on land and property values in the existing urban area.الارتفاع المبالغ فيه في أسعار العقار في المنطقة الحضرية الحالية.	66.45%	103
Extreme housing shortages in the existing urban area.عدم وجود مساكن كافية في المنطقة الحضرية الحالية.	26.45%	41
Very long commuting times in the existing urban area.وقت طويل جدا للتنقل في المنطقة الحضرية الحالية.	35.48%	55
High rates of accidents in the existing urban area.ارتفاع عدد الحوادث بشكل مبالغ في المنطقة الحضرية الحالية.	14.84%	23
All needed public services provided in the new city.توفر جميع الخدمات العامة في المدينة الجديدة.	26.45%	41
Open a branch of your job in the new city.افتتاح فرع من جهة عملك في المدينة الجديدة.	23.23%	36
New modern train network established.انشاء شبكة قطارات حديثة.	12.90%	20
None, I will not change my mind.لا يوجد، و لن أغير رأيي.	14.19%	22

Other (please specify)(أخرى (الرجاء ذكرها)	**1.94%**	3
Total Respondents: 155		

Q74 Are there any important issues not covered in this survey that you would like it to be added? If so, please write the questions and answer them kindly in the space provided below.هل هناك أي أسئلة مهمة لم يشملها هذا الاستبيان و ترغب في اضافتها؟إذا كان الأمر كذلك، يرجى كتابة الأسئلة والإجابة عليها في المكان المخصص أدناه

Answered: 88   Skipped: 1,252

Appendix D: Supplementary material for the 1st scenario- Chapter 4

Supplementary Material - Modelling future impacts of urban development in Kuwait with the use of ABM and GIS

Nayef Alghais† and David Pullar†

†School of Geography, Planning and Environmental Management, The University of Queensland

Purpose: Evaluate population growth in Kuwait over time and it impact on urban systems.

Overview: Refer to paper generally and see Figure 4-12 showing flowchart of the model.

Entities and variables

The focal agents are the high level decision makers, i.e. government and developers, and actions they take to manage population growth. The population is structurally differentiated between Kuwaiti and non-Kuwaiti citizens as the former (young families) have a right to Government supported housing. Government regulation also affects urban land uses with housing differentiated as residential districts (mainly Kuwaiti with some non-Kuwaiti household support staff) and mixed districts (predominantly apartment housing with non-Kuwaiti and smaller number of Kuwaiti). New urban residential districts are opened by the Government to provide housing for young families, whereas new mixed districts are influenced by developers. The location for new urban districts is determined by characteristics of developable districts stored in ABM environment.

Variables:

Population_projections: projections for Kuwaitis and Non-Kuwaiti population growth from 2015 to 2050

Housing_waiting: count for (young) Kuwaiti family who apply (await) residential housing

Housing_allocation: number of allocated welfare housing each year

Over_spill_increment: adjustment for the districts' capacity to hold new population

Districts_CBD_Traffic: the level of traffic catchment to the capital (CBD)

Number_dwellings: number of PAHW new dwellings based on the scenario

Average_change_applicants: the average annual rate of change in housing applications

Agents:

Government is main decision agent responsible for urban settlement. It may exhibit rigid growth regulation (scenario where it allocates fixed number of new urban districts) or adaptive (scenario where it anticipates housing shortages and allocates variable number of new urban districts)

Developers influence government decision for mixed urban development and the builder for dwellings in mixed districts.

Residents (Kuwaitis and non-Kuwaitis) are the agent whom located in the districts based on urban development and growth.

Environment

Districts with: i) types for restricted, developable (currently un-occupied), residential, mixed, purposed, ii) current population for Kuwaiti and non-Kuwaiti, iii) area, and iv) land cost

Input data

Table D-S1: Data types and sources

Variable	**Data**	**Type/ Format**	**Source**
Population_projections	Population Projection for both Kuwaitis and non-Kuwaitis from 2015 to 2050	Table as image	KISR (Alramadan & Almusallam 2013)
Districts	Population distribution on districts both Kuwaitis and non-Kuwaitis in 1995, 2000, 2005, 2010 and 2015	Excel	(PACI 2015)
Districts	Kuwait land use (districts), street networks, landmarks (ministries, companies, hospitals, universities and shopping malls)	GIS ready data	KISR, requested officially
Districts	Cost (rent and sale) of districts	Table as image	(KFH 2015)

Initialization

Initialise parameters

number_new_urban_districts is set from historical figures as 4 new residential districts and 0.5 mixed district every 5 years

Housing_waiting initiated from current status

Process overview and scheduling

The model is run for 35 years with 5 yearly steps. The main driver of change is propulation growth and how they are spatially distributed to available land and the urban impacts of this growth.

```
for each 5 yearly period from 2015 to 2050
    compute district Suitability

    if government Expects_housing_shortage then
        number_new_urban_districts is increased
    else
        number_new_urban_districts is decreased

    for number_new_urban_districts
        new_district = Greenfield_choice
        re-assign (move) proportion of Housing_allocation to new_district

    intensification loop:
        for all urban districts (in a random order)
            if district type = residential and Capacity < population then
                add kuwaiti and nonkuwaiti population increment to district
            if district type = mixed and Capacity < population then
                add kuwaiti and nonkuwaiti population increment to district

    if new population not assigned then
        increase capacity for districts by Over_spill_increment
        go to intensification loop
```

evaluate impacts on *Housing_waiting* and traffic congestion

Submodels

District *Capacity*

Capacity of district to settle new population. A maximum capacity was determined from existing data based on average density. Different capacities are calculated for Kuwaiti and non-Kuwaiti based on nationality and district type.

If type is residential

capacity = (max_density_residential × district_area) – population_current_kuwaiti and nonKuwaitis

else if type is mixed

capacity =(max_density_mixed × district_area) – population_current_kuwaiti and nonKuwaitis

District *Suitability*

Suitability scores for districts are determined by composite factors for proximity to infrastructure, proximity to facilities, proximity to other urban areas and land costs (see section 3.4 article). Most of these factors are stable and may be held fixed for the simulation, but proximity to other urban areas and land costs will change as un-occupied developable districts are converted to residential or mixed districts. So district suitability is re-computed each time step.

District *Greenfield_choice*

Developable districts have a suitability score for their preference for development, i.e. conversion to a residential or mixed land use district. The choice of a district to develop is mostly determined by a suitability score but it is also stochastic; so a new district for development is selected based upon a sampling method using weighted sampling without replacement, where the suitability score is normalised to a weight distribution.

Housing *re-assign*

Reduce Kuwaiti population in over capacity residential districts; this is reflects move of young families from extended family home.

Fututre accidents predection

From the analysis of the historical accidents data, a regression analysis model was used to estimate the future accidents rates, which in turn used as an indicator for congestion. The regression is linear and projects the accidents data to the future with two dynamic variables: the population and the level of traffic catchment to Kuwait capital (CBD). Therefore, the equation used for the regression analysis is:

If type is residential or mixed

accidents = (0.01585 × population_current_kuwaiti and nonKuwaitis) +(86.2 × Districts_CBD_Traffic)

Housing shortage impact

A simple equation had used to calculate the housing shortage impact based on the housing applications and the new government provided dwellings.

New dwellings =Number_dwellings × time_step_years × number_new_residential_districts

Housing_applications = (Current_housing applications × Average_change_applicants × time_step_years) - New dwellings

Model Design

The work presented in this paper regarding the design of the ABM is based on the Overview, Design concepts and Details protocol (ODD) (Grimm et al. 2010), which is a common nomenclature in the field. According to the ODD the following principles were utilized:

• Adaptation represents spill-over mechanisms in the simulation algorithm. Adaptation occurs when it is not possible to add new dwellings to a region, so the density is increased instead. An example of this is whenever new families live in their parents' houses or newly arrived non-Kuwaitis share the same dwelling with their friends from the same nationality. In the adaptive scenario the government reacts to the housing shortage problem based on an if rule.

• Objective represents the desired goal of agents. In this work this is moving to new districts based on suitability, based on historical trends and various dynamically changing weights for each parameter.

• Predictions are the simulation outputs made according to multiple criteria (suitability parameters). In this work, the predictions are in regards to residents seeking to find the best suitable place to live in according to their behaviours and the parcel parameters.

• Stochasticity is a random selection process in the simulations. A set of suitable districts for future development is present in the simulation steps, but only a specific number will be actually developed. Any districts that were not selected will have a better chance to be selected in the next time steps, as they have higher suitability weights than others.

• Observer variable, housing shortages impact accumulated as a direct observer variable in the model.

References

Alramadan, M & Almusallam, M 2013, *The state of Kuwait population projection*, Kuwait: Kuwait Institute for Scientific Research KISR. In Arabic.

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Appendix E: Supplementary material for the 3rd scenario – Chapter 6

Supplementary Material – Involving residents' preferences in establishing new cities: a case study of population in Kuwait

1. ***Survey responses and statistical tests***

The response options for Questions 1-6 were given in Likert scale, quantified with values between 0 and 5. The Likert scale responses were subject to single way ANOVA test to determine if there is a significant difference between Kuwaitis and non-Kuwaitis in their behaviours and needs. Table E-S1 below shows the assigned values for each Likert scale response used in the survey analysis.

Table E-S1: Likert Scale

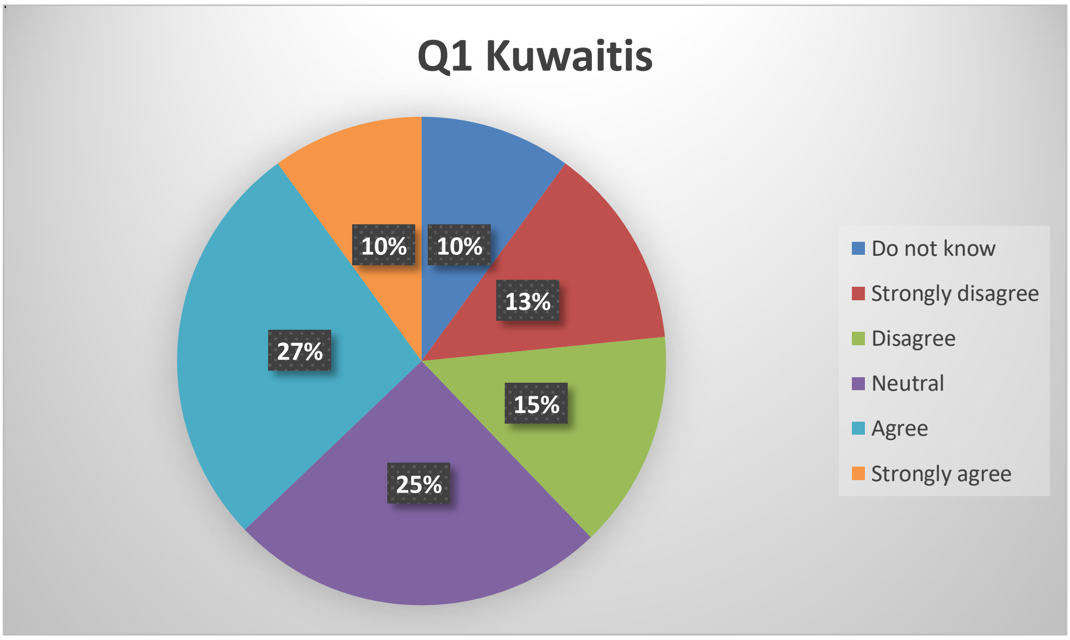
Response	**Value**
Do not know	0
Strongly Disagree	1
Disagree	2
Neutral (Neither Agree nor Disagree)	3
Agree	4
Strongly Agree	5

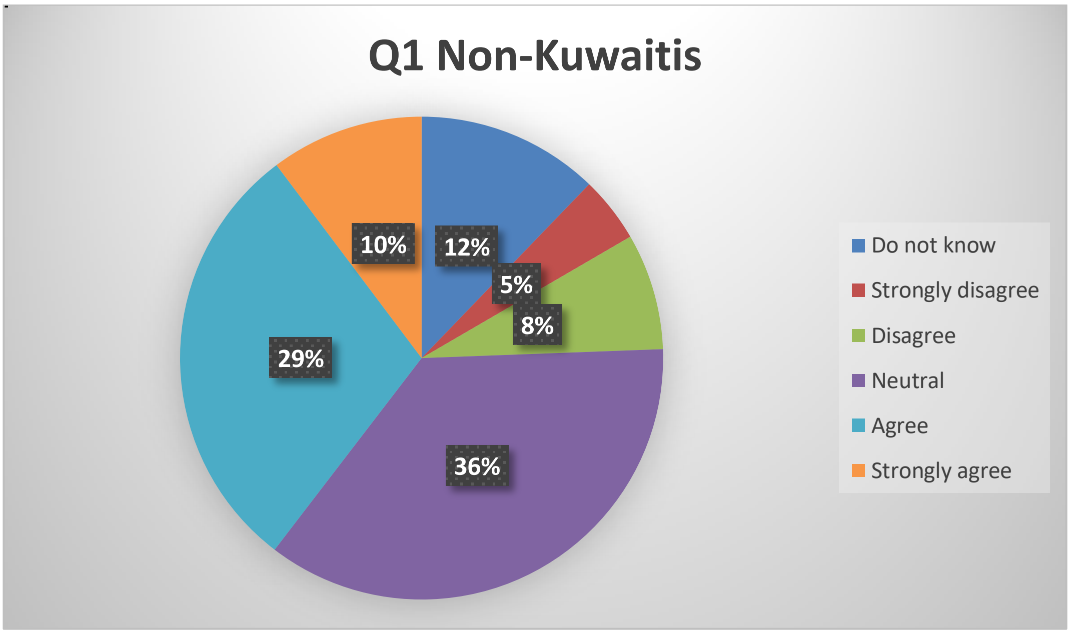
For each single way ANOVA test, 0.05 was taken as the significance level value and each question was tested with a confidence level of 95%.

Q1: Kuwait government is planning to develop new cities outside the existing urban area. I am considering moving to these new cities within the next 5-10 years.

Answers by nationality			**Response count**	**Response percent**	**Valid response percent**
Kuwaitis	Valid	0 Do not know	86	9.9	10.0
		1 Strongly disagree	115	13.2	13.4
		2 Disagree	124	14.3	14.4
		3 Neutral	215	24.8	25.0
		4 Agree	233	26.8	27.1
		5 Strongly agree	87	10.0	10.1

		Total	859	98.8	100.0
	Missing		10	1.2	
	Total		**869**	**100.0**	
Non-Kuwaitis	Valid	0 Do not know	41	10.8	11.9
		1 Strongly disagree	15	3.9	4.3
		2 Disagree	26	6.9	7.6
		3 Neutral	121	31.9	35.1
		4 Agree	98	25.9	28.6
		5 Strongly agree	43	11.4	12.5
		Total	343	90.7	100.0
	Missing		35	9.3	
	Total		**378**	**100.0**	





Kuwaitis	N	859
	Mean	2.7617
	Std. Error of Mean	0.05058
	Std. Deviation	1.48226
	The 95% confidence interval of this difference	2.6624 to 2.8609
Non-Kuwaitis	N	343
	Mean	3.0185
	Std. Error of Mean	0.07836
	Std. Deviation	1.45207
	The 95% confidence interval of this difference	2.8643 to 3.1726

ANOVA test

	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	858	2.7949	1.43628	.04903	2.6986	2.8911
Non-Kuwaitis	376	2.8218	1.54494	.07967	2.6651	2.9785

Total	1234	2.8031	1.46966	.04184	2.7210	2.8852

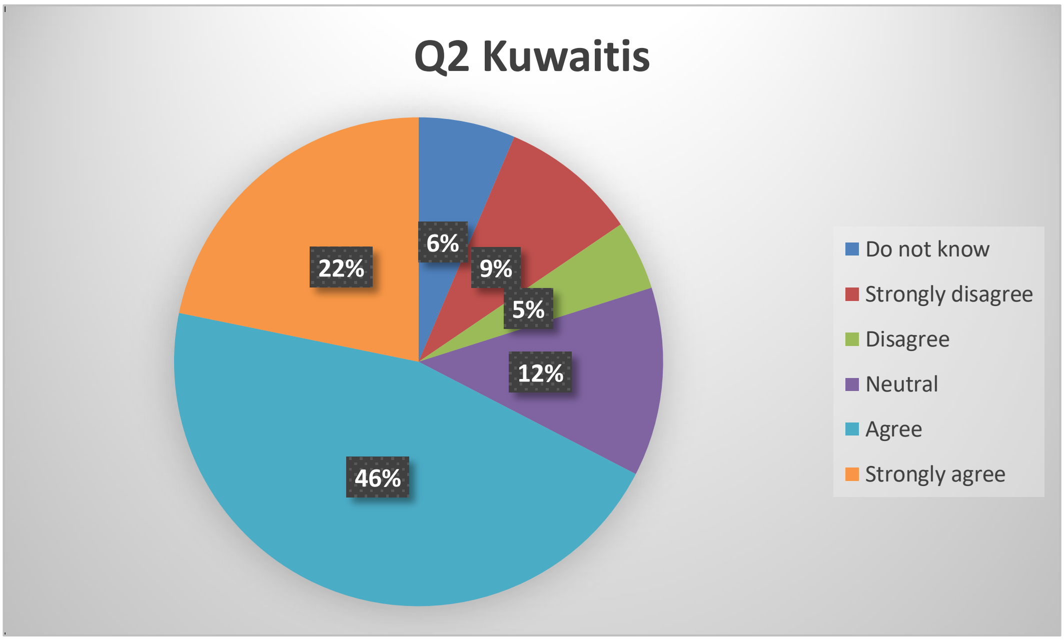
	Sum of Squares	df	Mean Square	F	Sig.
Between groups	0.190	1	0.190	0.088	0.767
Within groups	2662.959	1232	2.161		
Total	2663.148	1233			

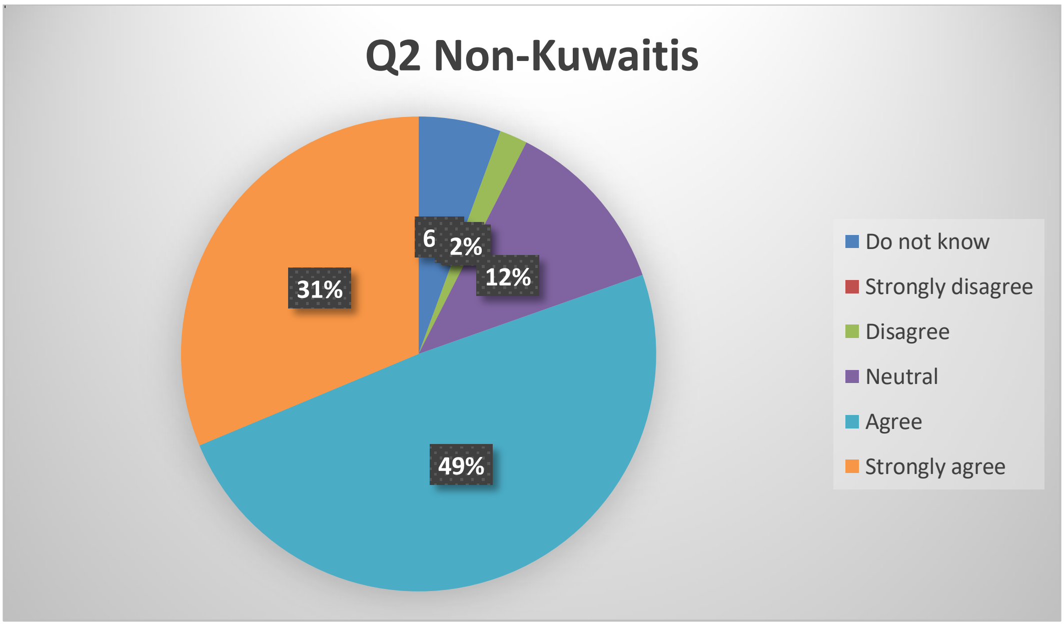
There were no statistically significant differences between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1,1232)$= 0.088, p = 0.767 > 0.05).

Q2: I am considering moving because of financial reasons i.e. lower real estate cost or new employment opportunities. (If answer was strongly agree or agree in Question 1).

Answers by nationality			Response count	Response percent	Valid response percent
Kuwaitis	Valid	0 Do not know	20	2.3	6.4
		1 Strongly disagree	28	3.2	9.1
		2 Disagree	14	1.6	4.6
		3 Neutral	39	4.5	12.5
		4 Agree	142	16.3	45.6
		5 Strongly agree	68	7.8	21.8
		Total	310	35.7	100.0
	Missing		559	64.3	
	Total		**869**	**100**	
Non-Kuwaitis	Valid	0 Do not know	8	2.1	5.6
		1 Strongly disagree	0	0	0
		2 Disagree	3	.7	1.9
		3 Neutral	17	4.5	12.1
		4 Agree	69	18.2	49.1

		5 Strongly agree	44	11.6	31.3
		Total	141	37.1	100.0
	Missing		238	62.9	
	Total		**378**	**100.0**	





Kuwaitis	N	310
	Mean	3.4721
	Std. Error of Mean	0.08223
	Std. Deviation	1.44848

	The 95% confidence interval of this difference	3.3103 to 3.6339
Non-Kuwaitis	N	141
	Mean	3.9306
	Std. Error of Mean	0.10010
	Std. Deviation	1.18662
	The 95% confidence interval of this difference	3.7327 to 4.1285

ANOVA test

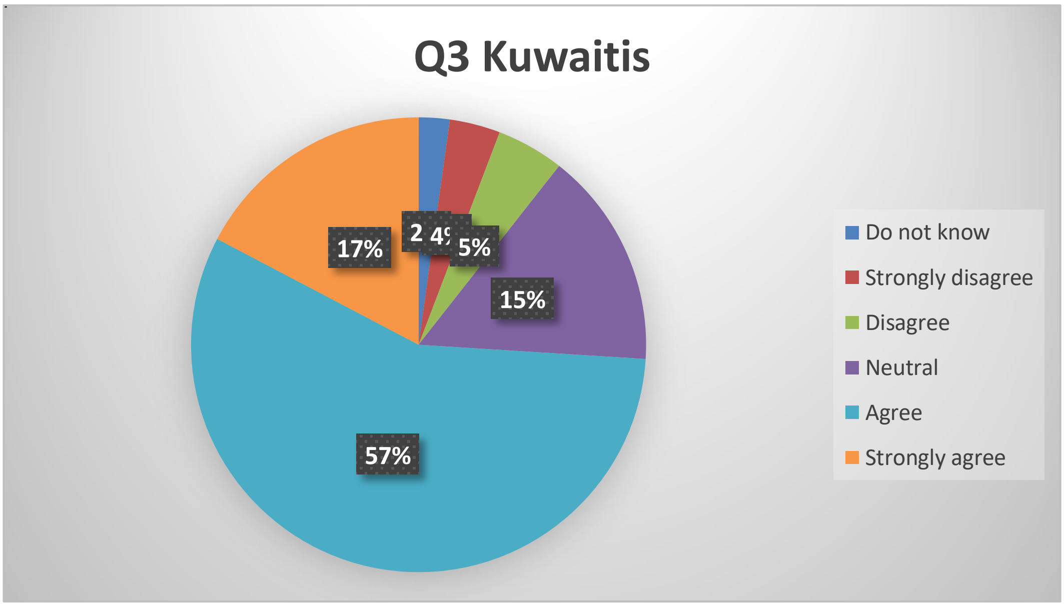
	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	316	3.4494	1.42114	.07995	3.2921	3.6067
Non-Kuwaitis	142	3.9366	1.10585	.09280	3.7532	4.1201
Total	458	3.6004	1.34919	.06304	3.4765	3.7243

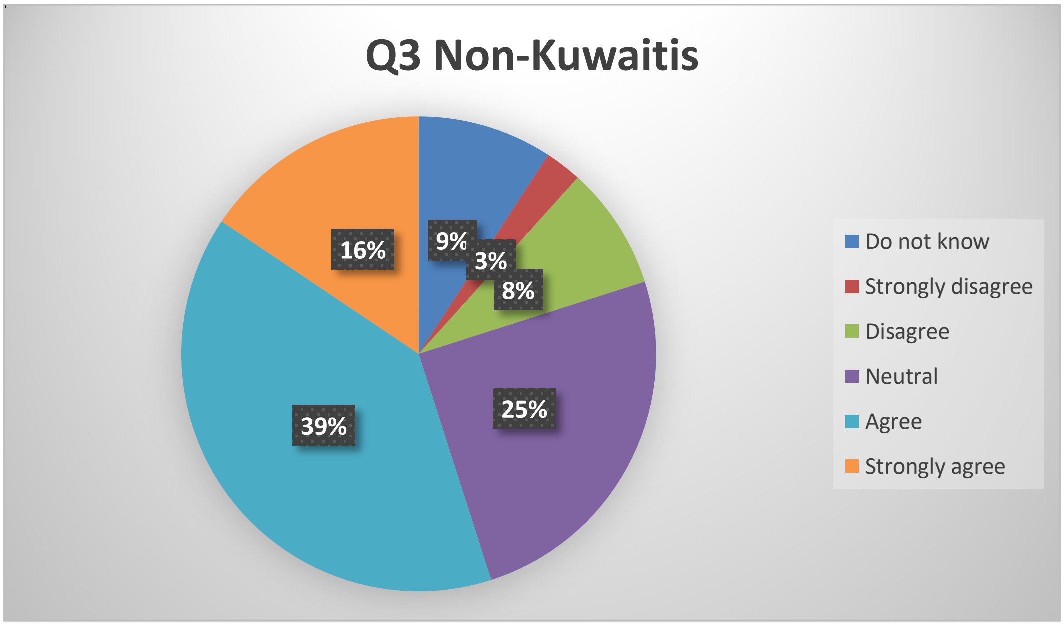
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between groups	23.260	1	23.260	13.117	0.000
Within groups	808.619	456	1.773		
Total	831.880	457			

There was a statistically significant difference between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1, 456)$= 13.117, $p = 0.000 < 0.05$).

Q3: I am considering moving because of social or other reasons i.e. to be near to relatives or friends, change of family size or to obtain free dwelling provided from the government. (If answer was strongly agree or agree in Question 1).

Answers by nationality			Response count	Response percent	Valid response percent
Kuwaitis	Valid	0 Do not know	7	.8	2.2
		1 Strongly disagree	11	1.3	3.6
		2 Disagree	15	1.7	4.8
		3 Neutral	48	5.5	15.4
		4 Agree	176	20.2	56.7
		5 Strongly agree	54	6.2	17.3
		Total	310	35.7	100.0
	Missing		559	64.3	
	Total		**869**	**100.0**	
Non-Kuwaitis	Valid	0 Do not know	13	3.4	9.2
		1 Strongly disagree	3	.9	2.5
		2 Disagree	12	3.1	8.4
		3 Neutral	35	9.3	25.0
		4 Agree	55	14.6	39.4
		5 Strongly agree	22	5.8	15.6
		Total	141	37.1	100.0
	Missing		238	62.9	
	Total		**378**	**100.0**	





Kuwaitis	N	310
	Mean	3.7264
	Std. Error of Mean	0.06032
	Std. Deviation	1.06254
	The 95% confidence interval of this difference	3.6077 to 3.8451
Non-Kuwaitis	N	141
	Mean	3.2986
	Std. Error of Mean	0.11784
	Std. Deviation	1.39695
	The 95% confidence interval of this difference	3.0656 to 3.5316

ANOVA test

	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	316	3.7057	1.09780	.06176	3.5842	3.8272
Non-Kuwaitis	142	3.3099	1.31647	.11048	3.0915	3.5283

Total	458	3.5830	1.18280	.05527	3.4744	3.6916

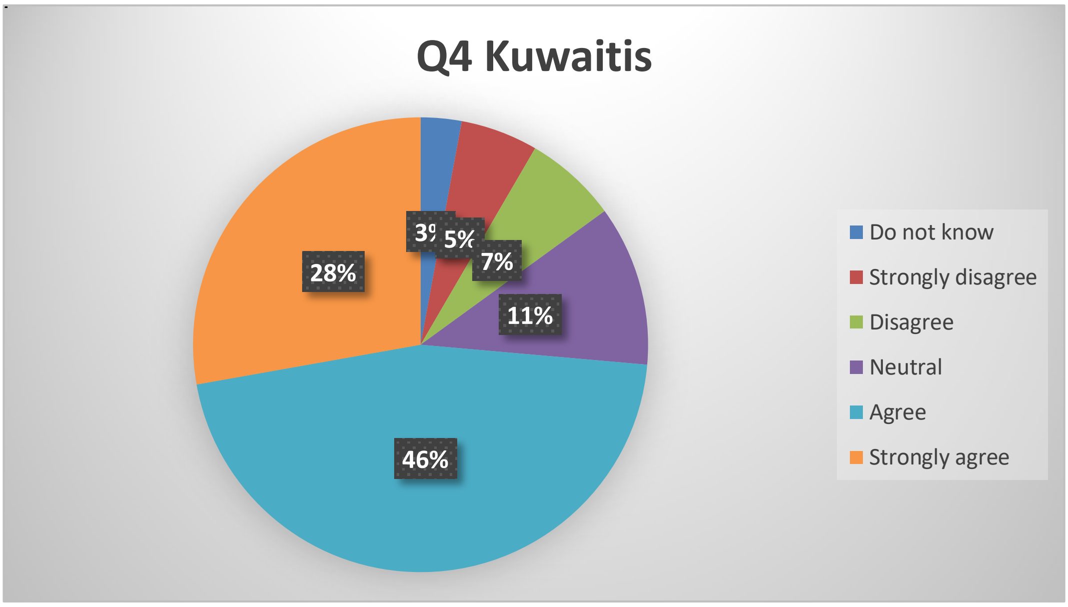
	Sum of Squares	df	Mean Square	F	Sig.
Between groups	15.351	1	15.351	11.218	.001
Within groups	623.996	456	1.368		
Total	639.347	457			

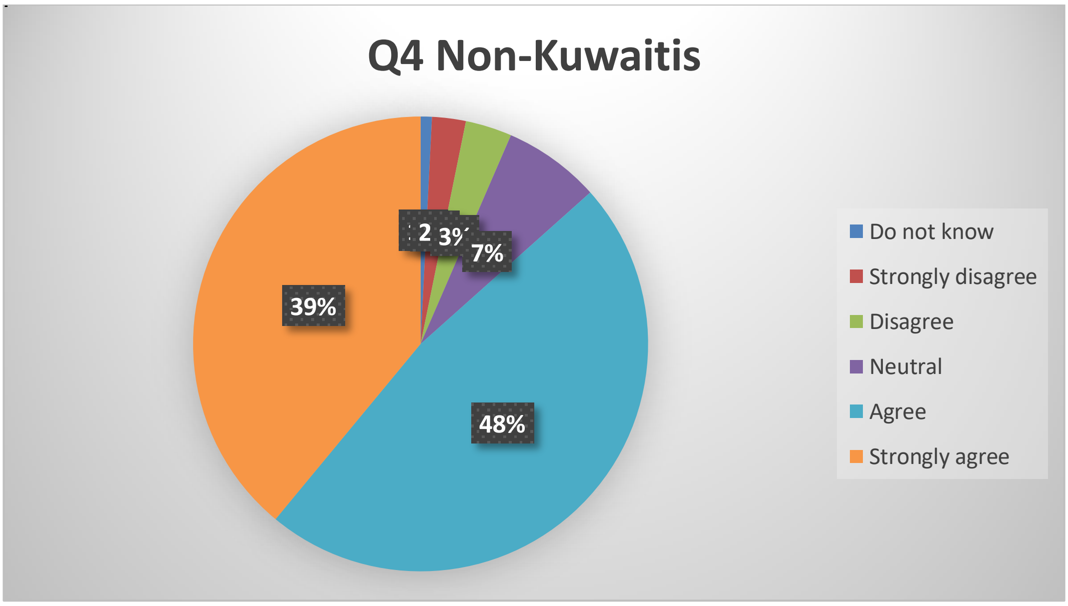
There was a statistically significant difference between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1, 456)$= 11.218, p = 0.001 < 0.05).

Q4: I am not considering moving because of financial reasons i.e. living near to work or living cost is reasonable. (If answer was strongly disagree or disagree in Question 1).

Answers by nationality			Response count	Response percent	Valid response percent
Kuwaitis	Valid	0 Do not know	7	.8	2.9
		1 Strongly disagree	13	1.4	5.5
		2 Disagree	15	1.7	6.6
		3 Neutral	26	3.0	11.4
		4 Agree	105	12.1	45.8
		5 Strongly agree	64	7.3	27.8
		Total	229	26.3	100.0
	Missing		640	73.7	
	Total		**869**	**100.0**	
Non-Kuwaitis	Valid	0 Do not know	0	.1	.8
		1 Strongly disagree	1	.2	2.4
		2 Disagree	1	.3	3.3
		3 Neutral	3	.7	6.9
		4 Agree	18	4.8	47.6

		5 Strongly agree	15	3.9	39.0
		Total	38	10.0	100.0
	Missing		341	90.0	
	Total		**378**	**100.0**	





Kuwaitis	N	229
	Mean	3.7521
	Std. Error of Mean	0.08259
	Std. Deviation	1.24865

	The 95% confidence interval of this difference	3.5894 to 3.9149
Non-Kuwaitis	N	38
	Mean	4.1504
	Std. Error of Mean	0.15769
	Std. Deviation	0.96958
	The 95% confidence interval of this difference	3.8309 to 4.4700

ANOVA test

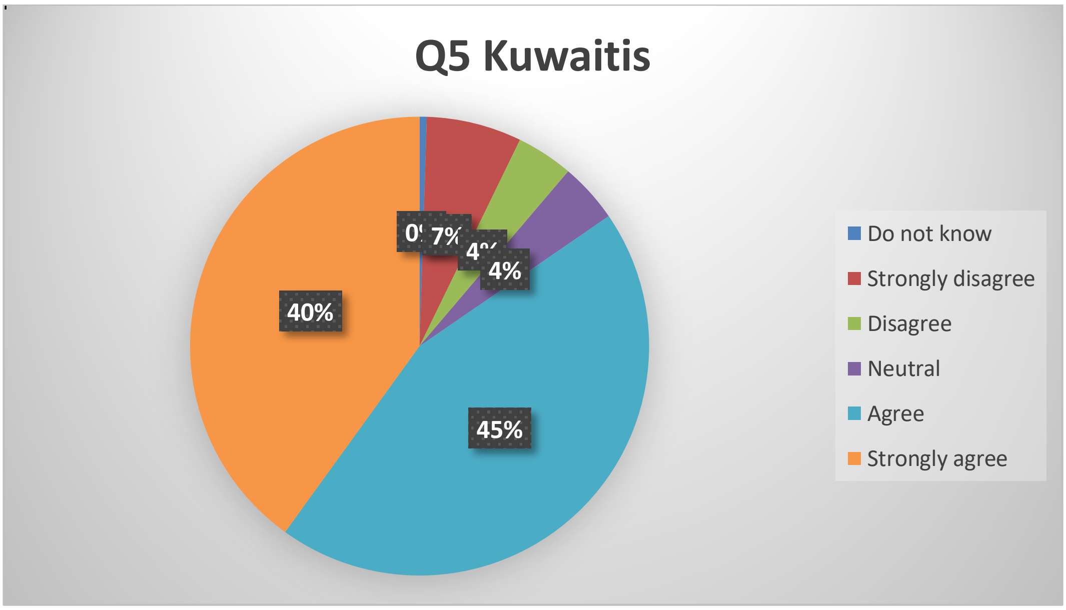
	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	237	3.6878	1.29027	.08381	3.5226	3.8529
Non-Kuwaitis	44	4.0455	1.05554	.15913	3.7245	4.3664
Total	281	3.7438	1.26145	.07525	3.5956	3.8919

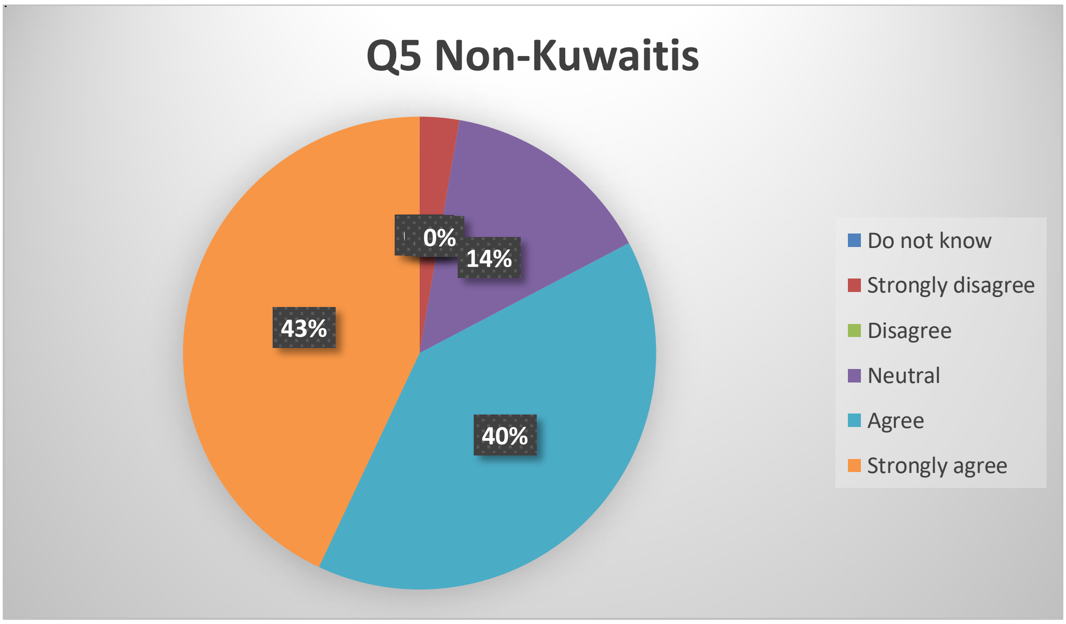
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between groups	4.748	1	4.748	3.005	.084
Within groups	440.804	279	1.580		
Total	445.552	280			

There were no statistically significant differences between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1, 279)$= 3.005, p = 0.084 > 0.05).

Q5: I am not considering moving because of social or other reasons i.e. to be near to relatives or friends or own a house/ apartment. (If answer was strongly disagree or disagree in Question 1).

Answers by nationality			Response count	Response percent	Valid response percent
Kuwaitis	Valid	0 Do not know	1	.1	.5
		1 Strongly disagree	15	1.8	6.7
		2 Disagree	9	1.1	4.0
		3 Neutral	10	1.1	4.2
		4 Agree	102	11.7	44.5
		5 Strongly agree	92	10.5	40.0
		Total	229	26.3	100.0
	Missing		640	73.7	
	Total		**869**	**100.0**	
Non-Kuwaitis	Valid	0 Do not know	0	0	0
		1 Strongly disagree	1	.3	2.7
		2 Disagree	0	0	0
		3 Neutral	6	1.5	14.6
		4 Agree	15	4.0	39.7
		5 Strongly agree	16	4.3	43.0
		Total	38	10.0	100.0
	Missing		341	90.0	
	Total		**378**	**100.0**	





Kuwaitis	N	229
	Mean	4.0571
	Std. Error of Mean	0.07507
	Std. Deviation	1.13497
	The 95% confidence interval of this difference	3.9091 to 4.2050
Non-Kuwaitis	N	38
	Mean	4.2035
	Std. Error of Mean	0.14525
	Std. Deviation	0.89304
	The 95% confidence interval of this difference	3.9092 to 4.4979

ANOVA test

	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	237	4.0127	1.17704	.07646	3.8620	4.1633
Non-Kuwaitis	44	4.2045	.87815	.13239	3.9376	4.4715

Total	281	4.0427	1.13623	.06778	3.9093	4.1761

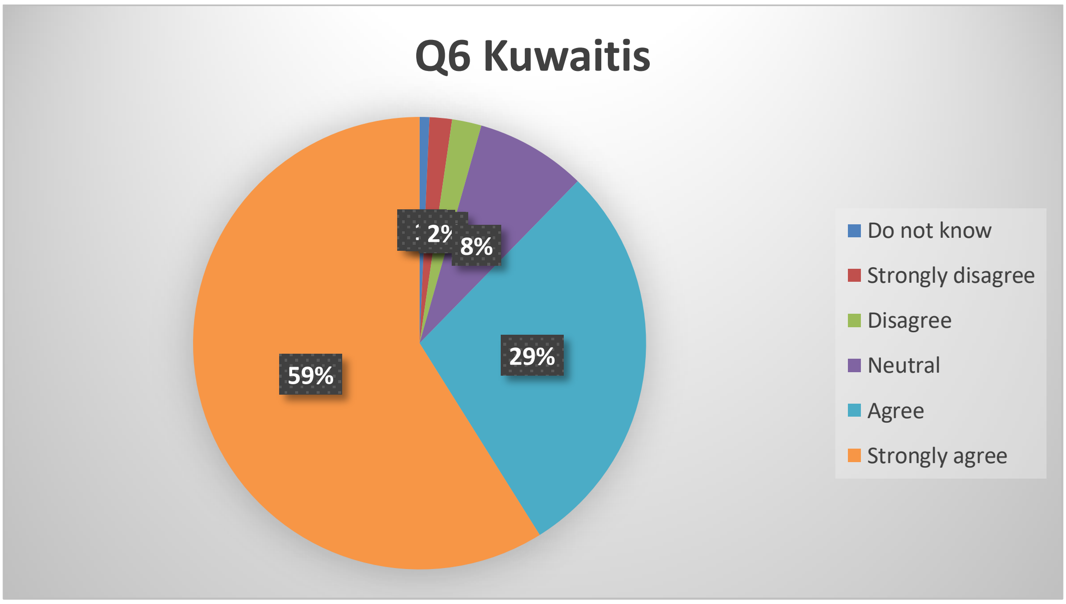
	Sum of Squares	df	Mean Square	F	Sig.
Between groups	1.366	1	1.366	1.059	.304
Within groups	360.121	279	1.291		
Total	361.488	280			

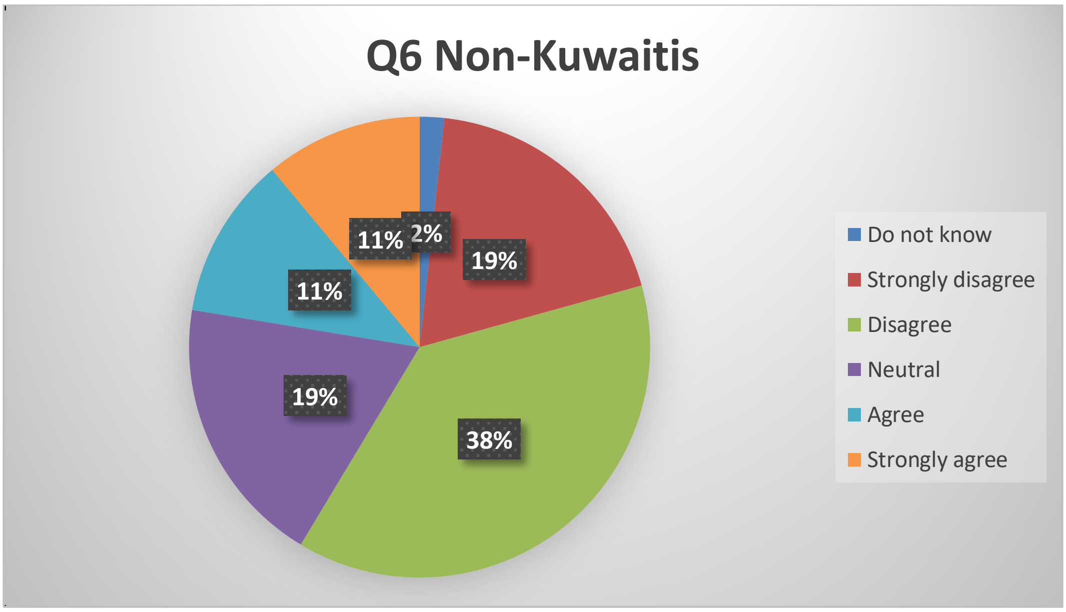
There were no statistically significant differences between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1, 279)$= 1.059, p = 0.304 > 0.05).

Q6: I prefer to reside in residential districts (Fiha, Surra or Audiliya) rather than mixed districts (Salmiya, Hawalli or Khaitan).

Answers by nationality			Response count	Response percent	Valid response percent
Kuwaitis	Valid	0 Do not know	5	.6	.7
		1 Strongly disagree	11	1.2	1.6
		2 Disagree	15	1.7	2.1
		3 Neutral	53	6.2	7.9
		4 Agree	196	22.6	28.8
		5 Strongly agree	401	46.1	58.9
		Total	681	78.3	100.0
	Missing		188	21.7	
	Total		**869**	**100.0**	
Non-Kuwaitis	Valid	0 Do not know	5	1.4	1.8
		1 Strongly disagree	55	14.5	18.9
		2 Disagree	110	29.0	37.9
		3 Neutral	55	14.6	19.1
		4 Agree	33	8.7	11.4

		5 Strongly agree	32	8.3	10.9
		Total	289	76.4	100.0
	Missing		89	23.6	
	Total		**378**	**100.0**	





Kuwaitis	N	681
	Mean	4.3918
	Std. Error of Mean	0.03548
	Std. Deviation	0.92576

	The 95% confidence interval of this difference	4.3222 to 4.4615
Non-Kuwaitis	N	289
	Mean	2.5213
	Std. Error of Mean	0.07490
	Std. Deviation	1.27376
	The 95% confidence interval of this difference	2.3738 to 2.6687

ANOVA test

	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	691	4.4038	.94051	.03578	4.3335	4.4740
Non-Kuwaitis	319	2.6301	1.32032	.07392	2.4847	2.7755
Total	1010	3.8436	1.35454	.04262	3.7599	3.9272

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between groups	686.582	1	686.582	594.208	.000
Within groups	1164.701	1008	1.155		
Total	1851.283	1009			

There was a statistically significant difference between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1, 1008)$= 594.208, $p = 0.000 < 0.05$).

Q7 & 8: For these questions, a summary of the average results can be seen in below table.

Nationality	**Household average size**	**Average number of servants**
Kuwaitis	7	2
Non-Kuwaitis	5	1

Q9: For this question, the ranking of migration criteria based on nationality can be seen in below table.

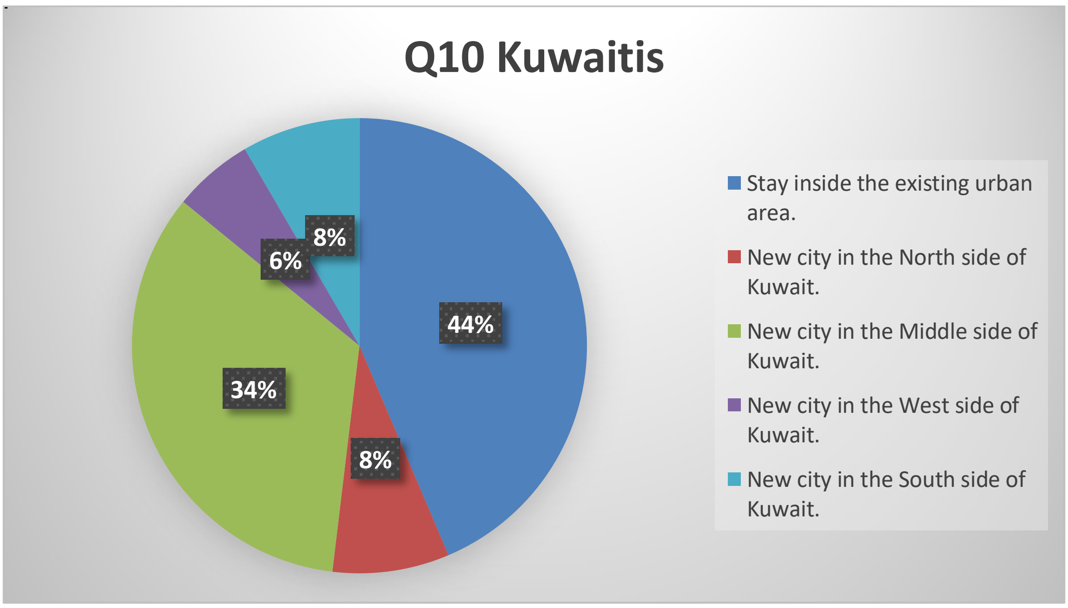
Criteria rank	**Kuwaitis**	**Non- Kuwaitis**
1	Lower cost of dwellings (purchase or rent).	Lower cost of dwellings (purchase or rent).
2	Closeness to the existing urban area.	Closeness to public services.
3	Closeness to public services.	Closeness to the existing urban area.
4	Closeness to government services.	Closeness to government.
5	Closeness to the sea/ beaches	Closeness to public transportation.
6	Closeness to public transportation.	Closeness to the sea/ beaches
7	Closeness to airports.	Closeness to airports.

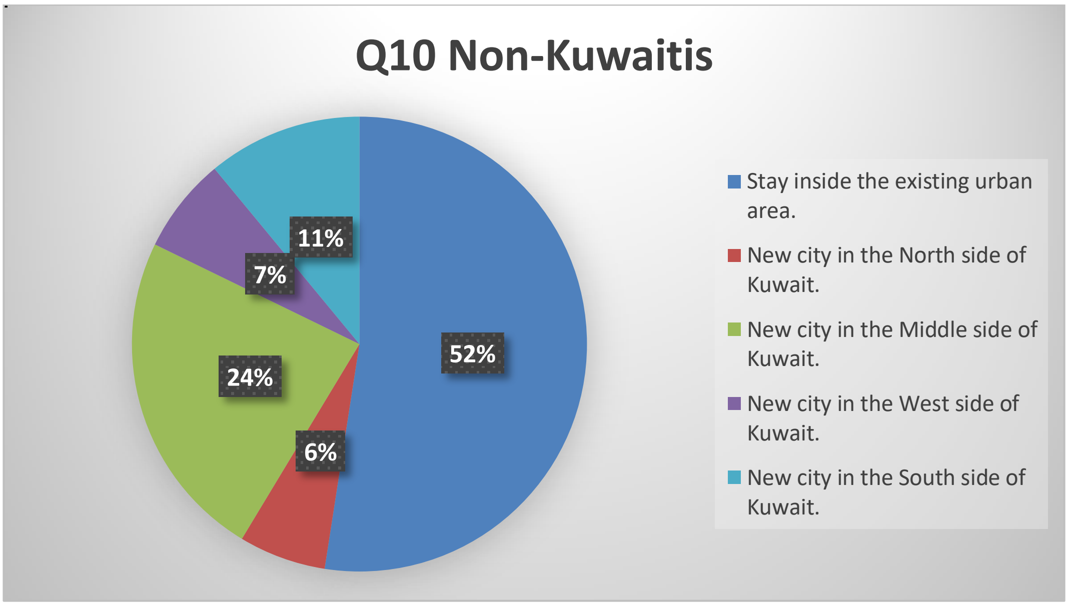
There is a significant difference between the two groups in terms of the criteria ranking order.

Q 10: Please choose your first preference for settlement location based on your demands and wishes:

<table>
<tr><th colspan="3">Answers by nationality</th><th>Response count</th><th>Response percent</th><th>Valid response percent</th></tr>
<tr><td rowspan="3">Kuwaitis</td><td rowspan="3">Valid</td><td>Stay inside the existing urban area.</td><td>265</td><td>30.4</td><td>43.6</td></tr>
<tr><td>New city in the North side of Kuwait.</td><td>50</td><td>5.8</td><td>8.3</td></tr>
<tr><td>New city in the Middle side of Kuwait.</td><td>206</td><td>23.8</td><td>34.0</td></tr>
</table>

		New city in the West side of Kuwait.	35	4.0	5.7
		New city in the South side of Kuwait.	51	5.8	8.4
		Total	607	69.8	100.0
	Missing		262	30.2	
	Total		**869**	**100.0**	
Non-Kuwaitis	Valid	Stay inside the existing urban area.	139	36.7	52.5
		New city in the North side of Kuwait.	17	4.4	6.2
		New city in the Middle side of Kuwait.	62	16.5	23.6
		New city in the West side of Kuwait.	18	4.7	6.8
		New city in the South side of Kuwait.	29	7.7	11.0
		Total	265	69.9	100.0
	Missing		114	30.1	
	Total		**378**	**100.0**	





Kuwaitis	N	607
	Mean	2.2692
	Std. Error of Mean	0.05274
	Std. Deviation	1.29919
	The 95% confidence interval of this difference	2.1656 to 2.3728
Non-Kuwaitis	N	265
	Mean	2.1757
	Std. Error of Mean	0.08680
	Std. Deviation	1.41222
	The 95% confidence interval of this difference	2.0048 to 2.3467

ANOVA test

	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
					Lower Bound	**Upper Bound**
Kuwaitis	625	2.3088	1.30544	.05222	2.2063	2.4113
Non-Kuwaitis	293	2.1160	1.38739	.08105	1.9565	2.2756
Total	918	2.2473	1.33441	.04404	2.1608	2.3337

	Sum of Squares	df	Mean Square	F	Sig.
Between groups	7.412	1	7.412	4.177	.041
Within groups	1625.456	916	1.775		
Total	1632.868	917			

There was a statistically significant difference between group means (Kuwaitis and non-Kuwaitis) as determined by one-way ANOVA ($F(1, 916) = 4.177$, $p = 0.041 < 0.05$).

Q11: For this question, the most important factors chosen by responders were as below:

Factor type	Order by nationality	
	Kuwaitis	**Non-Kuwaitis**
Push factors	High pressure on land and property values in the existing urban area.	High pressure on land and property values in the existing urban area.
	Very long commuting times in the existing urban area.	Very long commuting times in the existing urban area.
	Extreme housing shortages in the existing urban area.	Extreme housing shortages in the existing urban area.
	High rate of accidents in the existing urban area.	High rate of accidents in the existing urban area.
Pull factors	All public services provided in the new city.	All public services provided in the new city.
	Larger house sizes in the new city.	Ability to work in a new branch of own job in the new city.
	Ability to work in a new branch of own job in the new city.	New modern train network established.
	New modern train network established.	-

2. Model description

The model design description presented in this section follows the ODD (Overview, Design concepts, Details) protocol for agent based models description to make the model easily as possible to be perceived by modellers (Grimm et al. 2010).

Purpose:

The main objectives of the model are:

a. To simulate the residents' migration patterns towards new cities based on their preferences and choices.
b. To investigate and predict the future impacts of urban development on nationality segregation levels via three different scenarios:
    1. Government master plan scenario: Top-down development following the master plan and maintaining the existing segregation levels.
    2. Residents' preferences scenario: Bottom-up development following the resident opinions and preferences for migration, residence location and segregation, as derived from direct surveys.
    3. Global cities' scenario: Bottom-up development following the resident opinions and preferences for migration and residence location, as derived from direct surveys. However, the segregation will be simulated according to the Global Cities plan (no segregation in new cities, only mixed districts).

Entities, State Variables and Scales

Agents

Decision agents (government planning authorities): is the main decision agent responsible for establishing new cities and infrastructure.

Resident agents: are the agents that will be allocated to the new cities based on their preferences. They were classified into 8 different subgroups according to their age and nationality with an extra agent for the servant group (see Table 6-5- in Chapter 6).

Environment

Districts were classified in terms of:

i) Land use in the district (residential, mixed or other use)

ii) Current population of Kuwaitis and non-Kuwaitis in each age group

iii) Region location (existing urban area, north region, middle region, west region and south region).

Variables

The state variable input data is spatially distributed and saved as shapefiles in vector format. The environment in this model has two levels: high level (selected scenario) and low level (the land use represented in the districts). The residents residing in a particular district (polygon), which is a part of the environment, are associated with state variables, such as nationality, age group and district settlement ID. In addition, each district has attributes with the following static state variables: ID, type (residential, mixed or other uses), maximum capacity and suitability parameters (closeness to government services, public services, sea/ beaches, the existing urban area, public transportation and airport).

The dynamic state variables are: cost of dwellings (suitability parameter), suitability weight (see Table 6-7- in Chapter 6), statutes (new or old), open date (based on the scenario) and population per agent group.

Data sources for the aforementioned state variables are summarised in Table E-S2:

Table E-S2: Summary of state variables used in the model

Variable type	Content	Source
GIS data	Street networks, district locations and types in 2015.	Kuwait Institute for Scientific Research (KISR).
	New cities data: location, capacity, districts' types. Train network and station locations.	Kuwait municipality and interviews (Alghais & Pullar 2018).
Demographic data	Current population distribution on districts by nationality and age group.	Public Authority for Civil Information (PACI 2015).
Population projection	Aggregated projections from 2015-2050 by nationality and age group.	(Alramadan & Almusallam 2013).

Other input data was obtained from the surveys, including migration ratio, preferred locations, preferred district type and household size for each agent groups (see Table 6-8- in Chapter 6).

Initialisation

Urban development of new cities in all scenarios begins in 2015. In the initialisation of the model the following data will be loaded:

a. Input demographic data: current population distribution and population projections for each agent group (nationality, age and servants).
b. Input spatial data: existing district types, street and train networks and future available cities.
c. Resident responses from the survey.

Process Overview and Scheduling

In each 5-yearly time step after 2015, the government agent establishes new cities based on the selected scenario and then the resident agents start migrating to the new established districts. After the end of each time step the nationality segregation level is calculated and the output map is updated. After reaching year 2050, the model will stop. Establishing new cities and migration modelling vary according to the selected scenario and provide different outcomes in each scenario, as seen in Table E-S3.

Table E-S3: Scenarios main differences

<table>
<tr><th>Scenario</th><th>Establishing a new city</th><th>Migration</th></tr>
<tr><td>#1 Government</td><td>Open dates, locations, number of cities and order according to the new master plan.</td><td>Based on government expectations and the suitability weights of the districts.</td></tr>
<tr><td>#2 Resident</td><td rowspan="2">According to master plan only for number of cities.
Predominantly based on responses obtained from the survey.</td><td>Based on the suitability weights and locations by preferred district type.</td></tr>
<tr><td>#3 Global cities</td><td>Based on the suitability weights and considering all new established districts are similar (mixed use).</td></tr>
</table>

In the resident and global cities scenarios, opening a new city is modelled according to the state variables and after checking if there are enough residents for migrating. The model checks the responses for each resident group - young, middle and senior aged - and calculates the numbers of servants and underage residents that follow. The model establishes the new city only if there is enough interest compared to the minimum threshold, else it selects another location and repeats the process.

Before establishing a new city, infilling actions are run for each time step in order allocate the new population in existing districts. In regards to migration to the new cities, the number of willing residents is calculated from the survey responses. The willing residents are then allocated according to their preferred district type and the suitability factors, until all districts become full or there are no more residents willing to migrate. This is done by adding new residents (points) in the new city and then deleting an equal amount of residents from the existing urban area. At the end of this cycle, the model updates the district settlement ID.

Model flow and submodels

The model flow runs according to the following Pseudocode:

for each 5 yearly period from 2015 to 2050

<u>infilling loop:</u>

```
   for all urban districts (in a random order)
         if district type = residential or mixed and Capacity < population then
               add resident agent points to district based on the average of the age distribution on the
district type
```

<u>Establishing new cities:</u>

```
   if Current_Scenario=1:
      New Cities_IDs   = Select Current Time Step Cities
         for city in New_Cities_IDs   :
          result=Check_City
            if result.canOpen=true:
            Open_City
            Else:
              Writelog ("City is Faild to open this timeStep")

     elseif Current_Scenario >1:
          Sort cities based on their sutabity weights
      Get number should be Opened Cities=  get current_Year_CitiesCount()
           New Cities_IDs= Select Current remaining Cities()
```

```
for index=0 of Number should be Opened Cities  :
 city=New Cities_IDs_threshold[index]
    for city in New_CitiesIDs_thershold:
      Calculate available residents willing to migrate to the selected new city
         If available residents willing to migrate to the selected new city > citiy
         threshold
       result=Check_City
         if result.canOpen=True:
          Open_City
            Number should be Opened Cities = Number should be Opened Cities -
            1

         Else
           Writelog ("City is Faild to open this timestep")
```

Migration loop:

Select resident agent points randomly from existing urban area districts

Reallocate selected resident agent points to new city

Remove the reallocated resident agent points from existing urban area districts

Change district settlement ID for the reallocated resident agent points

Calculation of the suitability weights:

Suitability weights for cities and districts are determined by composite parameters related to proximity to government services, public services, sea/ beaches, the existing urban area, public transportation and airport and land costs. These weights are constant, except land costs that can change during the simulations, as unoccupied developable districts are converted to residential or mixed districts. The district suitability is re-computed each time step after the new land cost calculations have been finalised.

Calculation the number of residents willing to migrate to the selected new city:

This is calculated according to the household size for Kuwaitis and non-Kuwaitis residents as follows:

For Kuwaitis: 3 kids + 2 servants + 2 Kuwaitis

For non-Kuwaitis: 2 kids + 1 servant + 2 non-Kuwaitis.

Segregation distribution:

Residents are allocated according to their preferred district type. This action is skipped in the global cities scenario; instead, in this scenario all districts are treated as mixed and residents are distributed based on suitability only.

Calculate the nationality segregation average:

A simple equation is used to calculate the nationality segregation at the end of each time step:

$$Nationality\ segregation\ average = \frac{Total\ Kuwaitis\ in\ mixed\ districts}{Total\ non - Kuwaitis\ in\ mixed\ district}$$

Figure E-S1 shows the model overview with all submodels.

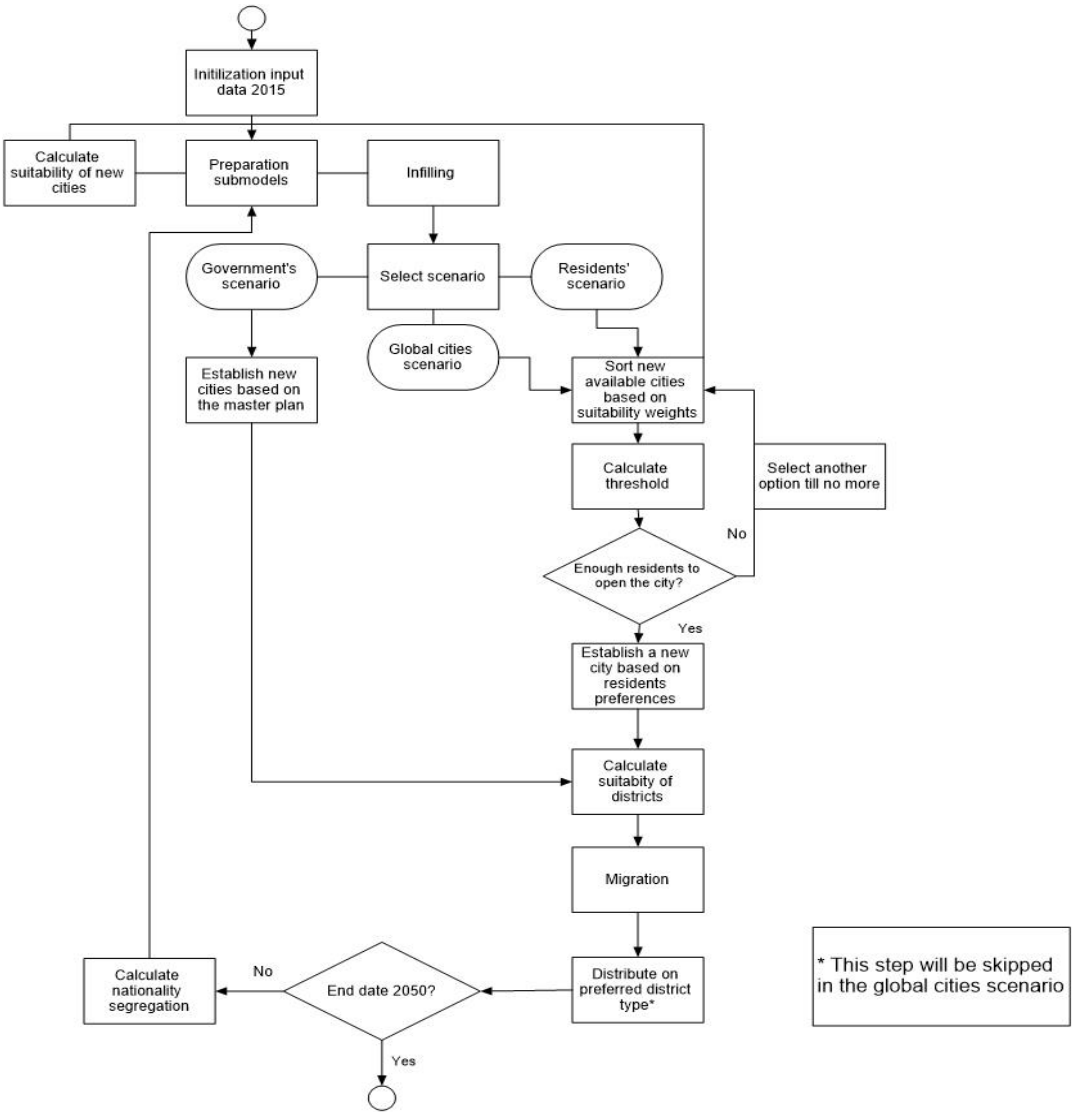


Figure E-S1: Model's overview flowchart

Design Concepts

- *Basic principles:* Obtaining resident opinions and applying them in simulation models provides an opportunity to evaluate the master plan and show any differences between the government planners and residents perspectives. In addition, comparing the nationality segregation levels provides insight about this urban issue and how it may affect transforming Kuwait into regional trade and financial centre. Finally, the resident scenario results help to assess the likelihood of the occurrence of underpopulated ghost cities in Kuwait.
- *Emergence:* The key results of the model are emerging from the agent behaviours, specifically the migration patterns to the new cities, the new resident distribution and the future nationality segregation levels.
- *Adaptation:* The resident agent groups act as decision makers in the resident and global cities scenarios, in selecting the new cities to be opened according to the suitability weights and their preferred locations. This process is based on *'if-then'* conditional decision rules. Migration to these newly opened cities is based on the suitability weights and the preferred district types (in the government and resident scenarios). In the global cities scenario, the resident agent behaviours (preferred district type) will be changed in response to environment stimuli.
- *Prediction:* Resident agent selections for their settlement district in residents and global cities scenarios are made directly from the survey input data (suitability weights and preferred locations) and after adding random sorting of the order of establishing the districts each time the model is run. The government scenario will produce only one outcome: the order of opening new cities. Additionally, the nationality segregation levels in any case will be heterogeneous.
- *Sensing:* During the migration action (allocation residents), agents based on their type are assumed to be able to sense their preferred location, district type, and suitability parameters for each district. However, they do not consider or know other residents' actions nor they do determine future consequences of their choices.
- *Interactions:* Agents generally do not interact with each other. However, underage citizens and servants are linked to other agents in households for migration purposes.
- *Stochasticity:* Stochastic processes are used to simulate randomisation in the model. For example, in the resident scenario the new city selection order is randomised for migration purposes. In the global cities scenario the distribution of residents based on citizenship will be randomly determined to obtain a low nationality segregation level.

- *Collectives:* The resident agents are collectives of 100 persons of the same nationality and age group. A specific number of individuals from the collective group forms a household that is needed for migration calculations.
- *Observation:* The model code is written and recorded in Python. The variable inputs, environment and agent parameters are saved in ArcGIS database as shapefiles. In addition, the resulting maps and diagrams from the scenarios simulations at each time step are added to the same database. This provides near-perfect observation of the model in its entirety (simulations with all variables, inputs and outputs).

References

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