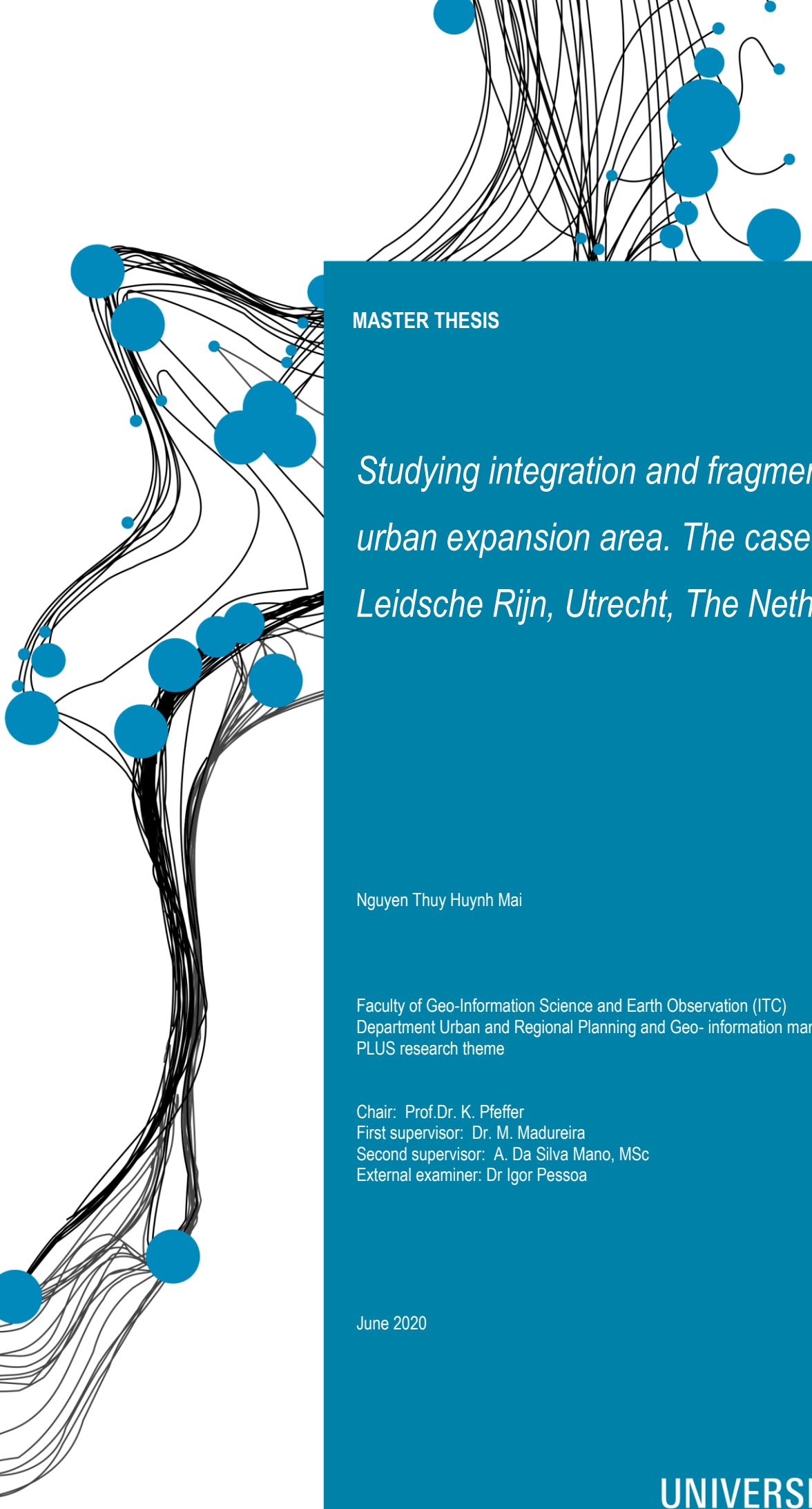

MASTER THESIS

Studying integration and fragmentation in the urban expansion area. The case study in Leidsche Rijn, Utrecht, The Netherlands

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Contents

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Translation

In Dutch, Leidsche Rijn is called as Wijk Leidsche Rijn, which could be translated to English as “district” or “neighbourhood” (according to van Dale online dictionary and Bab.la online dictionary). This thesis uses the term "district" to address the “wijk” area. Leidsche Rijn Centrum is one of the “subwijk” of Leidsche Rijn. This thesis uses the term “subdistrict” to address the “subwijk” area.

Abstract

Urban fragmentation is a phenomenon often encountered in urban areas facing urbanisation-related pressures, and a need to expand. Urban integration describes a city where socio-economic, spatial and demographic elements would share a similar structure and connect with each other. In the current literature, the two phenomena are usually discussed separately. This thesis studies the urban integration and fragmentation in the expansion area by considering the two phenomena as components of a continuum. The urban integration-fragmentation framework allows the analysis of dimensions of integration and fragmentation to (1) problematise the nature of the two phenomena, (2) better understand the interconnectivity between urban integration and fragmentation, and (3) serve as a basis for future research on this topic. The main objective of the thesis is to develop and apply an analytical framework for assessing integration and fragmentation of an urban area. For clarification of the framework's application, the thesis chooses the case study in Leidsche Rijn Centrum subdistrict, Utrecht city, The Netherlands. The dimensions and indicators of the framework are built according to literature about the topic of urban integration and fragmentation. Since the drivers and characteristic of urban integration and fragmentation vary according to contexts, the dimensions and indicators from the literature are modified according to planning documents of the Leidsche Rijn Centrum subdistrict, and the available data from Utrecht Municipality database. The main methods used in this thesis include case study research, interview and survey, and network analysis using QGIS. The results imply that Leidsche Rijn Centrum subdistrict is in the medium level of the urban integration – fragmentation framework. Although the relationships between different indicators and dimensions are mentioned in literature and also in the interview with Utrecht Municipality, the result from this analysis could not provide solid proof for those relationships. Future studies could focus on one of the two main topics: improving the accuracy of the framework and the relationship between the dimensions and indicators.

1. Introduction

1.1. Background and problem statement

Urban fragmentation is a phenomenon often encountered in urban areas facing urbanisation-related pressures, and a need to expand. Current literature describes urban fragmentation using various approaches such as settlement patterns, the characteristic of the population, accessibility to urban amenities, infrastructure distribution, to name but a few. In long-term, urban fragmentation can cause intensification of social segregation, racism and exclusionary land-use practices (Low, 2007). Some authors considered fragmentation as one of the reasons for insufficient uses and management of resources in cities. For example, urban fragmentation can intensify the disconnection between different elements in the infrastructures system, such as energy or traffic (Graham & Marvin, 2001; Monstadt & Coutard, 2019). Urban fragmentation can also cause proliferation of informal settlement, squatters and slum (Jimmy, Martinez, & Verplanke, 2019). Urban fragmentation can also lead to urban inequality and decrease in quality of life (Jimmy et al., 2019; Martinez, 2016; Moroke, Schoeman, & Schoeman, 2020). The antithesis of a fragmented city is an integrated city, meaning a city where socio-economic, spatial and demographic elements would share a similar structure and connect with each other. Macrorie & Marvin (2019) discussed urban integration as a factor for urban resource sustainability by presenting different frameworks (re)connecting fragmented infrastructure into an urban system (Macrorie & Marvin, 2019).

Current literature about urban integration and fragmentation usually focuses on the intrinsic characteristics of each phenomenon. For example, there are studies about urban integration with proposals for interventions to increase the level of integration within the area, and among different areas (Macrorie & Marvin, 2019; Monstadt & Coutard, 2019). Studies about urban fragmentation range from the development process of the urban area (Caldeira, 2000), to the relationship between physical fragmentation and social fragmentation (Bolt, Sule Özüekren, & Phillips, 2010), and negative consequences of urban fragmentation (Jimmy et al., 2019). This thesis discusses the two phenomena together as components of a continuum. Considering the two phenomena as components of a continuum is based on the observation that urban development is not always linear but can change between one form to another. For example, the project of HafenCity showcases a reconnection process of an abandoned area to the existing urban structure of Hamburg city, Germany (KCAP, 2019). This observation is also in line with Graham & Marvin (2001)'s discussion about the two concurrent processes of fragmentation and integration (termed "recombination" in their study) in a city (Graham & Marvin, 2001). By considering the two notions as components of a continuum, the urban integration – fragmentation framework might be helpful for municipalities to unentangle multiple elements influencing the integration and fragmentation level of an urban expansion area with the existing urban structure.

This thesis proposes a framework to quantify the level of integration and fragmentation of an area at a certain timestamp. From the academic perspective, the urban integration-fragmentation framework allows the analysis of dimensions of integration and fragmentation to (1) problematise the nature of the two phenomena, (2) better understand the interconnectivity between urban integration and fragmentation, and (3) serve as a basis for future research on this topic.

This thesis considers the quantitative perspective of urban fragmentation by considering the characters and the relationship between the expansion area with the existing urban structure through two main aspects, including the similarity level in urban structure, and the connectivity. The similarity level in urban structure aspect can be considered with various dimensions, including spatial structures (Balbo, 1993; Rotem-mindali, 2012) and the socioeconomic structure (Balbo, 1993; Coy, 2006). The connectivity with the existing urban structure can be understood as connectivity with urban facilities such as infrastructure (Coutard, 2008; Monstadt & Coutard, 2019), or public areas. In the context of this thesis, an urban area with a high level of integration with the existing urban structure when it has a high similarity level and connectivity with the existing urban structure. On the contrary, an area with a high level of fragmentation has a low level of similarity and connectivity with the existing urban structure.

In other to provide a real-world context for the urban integration and fragmentation index, the thesis uses a case study in Leidsche Rijn Centrum subdistrict, Leidsche Rijn district, an expansion of Utrecht City, the Netherlands. In 2015, the Dutch Government launched a national urban agenda called "Agenda Stad". The agenda confirms the crucial role of cities in the future development of the country (Nabielek, Hamers, & Evers, 2016). The pressure is more severe in the cities of the Randstad area - the urban area that includes the cities of Amsterdam, Leiden, Den Hague, Utrecht and Rotterdam. For example, 61% of the new housing units in an urban system built in the period 2000 – 2010 was in the Randstad (Broitman & Koomen, 2015). It might imply a high demand for urban development in the Randstad.

In line with that trend, the Utrecht municipality launched a large project in Leidsche Rijn district to cope with the housing demand from the Utrecht city with the ambition to create two complementary centres of the Utrecht city. Visually, the whole district appears separated from the existing city by the Amsterdam-Rijnkanaal and the major motorway connecting Utrecht and Amsterdam – A2 highway (Van Duppen & Spierings, 2013). Tremendous effort was made to abate the influence of the major road by providing a cover over the highway, as well as improving the public transport network to improve the connection between the two areas. One of the motivations for this effort is the principles defined for all housing projects in main urban areas of The Netherlands. Those areas are defined as VINEX-neighbourhood and are expected to become one coherent urban structure with the existing city (Galle & Modderman, 1997). Leidshce Rijn Centrum subdistrict has a common disadvantage of the new development area in the rapid urbanisation process, which is the distant location from the existing urban structure. The results from Leidsche Rijn Centrum subdistrict can presents example for strategies to overcome the disadvantage in proximity (Van Leynseele & Bontje, 2019).

1.2. Research objectives and research questions

The main objective of the thesis is to develop and apply an analytical framework for assessing integration and fragmentation of an urban area. This proposed a framework that treats fragmentation and integration as part of a continuum, and each concept represents an opposing end of this continuum. For that objective, it is necessary to understand how urban integration and fragmentation are described according to the relevant dimensions and develop a set of indicators to measure integration – fragmentation level according to the identified dimensions. To reach the main objective, a set of sub-objectives and research questions (RQ) is formulated:

Sub-objective 1: To understand how dimensions identified in previous research have been used to describe the phenomena of urban integration and fragmentation, and whether these dimensions consider integration and fragmentation as part of a continuum phenomenon of urban development

RQ 1.1 Which dimensions have been used in previous research to describe the integration and fragmentation of urban areas?

RQ 1.2 How did those dimensions quantify the level of urban integration and fragmentation of an urban area?

Sub-objective 2: To verify the urban integration-fragmentation framework by applying to the case study in Leidsche Rijn Centrum subdistrict

RQ 2.1 What are the dimensions and indicators that could measure the urban integration – fragmentation level of the studied area?

RQ 2.2 How to give a score for the urban integration – fragmentation level of the studied area?

RQ 2.3 What is the integration – fragmentation level of the Leidsche Rijn Centrum subdistrict in the urban integration – fragmentation index?

Sub-objective 3: To justify the urban integration-fragmentation framework by discussing the outcome from the case study

RQ 3.1 What is the relationship between the dimensions in urban integration-fragmentation?

1.3. Study area – Leidsche Rijn Centrum subdistrict, Utrecht

The development of Leidsche Rijn project started in 1997 and planned to finish in 2025 with the ambition to accommodate approximately 80,000 people, not only housing but also urban facilities including public space and services (van der Hoeven, 2012; Van Duppen & Spierings, 2013). The major residents of Leidsche Rijn district are from the city and older suburbs of Utrecht (van der Meulen, 2012).

Leidsche Rijn district consist of five subdistricts including Terwijde-De wetering, Het Zand, Leidsche Rijn Centrum, Parkwijk-Langerak and Leidsche Rijn Zuid. The planning document for Leidsche Rijn Centrum subdistrict mentions the hierarchy of

Leidsche Rijn Centrum subdistrict to be the second centre of Utrecht city, and complementary with the city centre (Binnenstad) of Utrecht city (Gemeente Utrecht, n.d.-a). Therefore, it is reasonable to compare the Leidsche Rijn Centrum subdistrict with Binnenstad district in quantifying the level of fragmentation of the area regardless the difference in administrative levels of the two areas.

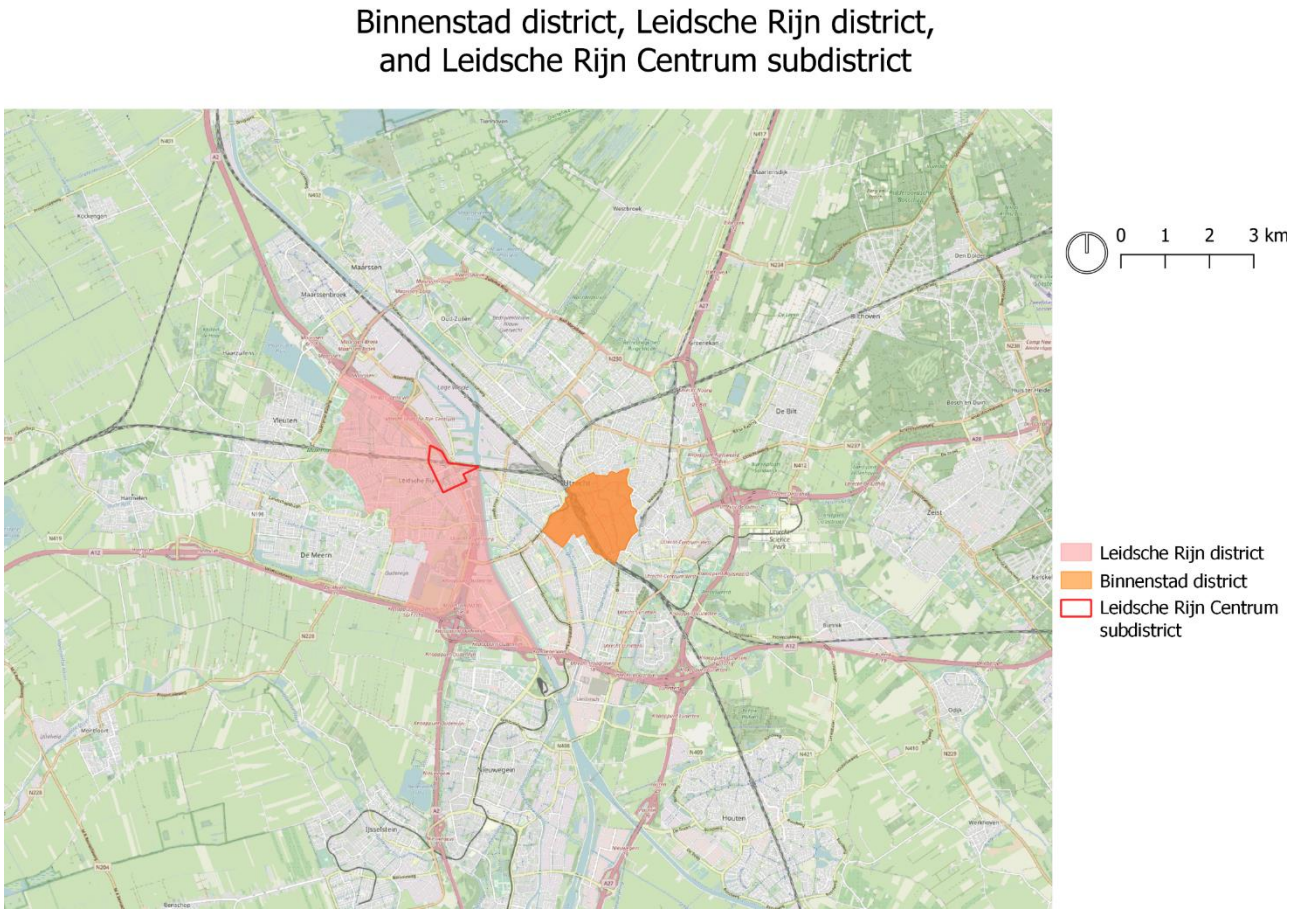

Figure 1-1 Marking of Leidsche Rijn Centrum neighbourhood and Binnendstad neighbourhood in the map of neighbourhoods in Utrecht adopted from Openstreetmap base map on QGIS, 2020

The project aimed to create a complementary centre for Utrecht region and reduce the pressure on the existing urban city centre (Gemeente Utrecht, n.d.-a). Leidsche Rijn should have its own identity and still be part of the existing urban structure of Utrecht city centre. According to the planning documents for Leidsche Rijn district project, the new expansion urban area, Leidsche Rijn district and especially the Leidsche Rijn Centrum subdistrict, is expected to integrate with the existing structure of Binnenstad district. The "second complementary centre" Leidsche Rijn Centrum subdistrict focuses on residential characteristics or termed in the Master Plan as "The living centre" ("Het levende centrum" in Dutch) (Gemeente Utrecht, n.d.-a). Accordingly, housing provision, high quality of public space, multi-function areas, and transport accessibility are some exemplar aspects mentioned in the Master Plan (Gemeente Utrecht, n.d.-a, 2009). According to the interview with Utrecht municipality, public facilities, and public spaces play an important role in integrating the two areas.

In term of distinguishing the area with the other parts of the city, two important elements mentioned in the Master Plan included constructing a cover above A2 highway to improve the connectivity with the existing city, and the green and canal network (Gemeente Utrecht, n.d.-b). Binnenstad district remains its key role in multiple aspects such as culture, entertainment, and leisure activities (Gemeente Utrecht, n.d.-a). In other to achieve the above-mentioned ambition, tremendous effort was made to decrease the influence of the major motorway and increase the connectivity between Leidsche Rijn Centrum subdistrict and Binnenstad district. Those elements make Leidsche Rijn Centrum subdistrict an appropriate case for the empirical study on the urban integration and fragmentation framework.

Increasing connectivity between the two centres through high-quality infrastructure was one of the main aims but also a great challenge (Gemeente Utrecht, n.d.-a; Jo-Coenen & Co Architekten, 2019). The overall concept for the development of Leidsche Rijn district referred to the model of a compact city where connectivity with the existing city centre is one of

the key aspects (van der Hoeven, 2012; Van Duppen & Spierings, 2013). The divisive major motorway A2 between Leidsche Rijn district and the existing city was one of the biggest problems. Major work was done to encapsulate the motorway to allow a physically close relationship between the two districts (van der Hoeven, 2012). Encapsulating the motorway also allows the district to develop housing and public facilities close to the motorway, to facilitate soft mode of transport (walking and cycling), and to reduce the negative influence of noise and air pollution (van der Hoeven, 2010, 2012).

As cited by van Duppen & Spiering (2013) in their study about cycling experience of people commuting between Leidsche Rijn and Utrecht city centre, the experience of passing through different territories could influence on the perception of seeing the city as a whole (Van Duppen & Spierings, 2013). However, the study recognised the positive contribution of the bridge and the tunnel encapsulating the motorway in smoothen the connection between the two areas (Van Duppen & Spierings, 2013).

2. Urban integration and fragmentation

This section contextualises the two phenomena urban fragmentation and integration, highlights definitions, drivers, together with dimensions and indicators describing the urban integration and fragmentation phenomena in current literature. The main objective of this chapter is to understand how dimensions identified in previous research have been used to describe urban integration and fragmentation, and whether these dimensions consider integration and fragmentation as part of a continuum phenomenon of urban development. This chapter addresses the research questions RQ 1.1 and RQ 1.2:

RQ 1.1 Which dimensions have been used in previous research to describe the integration and fragmentation of urban areas?

RQ 1.2 How did those dimensions quantify the level of urban integration and fragmentation of an urban area?

2.1. Drivers of urban integration and fragmentation

There are different explanations for the drivers of urban integration and fragmentation, ranging from rapid urbanisation processes to the political influence (Abdelbaseer A Mohamed, Akkelies Van Nes, Mohamed A Salheen, Marwa A Khalifa, & Johannes Hamhaber, 2014; Labbé & Boudreau, 2011; Monstadt & Coutard, 2019). Level of integration and fragmentation varied according to context and type of the fragments (Jimmy et al., 2019). For example, Monstadt & Coutard (2019) mentioned that urban fragmentation was the result of a complex combination of various factors including policy ambitions, social practices, institutional arrangements, knowledge and values, together with a set of artefacts with both enabling and constraining influence on city development (Monstadt & Coutard, 2019). At the opposite side of the phenomenon, they discussed different conceptual models to address the urban fragmented infrastructure and aimed to achieve a better functioning city such as resource efficiency and connectivity of urban infrastructure (Monstadt & Coutard, 2019). Meanwhile, Balbo & Navez-Bouchanine (1995) with the case study in Rabat-salé, Morocco, the outcome debated that physical fragmentation caused by rapid urban growth (Balbo & Navez-Bouchanine, 1995; Lak, Aghamolaei, & Azizkhani, 2018; McFarlane, 2018).

In the discussion about political influence to urban fragments, McFarlane (2018) highlighted that urban fragments have a deep influence in experience, rhythms, and politic of urban life, especially those in urban poverty and inequality, (McFarlane, 2018). He also debated that urban fragmentation could be the sources of urban transformation (McFarlane, 2018). Real estate speculative, privatisation and commodification of infrastructure and services, bubbles of exclusive high-end consumer, and labour exploitation could influence the urban transformation process (McFarlane, 2018) and could eventually lead to urban fragmentation (Fernández-Maldonado, 2008).

In the same line, governance, taxation and level of privatisation are other drivers influencing the level of integration and fragmentation of an urban neighbourhood (Low, 2007). In a study about satellite cities model in African cities, Van Leynseele & Bontje (2019) highlighted that in the investor-based development approach, it might happen that only a certain social group, for example, elite community, would afford to live in a specific area (Van Leynseele & Bontje, 2019). That description corresponds with the definition of urban fragmentation in this thesis. In that case, urban governance might have an important role in mitigating the fragmentation of the neighbourhood (Van Leynseele & Bontje, 2019). It is both the driver and indicator for the urban integration and fragmentation measurement.

The discussion about the economic aspect of the urban fragmentation has two distinctive perspectives. From the perspective of the residents in some urban fragments, especially the high-end gated communities, the homogeneity of community needs and desires were an efficient solution for the provision of goods and services (Low, 2007). Low (2007) argued that the restructuring of economic that intensified the existing inequalities of resources and services contributed to the emergence of the gated community in the United States (Low, 2007). The economic restructuring in that way escalated the burden on urban poor in numerous aspects, including housing, services and infrastructure, political and legal right, and economic opportunity (McFarlane, 2018).

The combination of political and economic influence is another contribution of the urban fragmentation process in some cases. For example, Coy (2006) highlighted in his study that real estate companies, the target group (economic influence), and public authorities (political influence) are the main actors of urban fragmentation. Real estate companies in housing

development projects focused exclusively on a social group with homogenous needs and desires (terms as "target group" in Coy's research), which eventually created sociospatial differences among neighbourhoods. In his study, this process fostered the fragmentation process in the city (Coy, 2006).

Gathering and separating a certain social group in a specific area would decrease the feeling of territorial belonging for the whole area. Eventually, the composition of a neighbourhood become more homogenous, and at the same time become distinctive with those among them. Gomez Maturano (2014) defined that condition as urban fragmentation (Gomez Maturano, 2014). In other words, an area is a fragment when it has two characteristics: 1) unified in the resident composition and 2) different in the resident composition of the overall city. In the context of this thesis, the quantification for the level of urban fragmentation was done by measuring the similarity of social elements of the study area with the existing city. The social elements worth considering included demographic and household characteristics. Studying the demographic would provide insights if there is a specific group in the study area that would increase the potential for the area to become a gated community.

Fear of crime, racism, and discrimination are other drivers of urban fragmentation (Farrell, 2008; Low, 2007). Due to concern about safety outside the neighbourhoods, especially of the residents in gated communities, residents in those exclusive areas tend to avoid contact with the outsiders. This concern led to physical barriers isolating those neighbourhoods. In Low (2007)'s study, the contact between residents in the gated community was little to none (Low, 2007).

The mentioned above drivers influence the urban physical and non-physical structure, as well as connectivity between different areas. This thesis discussed the definition of urban integration and fragmentation in two main aspects, namely the similarity level between the expansion area and the existing urban area. Both are described in the next section.

2.2. Urban integration and fragmentation as similarity in the urban structure

Fragmented urban areas usually differ significantly with the existing physical (Abdelbaseer A Mohamed et al., 2014; Lak et al., 2018; Legeby, 2015; Wan et al., 2019) and non-physical urban structure (Balbo & Navez-Bouchanine, 1995). For example, Lak et al. (2018) highlighted the fragmentation in Qehi by pointing out the contrast in urban pattern between the new development and the historical settlement (Lak et al., 2018). Abdelbaseer A Mohamed et al. (2014) highlighted urban fragmentation in Cairo with the description of its combination of small cities which spatially differ from each other (Abdelbaseer A Mohamed et al., 2014). Balbo & Navez-Bouchaine (1995) mentioned in their study that rural-urban migration and inter or intra-urban movements would encourage social integration by the concentration of analogous populations (Balbo & Navez-Bouchanine, 1995). In other words, areas with a high similarity level of urban structure could improve the overall level of integration among them. It also means that areas with low similarity level of urban structure could signify the overall level of fragmentation among them. This thesis analysed urban integration and fragmentation of the expansion area by measuring the similarity level between that area and the existing urban structure.

Elements of urban structure relating to urban integration and fragmentation cover both physical and non-physical aspects, in which urban fragments usually differ intensely with the existing city. Balbo (1993) described an integrated city as a combination of different parts, forming a unified organism in term of the physical environment, services, income, cultural values and institutional system (Balbo, 1993), while the fragmented city was described as the collection of "physically juxtaposed but architecturally and socially distinct" elements. These elements could vary at different levels from the neighbourhood levels to street levels (Balbo, 1993). In short, one approach for measuring the level of urban integration and fragmentation is the level of homogeneity among the various areas (Balbo & Navez-Bouchanine, 1995).

In term of physical urban structure, Balbo (1993) discussed the difference in the built environment between the fragments and the existing city (Balbo, 1993). He compared urban structure between western planned cities and cities in developing countries (Balbo, 1993). He mentioned that the difference in urban structure between urban fragments and existing urban structure varied at different levels from the neighbourhood levels to street levels (Balbo, 1993). On the street level, the similarity level of housing typology could provide insights for measuring the level of integration and fragmentation of a neighbourhood (Jimmy et al., 2019; Low, 2007). In line with that discussion, Seeliger & Turok (2015) mentioned low average density as an indicator to measure the urban fragmentation (Seeliger & Turok, 2015).

The urban form of land development provided insights to measure the level of urban integration and fragmentation (Jimmy et al., 2019; Low, 2007). According to Schneider & Woodcock (2008), land development is fragmented if it is patchy in style and have non-urban uses with urban function (Schneider & Woodcock, 2008). Accordingly, the following dimensions could access the urban fragmentation: 1) the spatial distribution of the area and 2) the components forming the structure of the area. In the first dimension, the area with patchy spatial distribution shall be more fragmented. In the later dimension, the area with a higher level of mixture between urban and non-urban uses are more fragmented. In this thesis, quantification of urban fragmentation focused on connectivity and the similarity of the area by studying components forming the structure of the areas.

In term of non-physical urban structure, various elements could contribute to the quantification of urban integration and fragmentation. Most of them focused on describing the socio-economic characteristic of the areas. For example, Bablo (1993) mentioned services, income, cultural values and the institutional system as dimensions to describe an urban fragment (Balbo, 1993). His description of urban fragments would be developed into the following subdimensions and indicators for quantifying urban integration and fragmentation, including 1) the ratio of specific physical elements in the city (for example, the ratio of different housing typology, the ratio of residential areas, the ratio of the public area), 2) the accessibility to services of different neighbourhoods, 3) the ratio of different income groups (for example, the ratio of the high-income group in comparison with the ratio of other income groups in a certain neighbourhood), 4) the ratio of elements contributing to the cultural value of the neighbourhood (for example, the ratio of different migration background population), and 5) whether the involvement of certain institution systems (for example, the existence of explicit regulation for the certain neighbourhood). Some other indicators measuring the level of urban integration and fragmentation included 1) the household size (the number of people per household), 2) household type, 3) age and sex of the head of the household, 4) the working population, 5) population with high education and 6) income (Balbo & Navez-Bouchanine, 1995).

Some of the above dimensions also arise in the study of more contemporary authors. For example, Coy (2006) and Low (2007) discussed urban fragmentation by studying gated communities (Coy, 2006; Low, 2007). Coy (2006) argued that the increase of gated housing areas in Latin America was the visible consequence of social disparities (Coy, 2006), while Low (2007) pointed out that the character of urban fragments varied from regions to regions (Low, 2007). In their study, the income-group composition was one of the aspects to study urban integration and fragmentation. Accordingly, income-group composition in urban fragments was homogenous (either high, or low, or middle-income group) and separated with the existing urban area (Bayón & Saraví, 2013; Coy, 2006; Low, 2007). Seeliger & Turok (2015) also shared the same concept by describing urban fragmentation as areas with large low-income settlements situating in the urban periphery (Seeliger & Turok, 2015). In the same line, Gomez Maturano (2014) discussed urban fragmentation with numbers of examples, including luxury city, gentrified city, suburban town of middle classes, the city of apartment blocks rented by the low-income working population, the ghetto in both racial senses and in the location exclusion, the very poor, the unemployed, the homeless (Gomez Maturano, 2014). Similar to the findings of other authors, urban fragments in his study also have distinct characteristics, which could be defined according to one specific dominant part of the population. At the micro-level, urban fragmentation is associated with “rupture, separation of social distancing in the city” (Gomez Maturano, 2014).

The non-physical urban structure also referred to the intrinsic characteristic of the population, such as demographic and social traits of the areas (Low, 2007; Schneider & Woodcock, 2008). Balbo & Navez-Bouchanine (1995) in their study about household’s residential trajectory in urban fragments considered two indicators: 1) the percentage of families living in the same dwellings before moving to the dwelling at the time of the survey, and 2) the ownership of the dwelling (owner-occupied or renter-occupied) (Balbo & Navez-Bouchanine, 1995). Balbo & Navez-Bouchanine (1995) studied family network as one dimension of urban non-physical structure and quantified it by measuring the ratio of families, of which members having family-related persons living in the same neighbourhood (termed “fragments” in their research) (Balbo & Navez-Bouchanine, 1995). Cultural pattern of social sanction/norm/authorisation, cultural meaning of certain elements in the city, and community identity are other dimension describing the non-physical structure of a neighbourhood when studying urban integration and fragmentation (Bolt et al., 2010; Low, 2007). Characteristics of the population could also be described by the composition of household structure, such as the ratio of the population according to age groups (retirement ages, young people, working ages), and composition of income group (Low, 2007).

Tenure composition is one of important element describing the non-physical structure of a neighbourhood that relates to the level of integration and fragmentation (Ruiz-Tagle, 2013). Balbo (1993) also mentioned tenure system as an element to consider spatial fragmentation in the city since different land tenure had different influence on the community (Balbo, 1993). This dimension would be developed to the ratio of different house ownership status in a neighbourhood to quantify

urban integration – fragmentation framework. He discussed population components as an important role in the causes of urban fragmentation (Balbo, 1993). He argued that natural growth and migration flows would have different influence in the city structure, especially in the form and characteristic of residential settlement (Balbo, 1993). His argument developed into an indicator for urban integration – fragmentation framework as the ratio of different migration background of the neighbourhood.

Social status, lifestyle, and security are other elements describing the non-physical structure of an area and provide input for measuring the level of integration and fragmentation (Bolt et al., 2010; Coy, 2006; Low, 2007). Coy (2006) described the characteristic of a fragmented city as follow: 1) high level of disintegration, 2) expansion of informal settlement and economy, 3) self-segregation of the privileged, 4), an increase of socio-economic and ecological conflict potentials, 5) high level of vulnerability, 6) loss of governability, 7) high level of urban-suburban conflicts and socio-economic disparities and 8) high level of disorganisation and destabilisation (Coy, 2006; Low, 2007). The ratio of crime and ratio of unemployment also describe the non-physical structure of a neighbourhood in the discussion of urban integration and fragmentation framework (Martinez, 2016). Migration background sometimes turns up while describing the non-physical structure of a neighbourhood in the discussion of urban integration and fragmentation (Ruiz-Tagle, 2013).

The relationship between physical fragmentation and non-physical fragmentation is still under debate. On the one hand, the physical urban structure interrelates strongly with non-physical urban structure (Abdelbaseer A Mohamed et al., 2014; Chen, Hui, Wu, Lang, & Li, 2019; Dewar, 2018; Lang, Long, & Chen, 2018; Legeby, 2015; Mouratidis, 2018; Tian, Wu, & Yang, 2010). It means that physical urban structure, for example, urban form, could influence different non-physical aspects of the city including socioeconomic characteristic (Tian et al., 2010), socioeconomic interaction (Hanson, 2000; Lak et al., 2018), poverty, inequality, unemployment (Dewar, 2018), accessibility, common resources, and other important features in the city (Legeby, 2015). At the same time, non-physical aspects, for example, fear of crime, could influence the built environment – physical aspect, such as the establishment of physical fences isolating the exclusive communities from the rest of the city (Sabatini & Salcedo, 2007). Various empirical studies also point out the association between physical urban structure and non-physical urban structure, for example, urban activities (Chen et al., 2019; Shaw & Yu, 2009; Tian et al., 2010). A study by Moroke et al. (2020) mentioned socioeconomic inequality as one of the factors causing spatial fragmentation (Moroke et al., 2020).

On the other hand, various empirical studies questioned the direct correlation between physical urban fragmentation and non-physical urban fragmentation. For example, the study of Andersson et al. (2010) criticised the direct link between physical integration and social integration with the example of housing policy. They highlighted that mixed housing could improve spatial integration but could not link with social integration (Andersson, Bråmå, & Holmqvist, 2010; Holmqvist & Bergsten, 2009). Their study implied the possibility of social fragmentation in a mixed housing neighbourhood. Their outcome aligned with the discussion of Balbo & Navez-Bouchanie (1995). Balbo & Navez-Bouchanie (1995) argued that not all physically fragmented areas have social components different from the rest of the city. With those cases, Balbo & Navez-Bouchanine (1995) did not consider them as social fragmentation (Balbo & Navez-Bouchanine, 1995).

In the similar topic, Ruiz-Tagle (2013) questioned the direct link between spatial fragmentation and social fragmentation and stated that physical proximity was just one dimension (Bayón & Saraví, 2013; Ruiz-Tagle, 2013). He argued that conceiving (physical) fragmentation as a result of the need for integrity and continuity for communities would neglect the major social consequences of fragmentation (Ruiz-Tagle, 2013). Ruiz-tagle also discussed different perspectives considering the idea of urban integration. He pointed out that the idea of "together-in-difference" (Young, 1999), which assumed that people in the same administrative area would turn into isolated groups, might not fully be considered the influence of economic inequality inside the stated area (Ruiz-Tagle, 2013). From an institutional perspective, he cited the work of Sheryll Cashin (2004) about two kinds of integrated communities, including mixed-race, middle-class enclaves and multicultural islands (Ruiz-Tagle, 2013). In the mentioned study, mixed-race, middle-class enclaves consist mainly of highly educated older suburbs neighbours articulated by a historical activist for diversity. Multicultural islands include an ample range of incomes and diverse tenure, attracting mixed-race middle-income residents without causing gentrification (Ruiz-Tagle, 2013).

Although the relationship between physical fragmentation and social fragmentation is not a causal relationship, the two aspects would intensify each other. Bolt et al. (2010) considered the link between urban social integration and spatial fragmentation was an interreacting relationship, especially between the minority ethnic groups and the host society (Bolt et al., 2010). They argued that ethnic mixing would not have direct causal influence with social integration (Bolt et al., 2010). In their study, residential fragmentation (term "segregation") was considered from a neutral perspective. The term

described the unequal distribution of a population group over a particular area (Bolt et al., 2010). Social integration was defined as "the process whereby the differences between ethnic/racial groups and the reference population gradually decline" (Bolt et al., 2010). In that sense, their definition was supported by some mentioned above authors about the equal accessibility to public amenity. Bolt et al. (2010) also argued that the integration process depended on both the reactions of that particular ethnic/racial groups and the reference population (Bolt et al., 2010).

This section discussed the similarity level of urban structure between areas as an approach to measure the level of integration and fragmentation of the areas. In general, a fragmented urban area constituted of distinctive parts which were unable to unite as a single organism (Balbo, 1993). However, considering only similarity level could not fully reflect all drivers of urban integration – fragmentation such as the inequality or separation among urban areas. Urban fragmentation could also happen without consideration of similarity among areas, for example, the case study in Sweden in Legeby (2010)'s study (Legeby, 2015). The presence of physical obstacles in studies about the gated community also implies the role of connectivity in measuring the level of integration – fragmentation of an area. Together with the measurement of similarity level between the urban expansion area and the existing city, this thesis measured the integration – fragmentation level with additional consideration to connectivity. The next section presents the measurement of connectivity in the measurement of integration – fragmentation level.

2.3. Urban integration and fragmentation as connectivity

The first part of this chapter points out that different drivers could have different influence on both similarity level and connectivity between urban expansion and existing urban structure. Connectivity is one of effective aspect to measure the integration – fragmentation level of an urban environment (Ellin, 2006; Lak et al., 2018). In the aspect of connectivity, urban fragmentation is the phenomenon that an area is disconnected with the existing city in infrastructure system (Bayón & Saraví, 2013; Graham & Marvin, 2001; Monstadt & Coutard, 2019; Schneider & Woodcock, 2008; Seeliger & Turok, 2015), urban form, and urban structure. The interaction among fragments are limited (Burgess, 2005; Jimmy et al., 2019; Rotem-mindali, 2012). In this thesis, connectivity in the urban integration and fragmentation refers to elements such as accessibility to the public facilities, unequal distribution of resources, and social interaction between different social groups or residential groups. Comparable to the similarity level in urban integration – fragmentation measurement, connectivity in urban integration and fragmentation measurement includes physical and social aspects. For example, the study of the fragmented city in Balbo's research pointed out that the urban poor has very low or no access to the infrastructure system (Balbo, 1993). It reflects low physical connectivity. Physical connectivity also includes the transport network and accessibility to public facilities and public space. The studies in gated communities with low interaction between exclusive residents and outsiders (Low, 2007) is an example of social connectivity.

Low physical connectivity could refer to the situation that fragmented areas have low accessibility or disconnection to the existing urban system, and eventually develop a separate system for themselves (Balbo, 1993). For example, the urban fragments in Balbo's description functioned autonomously, and eventually became separate "microstates" distancing themselves from the existing urban structure (Balbo, 1993). In Rotem-midali (2012)'s study on the retail fragmentation in cities, the concept of urban fragmentation describes disconnection in urban form, urban systems, and residential areas (Rotem-mindali, 2012). Low (2007) focused on the discussion of urban fragmentation in residential areas by studying various gated residential areas in diverse contexts (Low, 2007). Although the subject of the two studies was different, they both recognised the disconnection between fragments with existing urban structure. One of the causes of the disconnection was physical obstacles and enclosures with limited social encounter among different groups (Jimmy et al., 2019; Low, 2007; Martinez, 2016; Rotem-mindali, 2012).

Gated communities provided an exemplar image for the low accessibility to urban facilities, which usually due to the presence of physical walls surrounding those exclusive areas (Balbo & Navez-Bouchanine, 1995). In the gated communities, the disconnection between urban fragments and existing urban structure reflects in the restricted access not only to residents' home but also to the use of public spaces and services such as roads, parks, facilities and open spaces explicitly designated for a certain neighbourhood (Bayón & Saraví, 2013; Low, 2007).

In some cases, urban connectivity in urban fragment and integration relates to the intrinsic characteristics of the areas that influence to the opportunity to interact and connect with the urban system, such as the preference of residents, accessibility

to infrastructure and service, the household's residential trajectory within the neighbourhood, and the family network and its spatial location (Balbo & Navez-Bouchanine, 1995). Balbo & Naver-Bouchanine (1995) measure those dimensions by the following sub-dimensions: 1) the relationship between residence and the place, measured by the percentage of the population living and working in the same neighbourhood, and 2) the choice of place to live and work, measured by the percentage of the population considering the workplace of the head of the household while choosing a place to live (Balbo & Navez-Bouchanine, 1995). Regarding the accessibility to infrastructure and services, Balbo & Navez-Bouchanine (1995) used the percentage of the population attending the infrastructure and service at different locations (nearest service or elsewhere) as an indicator (Balbo & Navez-Bouchanine, 1995). Balbo & Naves-Bouchanine (1995) also used the frequency of the population coming to the focal point of the agglomeration to measure the accessibility to infrastructure and services (Balbo & Navez-Bouchanine, 1995).

In line with the mentioned above discussion, an area disconnects with the infrastructure system of the existing city is also an example of urban fragmentation (Bayón & Saraví, 2013; Graham & Marvin, 2001; Monstadt & Coutard, 2019; Schneider & Woodcock, 2008; Seeliger & Turok, 2015; Zérah, 2008), urban form, and urban structure, the phenomenon of urban sprawl shares some characteristic with urban fragmentation. Schneider & Woodcock (2008) adopted the definition of urban sprawl as a form of growth, including scattered development with lack of accessibility and connectivity between different buildings and infrastructure (Schneider & Woodcock, 2008). It means that the accessibility to urban facilities, for example, network distance jobs or commercial areas, could be used as dimensions to measure urban sprawl in Schneider & Woodcock (2008)'s study, and also as dimensions to measure integration – fragmentation level (Bayón & Saraví, 2013; Schneider & Woodcock, 2008). In short, the above discussion suggests the following indicators for the urban integration and fragmentation framework: 1) accessibility to existing facilities and 2) distance to the job or commercial areas.

Accessibility to urban functions, such as public space and urban services, is one of the common dimensions in the discussion about connectivity between urban fragments (Bayón & Saraví, 2013; Coy, 2006; Peregrino, Brito, & Silveira, 2017). There are different approaches to measure accessibility to urban functions, for example, the connectivity of road network (Omer & Zafrir-Reuven, 2015; C. Zhang, Huang, Cao, & Shen, 2019), or the distance to urban facilities (Seeliger & Turok, 2015). Omer & Zafrir-Reuven (2015) measures the connectivity of the road network by the number of connecting routes that link given areas to the city road network (Omer & Zafrir-Reuven, 2015). Seeliger & Turok (2015) explained the negative influence of the large distance between the two areas to its connectivity in consideration of the effectiveness of the transport system (Seeliger & Turok, 2015). Their study pointed out that long-distance from urban functions increased the cost in human resources, economic and environmental impact due to lengthy journeys decreased the effectiveness of the transport system (Seeliger & Turok, 2015), which could eventually decrease the connectivity between the expansion areas and the existing city. In the consideration of connectivity in uban integration and fragmentation of this thesis, accessibility to urban facilities is one dimension to quantify the connectivity between expansion areas and existing city. The outcome contributed to the measurement of urban integration and fragmentation level.

The disconnection between urban fragments and the existing city could have root in social disparities (Coy, 2006). Depending on the specific context, social disparities could include segregation and exclusion, unequal access to physical and social infrastructures, for example, jobs and amenities (Bayón & Saraví, 2013; Bolt et al., 2010; Martinez, 2016; Seeliger & Turok, 2015), or urban infrastructure as water and electricity (MacKillop & Boudreau, 2008). Bayón & Savarí (2013) described urban fragmentation by the level of social interaction (Bayón & Saraví, 2013). They discussed that in an urban fragment, the social interaction between the privileged and the lower classes was weak and encounter with other in public spaces would be avoiding or rejecting (Bayón & Saraví, 2013). The growing closure of the privileged sectors and the isolation of the poorest are examples of urban fragmentation process (Bayón & Saraví, 2013). In other words, the level of goods and services provisions could measure the level of integration and fragmentation of an urban area (Low, 2007).

2.4. Urban integration and fragmentation as a continuum

In the discussion about urban fragmentation (termed "splintering" in the original research), Graham & Marvin (2001) emphasised the critical role of infrastructure networks in the urban development process since infrastructure influenced on different aspects of urban life (Graham & Marvin, 2001). They recognized the concurrence of fragmentation and integration (term "recombination" in their research) processes in cities (Graham & Marvin, 2001). Accordingly, the research might support the continuation between fragmentation and integration. Graham & Marvin (2001) also highlighted the

strong link between the experience of the city and the interchange generated by the circulation of people, vehicles, and information (Graham & Marvin, 2001). Accordingly, the level of integration of a city would be measured by the density of circulation between people, vehicles and information within the city.

As a summary, some of the above-mentioned studies discussed urban integration and fragmentation together (Farrell, 2008; Jimmy et al., 2019; Lak et al., 2018; Zérah, 2008), but only a few of them considered the two phenomena as a continuum (Bolt et al., 2010; Graham & Marvin, 2001). In the context of this thesis, urban integration and fragmentation were considered by comparing the targeted area with the reference area with which it might integrate with or fragment. In other words, urban integration is defined as areas with a high similarity level and high connectivity with a pre-existing urban structure, while urban fragmentation is represented by areas with a high level of heterogeneity and disconnectivity from a pre-existing urban structure. Urban fragmentation and integration are discussed together as components of a continuum in consideration of the two aspects: (dis)similarity and connectivity with pre-existing urban structure. The measurement of the level of integration and fragmentation of an area should cover both physical and non-physical aspects (i.e. socioeconomic, cultural aspects) as the direct link between physical and non-physcial aspects are still arguable among authors. Section 2.5 summarises all dimensions that quantified urban integration and fragmentation explored in the literature above, regardless of the context of the study area.

2.5. Summary dimensions and indicators measuring the level of urban integration and fragmentation

Table 2-1 summaries all the dimensions and indicators discussed above. The extended table with quotations from literature is in Appendix A. There is an overlap in the use of dimensions to quantify urban integration and fragmentation despite the variety in the context of the study areas. However, it might be arguable that those dimensions, even the overlapped ones, were universally used to quantify urban integration and fragmentation since urban development is a complex process and each context might link to one dimension stronger than the other. In Chapter 3, dimensions quantifying urban integration and fragmentation shall be developed from related planning document and literature directly linking with the case study.

Table 2-1 Summary of dimensions and indicators used to measure urban integration and fragmentation in the existing literature

Aspect	**Dimensions**	**Subdimension/ *Indicator***	**Scale**
Structure of physical elements in the city	Settlement pattern	Visual shape of settlement pattern whether it is continuous or discontinuous	
	Settlement pattern	The similarity in characteristics of: - Service - Income - Cultural value - Institutional systems	The measurement could be at different scales from neighbourhood to street level, but the elements should be at the same scale
	Settlement pattern	- *The population density in an urban area* - *The amount of land developed per person* - The spatial extent of urban areas - *The rates of land conversion*	
	Characteristic of settlement	- Formation - Location - Size - Fitting - Construction typology	Neighbourhood level
	Housing typology	- Aesthetic value	
Structure of non-physical element in the city	Meaning of public space	- Cultural meaning - Cultural pattern of social sanction/norm/authorisation	The measurement could be at different scales from neighbourhood to street level, but the elements should be at the same scale
	House ownership composition	- *The ratio of different house ownership structure (for example ratio of the rental house, ration of self-own houses depending on the specific context)*	The measurement could be at different scales from neighbourhood to street level, but the elements should be at the same scale
	Characteristic of population	- *Rate of urban population growth* - Components of the population, including: + Migration background + Population density + Ratio of the population in urban areas + Amount of land developed per person + Citizenship - The working population - Population with high education	+ Between neighbourhoods *(Balbo, 1993)* + Varied: per country, census block (Schneider & Woodcock, 2008)
	Household characteristic	- Household size - Household type - Age and sex of the head of the household	
	Socio-economic characteristics and social structure	- Lifestyle - Status - The expansion of informal settlement and economy - Self-segregation of the privileges - Increase of socio-economic and ecological potential - *Level of vulnerability* - Loss of governability	

		- Level of urban-suburban conflicts and socioeconomic disparities - Identity - Income - Taxation *- Degree of privatisation*	
	Governance and organisation	- Level of disorganisation and destabilisation - Role of the state	
	Relationship between residents and the place	*Percentage of population living and working in the same neighbourhood*	
	Choice of place to live and work	*Percentage of the population choosing a place to live according to the workplace of the head of the household*	
	Household's residential trajectory	*- Percentage of families living in different neighbourhoods before the time of the survey*	
	Family network	*- The ratio of families, of which members having relatives living in the same neighbourhood*	
	Safety and security	- Fear of crime	
connectivity	Accessibility to services and infrastructure	- Auto dependence - Road network accessibility *- Distance to jobs or commercial areas* *- Distance to public facilities* *- The ratio of the population choosing cars as a key means of transport instead of public transport* - Provision of goods and services - Place of preference for public facilities *- Existing of restriction to access public space*	
	The visual form of the neighbourhood	*- Having fences and/or other types of barrier to separate the neighbourhood from the rest of the city/ surrounding areas* *- Having fences and/or types of barrier to prevent outsiders from accessing the exclusive public facilities in the gated communities*	Neighbourhood level

3. Urban integration and fragmentation in the case study of Leidsche Rijn Centrum subdistrict

The drivers and characteristics of urban fragmentation varied according to the context of the area (Low, 2007). Therefore, the quantification of urban integration and fragmentation should consider the specific character of the area, such as the cultural background, historical development, or planning ambition. This thesis uses the case study in Leidsche Rijn centrum to clarify the methodology to quantify the urban integration – fragmentation level of an expansion area. This chapter focuses on the integration and fragmentation in the Leidsche Rijn Centrum subdistrict and address research question RQ 2.1 and RQ 2.2:

RQ 2.1 What are the dimensions and indicators that could measure the urban integration – fragmentation level of the studied area?

Leidsche Rijn is the biggest Dutch VINEX-neighbourhood (Van Duppen & Spierings, 2013). Therefore, the development concept of Leidsche Rijn and especially the Leidsche Rijn Centrum should adhere to the general guidelines dictated in this document. According to the VINEX regulations, development within those areas should integrate with the core city as a single coherent urban structure (Galle & Modderman, 1997). In the discussion about how development in VINEX area could integrate with existing urban structure, Galle & Modderman (1997) mentioned three aspects including 1) mobility, 2) social and economic resources and 3) open areas (Galle & Modderman, 1997). Galle & Modderman (1997) also referred to the model of the compact city as an example of an integrated urban environment (Galle & Modderman, 1997).

According to the discussion in the interview with the director of spatial development and urban planning Leidsche Rijn, Vleuten-De Meern and manager of team Urban planning Leidsche Rijn, Utrecht Municipality, an integrated city is defined as having a place for everyone. In monitoring the integration level of the area, it is important to monitor the composition of different elements, for example, housing, public facilities and amenities, in the area (Utrecht Municipality, interview, 2019).

> *An integrated city has a place for everyone. So it's important that you have a mixture, a correct variation of facilities and amenities. And you need to keep a check on whether the balance is still correct. Because sometimes, for example, you need to check whether the other facilities are still okay. If housing goes up, and other things seem to go up as well. The most important is to keep in mind that you need to integrate all different households. And if you have a lack of a particular type of population, then it means a poorer constitution of your population. So you need to make sure that you have something for everyone.*

This thesis discussed the urban integration – fragmentation level of Leidsche Rijn Centrum subdistrict according to two aspects: 1) similarity level of urban structure between the subdistrict and the existing city centre, Binnenstad district, and 2) the connectivity between the subdistrict and the existing city centre, Binnenstad district.

3.1. Dimensions and indicators describing the integration and fragmentation level in similarity level of urban structure

Multiple dimensions and indicators could be used to monitor the integration – fragmentation level of the areas such as the provision of housing type, public areas, house ownership, family structure, and income. Those dimensions and indicators are discussed in more detail in the latter part of this chapter.

i. Housing types

In the context of the Netherlands, the composition of housing type contributes to the overall picture of population characteristics (Leidelmeijer, Marlet, Ponds, & Woerkens, 2014). Housing type connects with the living area of the household, which influences the housing price or rental price (Leidelmeijer et al., 2014). Different housing types also influence the architectural design of the residential buildings, not only the exterior appearance but also the building

density. For example, a neighbourhood with a high ratio of terrace houses, in general, expects lower building density because a terrace house, in general, has lower built density than a neighbourhood with a high ratio of apartments. Eventually, it can influence the differences in urban structure and urban life in the two areas. The difference in housing type could link with the difference in other aspects of the urban structure, including the physical appearance, building density, and possibly the population characteristic. In the discussion of integration and fragmentation, those differences influence the physical structure, and possibly the social structure of the two areas.

Leidshce Rijn project started as an approach to address the development of Utrecht, especially with the housing demand of the region. In the area of Leidsche Rijn Centrum, attention focused more on apartments, which refer to the target group of young people and young families (Gemeente Utrecht, n.d.-d). Non-stacked houses are also provided for other population groups (Gemeente Utrecht, n.d.-d). This thesis used similarity in housing type composition as an indicator to quantify the similarity of the two areas, which is one of the two main aspects to quantify the urban integration – fragmentation level.

Figure 3-1 Apartment with commercial functions at ground floor(s) in Leidsche Rijn Centrum

Figure 3-2 Non-stacked houses in Leidsche Rijn

ii. Public areas

The housing development is one of the important element of Leidsche Rijn Centrum project, but it should tie to the development with other facilities and development of public areas is the starting point (Gemeente Utrecht, n.d.-a, Utrecht Municipality, interview, 2019).

> *"The objective of development has become bigger. At first, we were only targeting 30 thousand houses. But now it is thirty-eight thousand. And the growth of employment and greenery, all goes hand in hand with the bigger targets. The development needs to be in balance. So if you add housing, you also need to add water, greenery, areas to relax."*

The important role of facilities, such as public area, including green spaces, water surface, and recreation area also arose in the discussion about the integrated city during the interview with Utrecht Municipality (Utrecht Municipality, interview, 2019):

> *"An integrated city has a place for everyone. So it's important that you have a mixture, a correct variation of facilities and amenities. And you need to keep a check on whether the balance is still correct. Because sometimes, for example, you need to check whether the other facilities are still okay. If housing goes up, and other things seem to go up as well. The most important is to keep in mind that you need to integrate all different households."*

Public areas have a major influence on the level of integration of the Leidsche Rijn project. This reflects in the planning documents with emphasis on the provision of the public area in Leidsche Rijn for both residents of Leidsche Rijn and residents from surrounding areas (Lenting, 2004). Among other attempts to provide public areas in Leidsche Rijn project, the strategy of covering the A2 highway and build on top of the cover parks and square is the most noticeable. This "roof" above the A2 highway is the main connector between the area and the existing city centre.

In this thesis, public areas structure is one of dimension used to quantify the similarity of the two areas in the urban integration – fragmentation measurement. Public areas in the context of this thesis include open spaces such as parks, squares, greenery, and water, and public services (both indoor and outdoor public services).

Public areas structure dimension consists of two indicators: 1) the ratio of the public area (both indoor and outdoor) in the total land use, and 2) the composition of different function of public areas (both indoor and outdoor). The ratio of public space and public service area gives an overview of the proportion of public areas

iii. Non-physical urban structure

In the mission of "making Leidsche Rijn a piece of Utrecht city", AWG Architect discussed that it is not simply imitating the external appearance of the two areas (AWG architects, 2019). It implied that together with the similarity in the physical structure between the expansion area and the existing city, the non-physical urban structure which could reflect the character of the area can influence the integration – fragmentation level of the two areas.

According to the discussion during the interview with Utrecht Municipality, house ownership, and income are among the elements that can describe the integration – fragmentation level of an area (Utrecht Municipality, interview, 2019):

> *"A fragmented city is if one particular group of people live primarily in one area. And we tried to combat that by creating a balance between house ownership. So rental properties and properties that can be bought by creating different types of housing in cheap, middle, and expensive housing."*

In the discussion about the development of the Leidsche Rijn project with Utrecht Municipality, monitoring the composition of family structure could provide input for monitoring the integration – fragmentation level of the area (Utrecht Municipality, interview 2019):

> *"A balance is needed not only in the amenities and facilities that you offer but also according to the household phases in which they are developing. For example, whether you are a young family or a senior citizen makes a difference in the type of housing that they need, and also advance in the types of salaries that people have."*

In the context of this thesis, non-physical urban structure elements are selected according to the study from the literature review presented in the previous chapter, which includes house ownership, family structure, and income.

In summary, in the aspect of similarity level in the quantification of the urban integration – fragmentation level of Leidsche Rijn Centrum subdistrict, this thesis discussed six dimensions including housing types, public areas (which reflect the physical urban structure), house ownership, family structure, and income (which reflect the non-physical urban structure). Those dimensions are summarised in Table 3-1 at the end of this chapter.

3.2. Dimensions and indicators describing the integration and fragmentation level in the connectivity

Connectivity is another aspect that has an important role in the mission "making Leidsche Rijn a piece of Utrecht city (AWG architects, 2019). It implies that measuring the connectivity between the Leidsche Rijn Centrum subdistrict and Binnenstad could contribute to the measurement of integration – fragmentation level of the area. The planning documents of Leidsche Rijn Centrum considered connectivity as an important element of the neighbourhood. The master plan of Leidsche Rijn Centrum mentioned connectivity for the car-based network, public transport, bicycle and pedestrian (Gemeente Utrecht, 2009). The planning documents also included the provision for parking (for both cars and bicycles) to foster the connectivity with other areas (Gemeente Utrecht, 2009).

The Leidsche Rijn Centrum project focuses on developing public facilities and infrastructure as an approach to connect the new expansion area with the Utrecht city centre (Gemeente Utrecht, n.d.-a; Lenting, 2004). Formerly, the Leidsche Rijn area was separated from the Utrecht city centre by the A2 highway. A tremendous effort was made to cover the highway partially to increase the accessibility to the neighbourhood by all means of transport (Lenting, 2004).

In this thesis, the connectivity between the Leidsche Rijn Centrum subdistrict and Binnenstad is measured by two indicators: 1) network distance between residential areas in the Leidsche Rijn Centrum subdistrict and the public areas in the Binnenstad districts, and 2) the ratio of the population choosing cycling and walking to go to Binnenstad. Figure 3-3 to 3-6 below presents some of the popular public areas in Binnenstad district.

Figure 3-3 Hoog Cathrijne shopping centre

Figure 3-4 Tivoli Vredenburg - cultural and entertainment centre in Binnenstad District

Figure 3-5 Steenweg shopping street in Binnenstad

Figure 3-6 de Bijenkorf Utrecht - shopping centre in Binnenstad district

Figure 3-7 The surrounding of Dom Tower when the building is under maintenance (picture was taken in 2020)

Figure 3-8 The cafe surrounding Dom Tower when the building is under maintenance (picture was taken in 2020)

Table 3-1 at the end of this chapter summarises the indicators and dimensions measuring the integration – fragmentation level of the Leidsche Rijn Centrum subdistrict.

3.3. Summary of the dimensions and indicators in the case study of Leidsche Rijn Centrum subdistrict

The planning documents of Leidsche Rijn Centrum focuses on creating mixed-function urban areas with the aim to provide a lively urban environment and to create a complementary centre with Binnenstad (Gemeente Utrecht, n.d.-a). In other words, the main focus of the planning documents is physical elements. Integration of physical elements, for example, mixed housing type, does not always connect with social integration (Andersson et al., 2010; Holmqvist & Bergsten, 2009). Therefore, including non-physical dimensions, for example, housing ownership, family structure (family structure), and income, in the urban integration and fragmentation provides a more accurate picture about the level of integration and fragmentation of the two areas.

In the Master Plan of Leidsche Rijn Centrum, transport accessibility is one of the main discussion points. A sophisticated study was done with ambition to optimise the connection between the two areas via a car-based, public transport, bicycle and walking network. Evaluating the accessibility of all means of transport requires a complete study on all aspects such as the influence of road design on decision making of the citizen on selecting route and means of transport, or the inter-relationship between different networks. This thesis will only focus on the aspects of distance from residential buildings to the public transports connecting the two areas, and the ratio of bicycle lanes to the total road network.

Table 3-1 summarises dimensions and indicators for quantifying urban integration and fragmentation in Leidsche Rijn Centrum.

Table 3-1 Combination of dimensions and indicators from literature and planning documents for urban integration and fragmentation between Leidshce Rijn Centrum and Binnenstad (Utrecht)

Aspect	Dimensions	Indicators	Scale	Rationale	Source type
The similarity in urban structures	Housing types	The ratio of the five different housing types: 1) Appartement 2) Terrace houses 3) Corner houses 4) Two houses under one roof 5) Free-standing houses	Leidsche Rijn Centrum and Binnenstad	- (Low, 2007) - The planning documents of LRC mentioned apartment as one character of the area but also mentioned other housing types. The indicator was modified according to the content on Utrecht Municipality database	From general literature From project of Leidsche Rijn
	Public areas	The ratio of public areas in the total land-use	Leidsche Rijn Centrum and Binnenstad	- The planning document of LRC mentioned public space, including squares, parks and water surface (canals) as one of the key characteristics of the area.	From project of Leidsche Rijn
	Composition of public areas	The ratio of the different public area: 1) Public service area 2) Social-culture service area 3) Greenery 4) Water surface 5) Other recreative service areas	Leidsche Rijn Centrum and Binnenstad	- Public areas and public service with different function promote different activities and influence the social interaction of the neighbourhood	From the project of Leidsche Rijn
	Structure of house ownership	The ratio of different tenure status: 1) self-owning 2) rental social housing 3) rental housing other than social housing 4) unknown ownership	Leidsche Rijn Centrum and Binnenstad	- (Balbo, 1993) - The ownership of the house would influence the quality of social life. (S. Zhang, Hou, & Chen, 2019) - In the Dutch housing management context, (social) housing providers are housing associations and have influence in the society (Costarelli, Kleinhans, & Mugnano, 2019). Housing association (social housing) use the social mix as a tool to re-balance the social composition	From general literature
	Family structure	The ratio of different household structure: 1) living alone (alleenstaand) 2) couple without child(ren) (paar zonder kind(en)) 3) couple with child(ren) (paar met kind(en)) 4) single parent (eenoudergezin) 5) other (overig).	Leidsche Rijn Centrum and Binnenstad	- Low (2007) emphasis on the retirement population but it could be generalised to the higher level. - The indicator was modified according to the content on Utrecht Municipality database	From general literature
	Income	The normalised value of income using Binnenstads district's average income as the reference	Leidsche Rijn Centrum and Binnenstad	- (Balbo, 1993), (Bayón & Saraví, 2013) - The indicator was modified according to the content on Utrecht Municipality database	From general literature
Connectivity	Distance to the public facilities	The average distance from residential buildings, and the residential neighbourhood to public facilities in Binnenstad, including: 1) Hoog Catherijne 2) Steenweg (shopping street) 3) de Bijenkorf Utrecht 4) TivoliVredenburg 5) Dom Tower 6) Museum Catharijneconvent 7) Universiteitsmuseum 8) Nijntje museum 9) Central museum 10) Universiteitsbibliotheek Utrecht Binnenstad	Leidsche Rijn Centrum in compare with other districts	(Bayón & Saraví, 2013) The planning document of LRC mentioned public transport as one important element to connect the area (LRC) with the Binnenstad of Utrecht (Gemeente Utrecht, 2009)	From general literature From project of Leidsche Rijn
	Bicycle and pedestrian accessibility	The ratio of bike chosen as an option to go to Binnenstad	Leidsche Rijn Centrum in compare with other districts	The planning document of LRC mentioned the important role of bike-accessibility as one of the strategy transport	From the project of Leidsche Rijn

4. Methodology

The main objective of the thesis is to develop and apply an analytical index for assessing integration and fragmentation of an urban area. Wong (2006) suggested four steps of indicators development, including 1) conceptual consolidation, 2) analytical structuring, 3) identification of indicators and 4) creation of an index (Wong, 2006). The previous chapters define the definition for urban integration and fragmentation, as well as develop the set of dimensions and indicators to measure the urban integration – fragmentation level from literature (chapter 2), and for the case study in Leidsche Rijn Centrum subdistrict (chapter 3).

This chapter discusses a method to build an index for measuring the integration – fragmentation level for Leidsche Rijn Centrum subdistrict. In other words, this chapter develops an index for each indicator in the urban integration – fragmentation framework to answer the research question RQ 2.2:

RQ 2.2 How to give a score for the urban integration – fragmentation level of the studied area?

The first part of this chapter summarised the data used in this thesis. Following sessions explain the methods used in this thesis to develop the urban integration – fragmentation index, including case study research method, interview and survey method, network analysis method, and indicator development.

4.1. Data

Unless specified otherwise, data used in this thesis is collected by the author from three main sources: 1) the fieldwork, including interview and site pictures, 2) from the open database of Dutch government at national and municipality level, and 3) public databases. Table 4-1 below summarised the dataset used in this thesis.

Table 4-1 Summary of datasets used

SN	Type of data	Name of source	Address	Note
1	Census data	Utrecht in Cijfers	https://wistudata.nl/	The census data for Binnenstad district is the average of its two subdistricts: subdistrict for shops and commercial activities ("Binnenstad en winkel gebied" subdistrict), and subdistrict for living area ("Binnenstad en wonning gebied" subdistrict)
		Statistic Netherlands (*Het Centraal Bureau voor de Statistiek* – CBS)	https://opendata.cbs.nl/	
2	Maps	Pulic services on map (Publieke Dienstverlening Op de Kaart – PDOK)	https://www.pdok.nl/	
3	Pictures	Taken from the fields during the time of the thesis (2019 – 2020)		
4	Interview	Interview with Utrecht Municipality on 14 February 2019		The transcript of the interview is available upon request

4.2. Case study research.

The dimensions measuring urban integration and fragmentation level differ according to its context, and drivers such as planning regimes, or cultural backgrounds (Low, 2007). Case study research helps to provide real-world understanding and the context for the analysis (Yin, 2014). Since the main objective of the thesis is to develop and apply an analytical framework

for assessing integration and fragmentation of an urban area, case study research is required to clarify the application the urban integration – fragmentation index.

In this thesis, the urban integration and fragmentation index of an area was considered by comparing it with the existing city in two aspects: 1) the similarity level in urban structure between the two areas, and 2) the connectivity between the two areas. One of the most critical visions for Leidsche Rijn project is to have the new neighbourhood connecting with the old city. The municipality wanted the area to be a second complementary centre for Utrecht city centre and at the same time to have its own identity. One architectural office involved in the project aimed to make Leidsche Rijn part of Utrecht city centre by reference to the existing urban structure (AWG architects, 2019). The report about the Leidsche Rijn project also mentioned an ambition to have social interaction between the neighbourhood and Utrech city (Lenting, 2004). Therefore, the Leidsche Rijn project is a suitable case to explore dimensions of integration and fragmentation, and similarity and the level of connectivity of the extension area with the existing urban structure.

4.3. Interview and survey

As mentioned above, the measurement of urban integration and fragmentation level differs according to its context (Low, 2007). This thesis conduct an interview with Utrecht Municipality with main focus on objectives: 1) clarification on the detail of planning documents of Leidsche Rijn and Leidche Rijn Centrum project, and 2) the perspective of Utrecht municipality's perspective on the dimensions, subdimensions and indicators identified from literature about urban integration and fragmentation, and planning documents of the projects. The interview was arranged via a contact provided on the main page of Utrecht Municipality. The interview template with interview questions, and general description of the interview (time, location, number of attendants, main discussion) is presented in the Appendix.

As noticed from the literature about urban integration and fragmentation, there is no uniformity in the choice of indicators and dimensions used in existing research. While there are overlapping dimensions, subdimensions, and indicators, there are also some dimensions and indicators emerge only in a certain context. It suggested that the relevance and influence of dimensions and indicators varied according to the context of the study area. Therefore, apart from the interview, the thesis also conducts a survey to weight the level of importance from 1 to 4 (1 being not important, 4 being extremely important) of each dimension in the urban integration – fragmentation framework. The respondents are members of the project team in the Leidsche Rijn project. The survey was conducted by using Google form send to the contact information provided on the main page of Utrecht Municipality after the interview. There are three responses from the project management team of Utrecht municipality. The value used for the final weight used in this thesis is the average of the three responses. For example, for the housing type dimension, there is one response giving the weight of 2 and two responses giving the weight of 3. Hence, the overall weight for this dimension is the average of 2; 3; and 3: 2,6 (((2 + 3 + 3)/3 = 2,6). By the time of the survey, the dimension of bicycle and pedestrian accessibility was not included. Because of that, the thesis discusses the overall score with the following scenario:

1. Not consider the weight

2. Consider the weight according to the outcome from the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 1

3. Consider the weight according to the outcome from the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 2

4. Consider the weight according to the outcome from the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 3

5. Consider the weight according to the outcome from the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 3

The format of the survey is presented in the Appendix.

The overall integration – fragmentation score is considered using the weight from the survey with Utrecht Municipality. The survey respondents give the value from 1 to 4 (with 1 being the least important, and 4 being extremely important) for each dimension. There are three responses from the project management team of Utrecht municipality. The value used for the final weight used in this thesis is the average of the three responses. For example, for the housing type dimension, there is one response giving the weight of 2 and two responses giving the weight of 3. Hence, the overall weight for this dimension is average of 2; 3; and 3 (i.e. (2 + 3 + 3)/3): 2,6. By the time of the survey, the dimension of bicycle and pedestrian accessibility was not included. Therefore, in the section discussing the overall score with the weight, the thesis includes some scenario for this dimension.

4.4. Network analysis for connectivity between the two areas

One of the dimensions used in this thesis is the distance between specific areas (residential buildings, residential neighbourhood, public space, and public facilities). This measurement is done by using Grass GIS on QGIS. The required dataset includes the road network of Utrecht city. The dataset retrieved from PDOK provides maps of the road, including car route, bike lanes, and pedestrian lanes. However, there were multiple routes was missing or not connected. The dataset was updated manually by following the base map from Openstreetmap integrated into QGIS, version 3.4.4-Madeira (roads that are under construction are not included). Since this thesis focuses only on the distance between the chosen areas, other aspects that might affect the actual choice of the route such as the mean of transport (for example route for car, bike lane, pedestrian), the type of road (for example highway, secondary road, to name but a few) were not considered. It means that there are routes that might consist of all road for car, bike lane, and pedestrian lane.

The public facilities in Binnenstad used for network analysis include buildings and areas relating to the following functions: commercial, cultural and entertainment, and educational. The buildings and areas related to commercial function include Hoog Cathrijne, Steenweg (one of the busy shopping streets in Binnenstad), and de Bijenkorf Utrecht. The buildings related to cultural and entertainment function include Tivoli Vredenburg, Dom Tower, and Museum Catherijne event. The building represents the educational function is Universiteitsbibliotheek Utrecht Binnenstad.

The thesis also conducted network analysis measuring the network distance between the park and public space in Leidsche Rijn Centrum subdistrict and other subdistricts in Utrecht city. The parks and public spaces selected are Park Grauwaart, Brusselplein square, and Berlijnplein square (the square on top of A2 highway).

4.5. Urban integration – fragmentation index

i. Developing indicators

In the previous chapters, the dimensions, subdimension, and indicators for the urban integration – fragmentation index are grouped according to two main aspects: 1) for consideration of similarity level in urban structure, and 2) connectivity between the two areas. Some indicators are refined according to the content on Utrecht Municipality database https://wistudata.nl/. For example, in this database, there are five housing types recorded: apartment, terrace houses, corner houses, free-standing house, and two houses under one roof. Accordingly, the thesis quantified the similarity of housing types in Leidsche Rijn Centrum by considering the ratio of these mentioned housing types. The same logic is applied for house ownership and family structure.

Wong (2006) also highlighted some requirement for indicators of a framework, including the following:

- The indicators have to be able to clearly describe the phenomenon: the indicators came from the combination of existing research about urban integration and fragmentation, and planning documents of the project.
- Benchmarking and cross-comparison: the indicator should be able to be used for different areas. In principle, the indicators in this thesis could be used for different scales of data, depending on the context of the projects. For

example, in this thesis, the indicators were used in the level of district and subdistrict. The indicators were comparable between the two areas.

- Use of soft indicators and qualitative information: the dimensions and indicators of the thesis were built according to the understanding of the phenomenon from the literature review. The thesis also used inputs from the interview with Utrecht municipality (director of spatial development and urban planning Leidsche Rijn, Vleuten-De Meern and manager of team Urban planning Leidsche Rijn) to refine weight of the dimensions, and to describe the expectation about urban integration for the area.
- Exploration of co-variations and interactive effects: the result chapter discusses the relationship between certain indicators and dimensions.
- Consistency and comparability: unless specified, the data used in the framework refers to the year 2018.

Figure 4.1 illustrates the workflow of the thesis in building the quantitative framework for accessing urban integration and fragmentation.

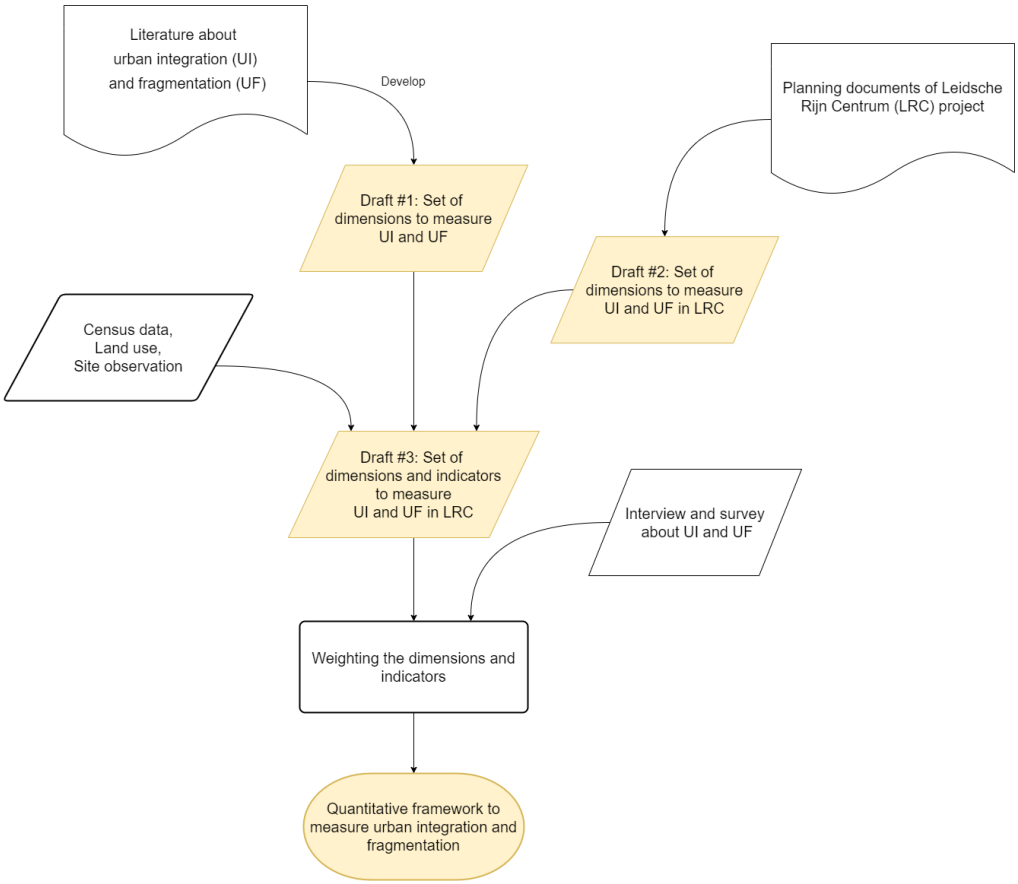

Figure 4-1 Workflow to build the urban integration and fragmentation framework

ii. Urban integration – fragmentation index

The score of the indicators describing the similarity between two areas is calculated by normalising the data set of all the subdistrict in Utrecht city in reference to the value of Binnenstad. : 1 is extremely similar, and 0 is extremely different. The value of Binnenstad is the average value of the two subdistricts (Binnenstad city- en winkelgebied, and Binnenstad woongebied), and equals to score 1 (reference value). Below is the formula calculating the score of urban integration – fragmentation level for each indicator:

$$S_{\text{subdistrict}} = \frac{|V_{subdistrict} - V_{extreme\ value}|}{|V_B - V_{extreme\ value}|}$$

Equation 1: Equation calculating the score of urban integration and fragmentation for each indicator

$V_{extreme\ value}$: The extreme value (minimum value or maximum value) of the indicator in the data set

V_B: The value of the indicator in Binnenstad

$V_{subdistrict}$: The value of the indicator of the subdistrict

The extreme values of the data set can be either the maximum value or the minimum value. For the indicators using census data, the values of Binnenstad district are neither the minimum nor maximum in the data set. In other words, the value of Binnenstad district divided the data set of each indicator into two groups, the group consisting values from minimum value to the value of Binnenstad (group 1), and the other group consisting values from the value of Binnenstad to the maximum value (group 2). Equation 2 is the formula for subdistricts with values in group 1, and equation 3 is the formula for the subdistricts with values in group 2:

$$\mathrm{S}_{\mathrm{subdistrict}} = \frac{V_{subdistrict} - V_{min}}{V_B - V_{min}}$$

Equation 2: Equation calculating the score of urban integration and fragmentation of an indicator in case the value of the indicator of the subdistrict with values in group 1

$$\mathrm{S}_{\mathrm{subdistrict(2)}} = \frac{\mathrm{V}_{max} - \mathrm{V}_{subdistrict}}{\mathrm{V}_{max} - \mathrm{V}_B}$$

Equation 3: Equation calculating the score of urban integration and fragmentation of an indicator in case the value of the indicator of the subdistrict with values in group 2

$\mathrm{S}_{\mathrm{subdistrict}}$: The integration/ fragmentation score of the indicator in case the value of the indicator of the subdistrict with value in group 1

$\mathrm{S}_{\mathrm{subdistrict(2)}}$: The integration/ fragmentation score of the indicator in case the value of the indicator of the subdistrict with value in group 2

V_{min}: The minimum value of the indicator in the data set

V_{max}: The maximum value of the indicator in the data set

V_B: The value of the indicator in Binnenstad

$\mathrm{V}_{subdistrict}$: The value of the indicator in the subdistrict

Below is an example for calculation of the score for the ratio of household living alone:

The maximum value (V_{max}) in the data set is 0,7506 (subdistrict Wilhelminapark, Rijnsweerd)

The minimum value (V_{min}) in the data set is 0,2086 (subdistrict Het Zand)

The value ratio of housing type apartment in Binnenstad (V_B) is: 0,7124

The value ratio of housing type apartment in Leidsche Rijn Centrum (V_{LRC}) is: 0,3753 < 0,7124 ($\mathrm{V_B}$)

The integration/ fragmentation score for indicator ratio of apartment in Leidsche Rijn Centrum ($\mathrm{S}_{\mathrm{LRC(rat\_al)}}$) is:

$$\mathrm{S}_{\mathrm{LRC(rat\_al)}} = \frac{V_{LRC} - V_{min}}{V_B - V_{min}} = \frac{0{,}3753 - 0{,}2086}{0{,}7124 - 0{,}2086} = 0{,}3309$$

Details of the calculation for all indicators are described in Appendix C.

For the indicators relating measuring distance from public services in Binnenstad to other areas, the value of Binnenstad is the minimum and equal to score 1, the maximum value (the maximum distance) equals to score 0. For the indicators relating to measuring the distance from public services in Leidsche Rijn Centrum to other areas, the value of Leidsche Rijn Centrum is the minimum and equal to score 1, the maximum value (the maximum distance) equals to score 0. The calculation for the score of those indicators also follows the formula in equation 1.

5. Results and discussion

The previous chapters address research question RQ 1.1, RQ 1.2, RQ 2.1, and RQ 2.2 by discussing the definition of urban integration and fragmentation, and developing an index for urban integration and fragmentation framework. Using the case study in Leidsche Rijn, this chapter discusses the results for the eight dimensions listed in table 4.1, including 1) housing types, 2) public areas, 3) house ownership, 4) family structure, 5) income, 6) distance to public facilities in Binnenstad district, 7) distance to public space in Leidsche Rijn centrum, and 8) bicycle and pedestrian accessibility. The first five dimensions reflect the similarity between the study area (Leidsche Rijn centrum subdistrict) and the existing urban structure (Binnenstad district), the other three dimensions reflect the connectivity between the study area and the existing urban structure of Utrecht city. Throughout the discussion of the individual score and the overall score, this chapter also discusses the relationship among the indicators, reflects on the relevance between the indicators and the phenomenon of urban integration and fragmentation, and possible future research direction on this topic. In short, this chapter aims to answer research question RQ 2.3 and RQ 3.1:

RQ 2.3 What is the integration – fragmentation level of the Leidsche Rijn Centrum subdistrict in the urban integration – fragmentation index?

RQ 3.1 What is the relationship between the dimensions in urban integration-fragmentation?

This chapter is structured as follow: Section 5.1 presents the results from the calculation for each indicator. Section 5.2 presents the calculation of integration – fragmentation index of the indicators in the integration - fragmentation framework.

Section 5.1 has two subsections according to the two aspects of the integration – fragmentation framework, namely 1) the similarity in urban structure, and 2) connectivity. After that, this chapter presents the integration – fragmentation index of each indicator, which applied the formula in previous chapters. In the section about the integration – fragmentation index, there is the discussion about the aggregated integration – fragmentation score with consideration the weight for each indicator. As mentioned above, there are four scenarios for the weight:

1. Not consider the weight

2. Consider the weight according to the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 1

3. Consider the weight according to the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 2

4. Consider the weight according to the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 3

5. Consider the weight according to the survey, assume that the weight for bicycle and pedestrian accessibility dimension as 3

5.1. Individual scores of each dimension

a) Dimensions and indicators describing the integration and fragmentation as similarity in the urban structure

i. Housing types

The housing type dimensions include the measurement of the similarity between Leidsche Rijn Centrum subdistrict and Binnenstad district using five housing type: 1) apartment, 2) terrace house, 3) corner houses, 4) 2 houses under 1 roof, and 5) free-standing house. The chart below presents the comparison between the ratio of housing typology in Utrecht city, Binnenstad and Leidsche Rijn.

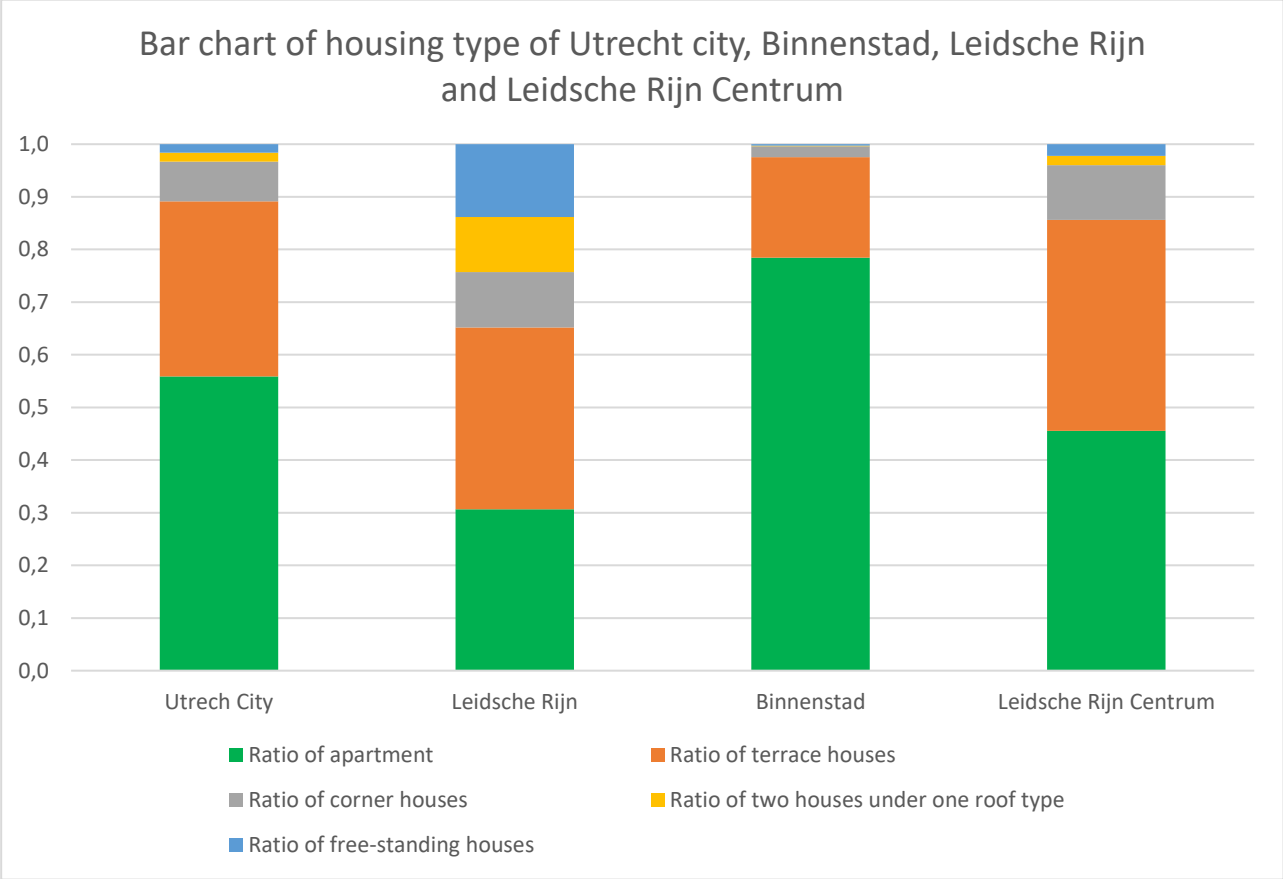

Figure 5-1 Bar chart comparing housing type of Utrecht city, Binnenstad, Leidsche Rijn and Leidsche Rijn Centrum

In the comparison between Leidsche Rijn Centrum and Binnenstad, the composition of housing types in Leidsche Rijn Centrum is slightly more spreading among the five housing types than in Binnenstad. For example, the ratio of apartment housing type dominates in the composition of both areas among the five housing types. The second most dominant housing type is terrace houses. In Leidsche Rijn Centrum, the ratio of terrace houses is greater than the respective ratio in Binnenstad. The dominance of these two housing types reflects the intention mentioned in the planning documents. From this result, it implies that the similarity level of housing type between the two areas is low. As discussed above, the difference in housing type could influence both the physical and non-physical structure of the areas. For example, the physical image of neighbourhoods which are dominated by apartment would be different from the physical image of neighbourhoods which are dominated by terrace houses. The difference in the image of the neighbourhood could influence the perception of its residents about their living environment (Lynch, 1960). In this case, figure 5-1 shows that Binnenstad is dominated by the apartment housing type, which would imply that the physical image of Binnenstad is different from the physical image in the Leidsche Rijn Centrum subdistrict. In other words, the integration – fragmentation level between Leidsche Rijn Centrum subdistrict and Binnenstad district in term of similarity level in urban structure aspect, in consideration of housing type dimension is more on the fragmentation form. The conclusion about overall urban integration – fragmentation level should also include the consideration of connectivity, which is present in the latter part of this chapter.

Figure 5-2 describes the integration – fragmentation score of housing type dimension of each subdistrict in Utrecht city. In general, the subdistricts that are closer to the Binnenstad district have a higher score for this dimension. It is unexpected that between the two subdistricts in Binnenstad district, subdistrict for shops and commercial activities ("Binnenstad en winkel gebied" subdistrict), and subdistrict for living area ("Binnenstad en woning gebied" subdistrict). The main cause for this difference could be the difference in the main function of the two subdistricts.

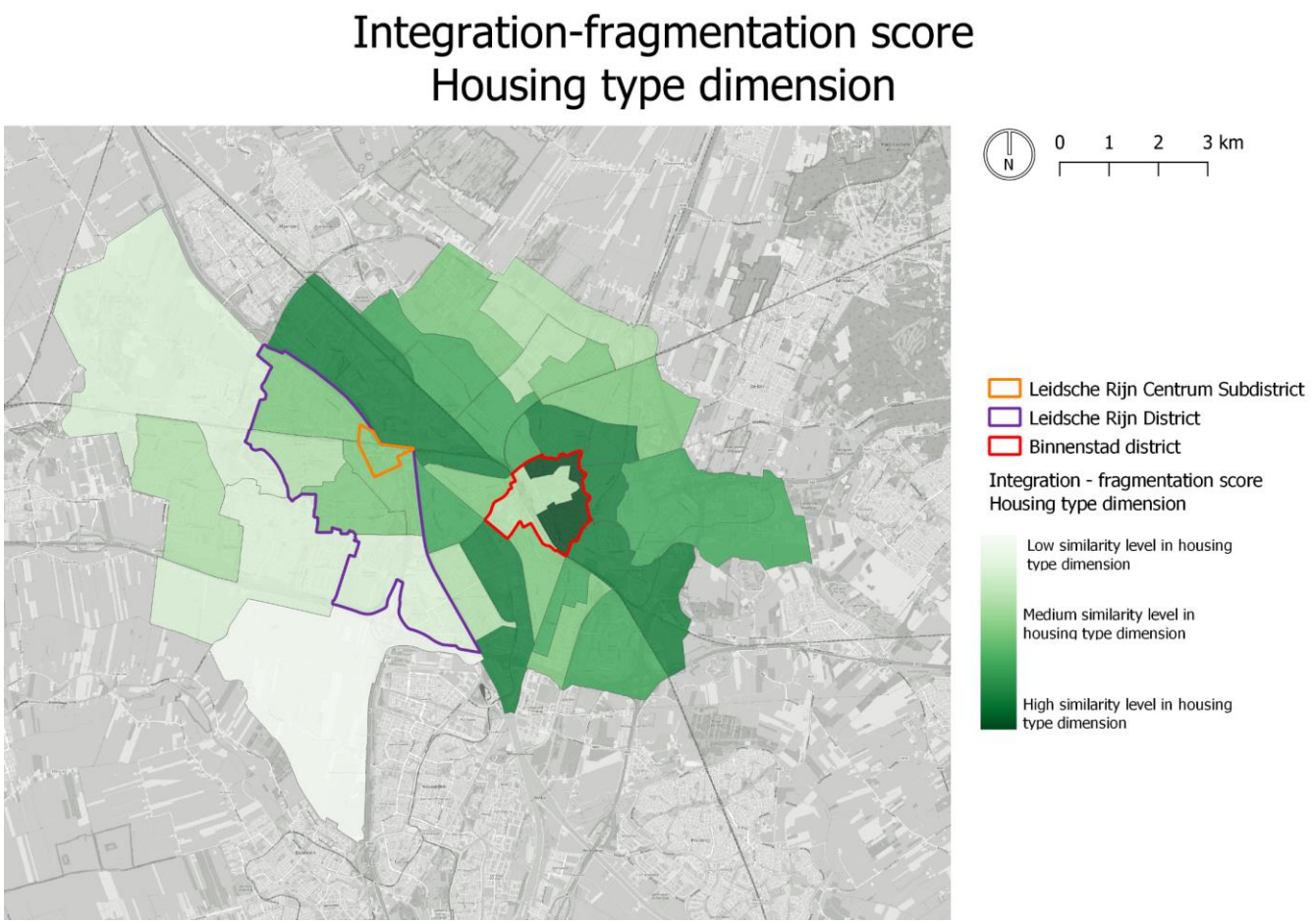

Figure 5-2 Integration-fragmentation score of housing type dimension

The study about the internal integration in Binnenstad district is not under the scope of this thesis but could be an interesting research topic. For the case study of Leidsche Rijn Centrum subdistrict, as mentioned in the interview with Utrecht municipality, mixed-function is among the most important element in the development direction of the area. However, the criteria to quantify the level of mixed functions is not clearly defined. Fortunately, the interview mentioned the role of public areas in the development strategies of the Leidsche Rijn district. The next section discusses the result from the analysis of the similarity in public areas between the Leidsche Rijn Centrum subdistrict and Binnenstad district.

ii. Public areas

This section uses the data from the land use map of the Utrecht city to discuss the similarity in the structure of public space and public service in Binnenstad district and Leidche Rijn Centrum subdistrict. Public areas are important elements in accessing the level of integration and fragmentation of an area since public space, and public services are the main area for social interaction of the population (Gelh, 2018; Leidelmeijer et al., 2014). In the interview with Utrecht Municipality, the role of public areas in an integrated urban area was also emphasised.

Figure 5-3 highlights the public areas in Utrecht city. In compare with the original maps, land use class with similar functions, for example, residential recreation, allotment, and daily recreations are considered as “other recreation areas in this analysis. “Public services” (“Openbare voorziening” in original land use map) indicates the building footprint of services including governmental offices such as police stations, infrastructure services centre such as electric, power, water treatment. “Greenery areas” includes parks, urban parks, and forest. “Social-cultural areas” (“Sociaal-culturele voorziening” in the original land use map) and indicates the building footprint of all area with social-cultural functions such as churches, art centres. “Water surface” indicates the water body regardless of the natural water body or man-made, for recreation purpose. “Other recreation areas” includes all the areas belonging to the Recreative function group (“Recreatie” in Dutch) excluding the greenery and water surfaces.

In general, the map shows that public spaces and public services in Utrecht are scattered in all subdistricts. It might be to ensure equal accessibility for all other subdistricts. The map highlights that social-cultural areas are distributed more on areas on the west of the city than in the east of the city. On the other hand, water bodies are mainly on the east side of the city.

As mentioned before, public areas are the main place for social interaction, and therefore influence the level of integration – fragmentation of an urban area. In the aspect of the physical environment, public spaces and public services contribute to the land use structure of the area. If the two areas have a different ratio of public areas in the land use structure, the physical urban structure of the two areas differs from each other, regardless of the spatial distribution. As discussed in the previous chapters, together with other indicators, this thesis quantifies the level of integration – fragmentation of an area by considering the similarity in the urban structure. The more similar in urban structure between two areas, the higher that the level of integration of physical environment increases.

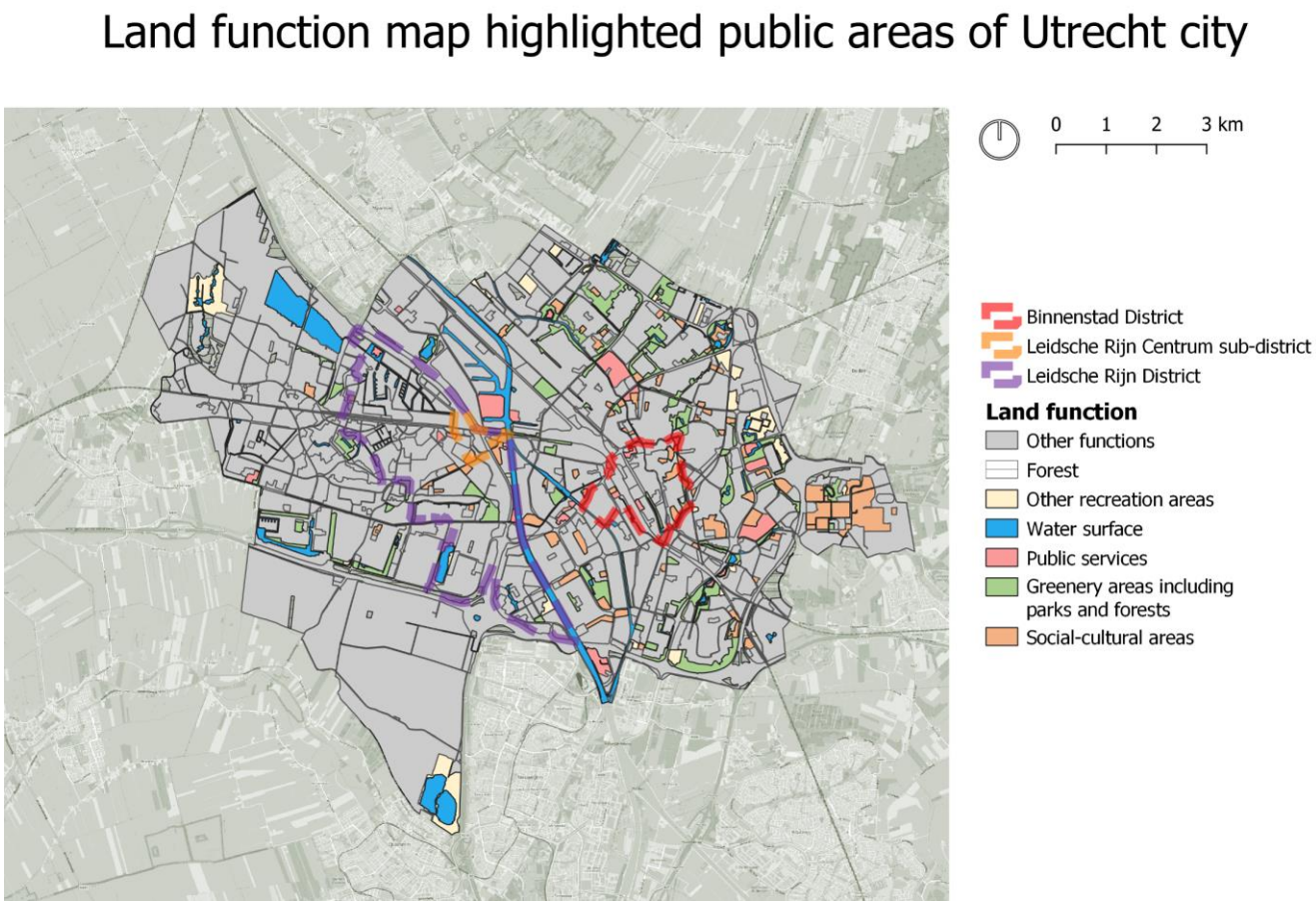

Figure 5-3 Land function map highlighted public areas in Utrecht City

Figure 5-4 describes the comparison of the ratio of different public areas in Utrecht, Binnenstad district, Leidsche Rijn district and Leidsche Rijn Centrum subdistrict. From the chart, the ratio of public areas in Leidsche Rijn Centrum subdistrict is noticeably higher than the ratio of public space and public service in Utrecht city centre. It is said that, in term of the physical environment, the Leidsche Rijn Centrum subdistrict has a relatively low level of integration with the Binnenstad district. This result alone should not conclude the overall integration – fragmentation between the subdistrict and the Binnenstad district.

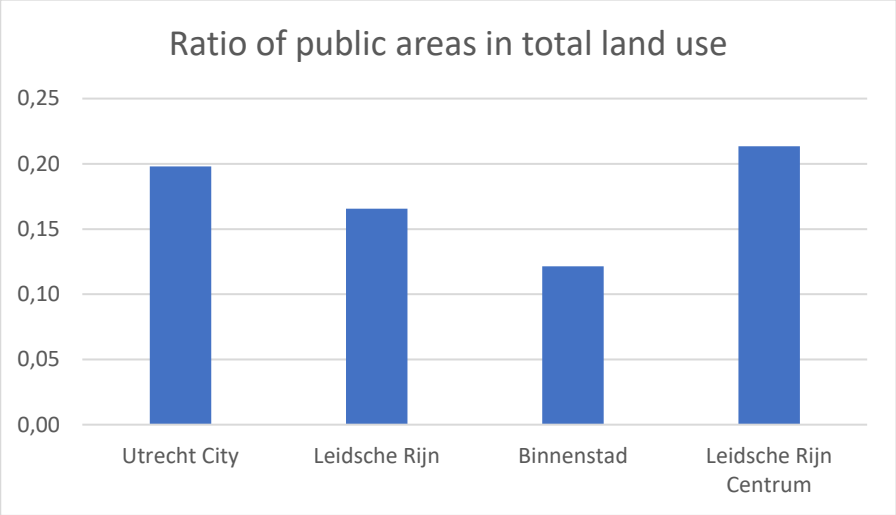

Figure 5-4 The bar chart describing the ratio of public space and publice service areas in Utrecht City, Leidsche Rijn district, Binnenstad district, and Leidsche Rijn Centrum subdistrict

According to one of the objectives of the Leidsche Rijn project, public areas are important to increase social interaction and also to attract more residents (Lenting, 2004). In the interview with Utrecht Municipality, the director of spatial development and urban planning Leidsche Rijn, Vleuten-De Meern and manager of team Urban planning Leidsche Rijn also highlighted the importance of providing sufficient public facilities, which includes public areas, for Leidsche Rijn project as it expects a major increase in population for this area. It means that sufficient access to those public areas can still improve the overall integration – fragmentation score.

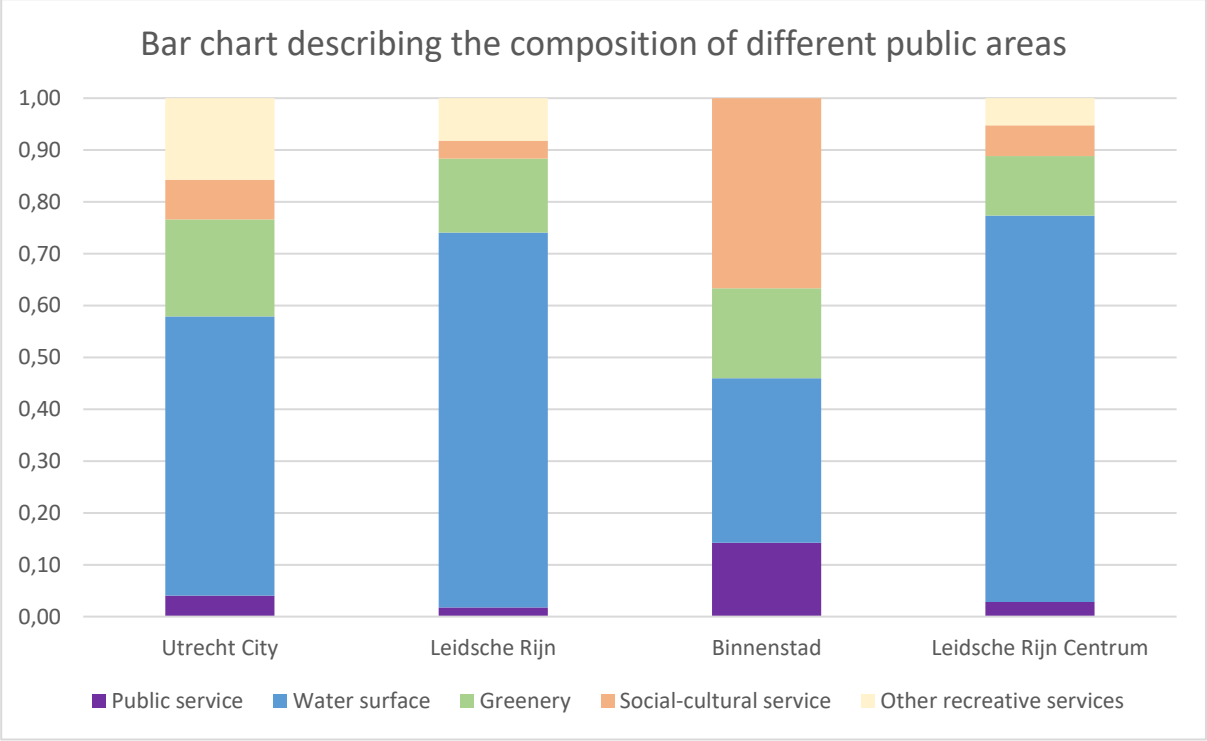

Figure 5-5 Bar chart describing the composition of public areas in Utrecht cit, Binnenstad, Leidsche Rijn, and Leidsche Rijn Centrum

In the discussion about the similarity level between the two areas, the functions of public spaces and public services areas contribute to the overall picture of the activities of the population. Eventually, it supports the discussion about the lifestyle of the population in the two areas. For example, activities in greenery areas are different from activities in the social-cultural areas. This indicator could not reflect the social interaction of the residents between the Leidsche Rijn Centrum subdistrict

and Binnenstad district. The possible social interaction in public areas could be measure by the connectivity between the two areas and is presented in the latter part of this chapter.

Figure 5-5 describes the composition of different public areas in Utrecht city, Leidsche Rijn district, Binnenstad district, and Leidsche Rijn Centrum subdistrict. The chart highlights the difference in the composition of types of public areas between Binnenstad district and Leidsche Rijn centrum subdistrict. Together with the graph in figure 5-4, they show that although the ratio of public areas in Binnenstad district is lower than the ratio of public areas in Leidsche Rijn Centrum subdistrict, the proportion of each type is more balanced and diverse than the proportion of each type in Leidsche Rijn Centrum subdistrict. In other words, the structure of public areas in the two areas is different. The integration – fragmentation level in the similarity level of public areas dimension in Leidsche Rijn Centrum subdistrict is relatively low. However, this dimension alone could not reflect the overall integration – fragmentation level of the subdistrict. There could be a possibility that residents living in Leidsche Rijn Centrum subdistrict have high accessibility to the public areas in Binnenstad district. In that case, the overall integration – fragmentation level between the two areas could increase. The integration – fragmentation level regarding the connectivity aspect is discussed in the later section of this chapter.

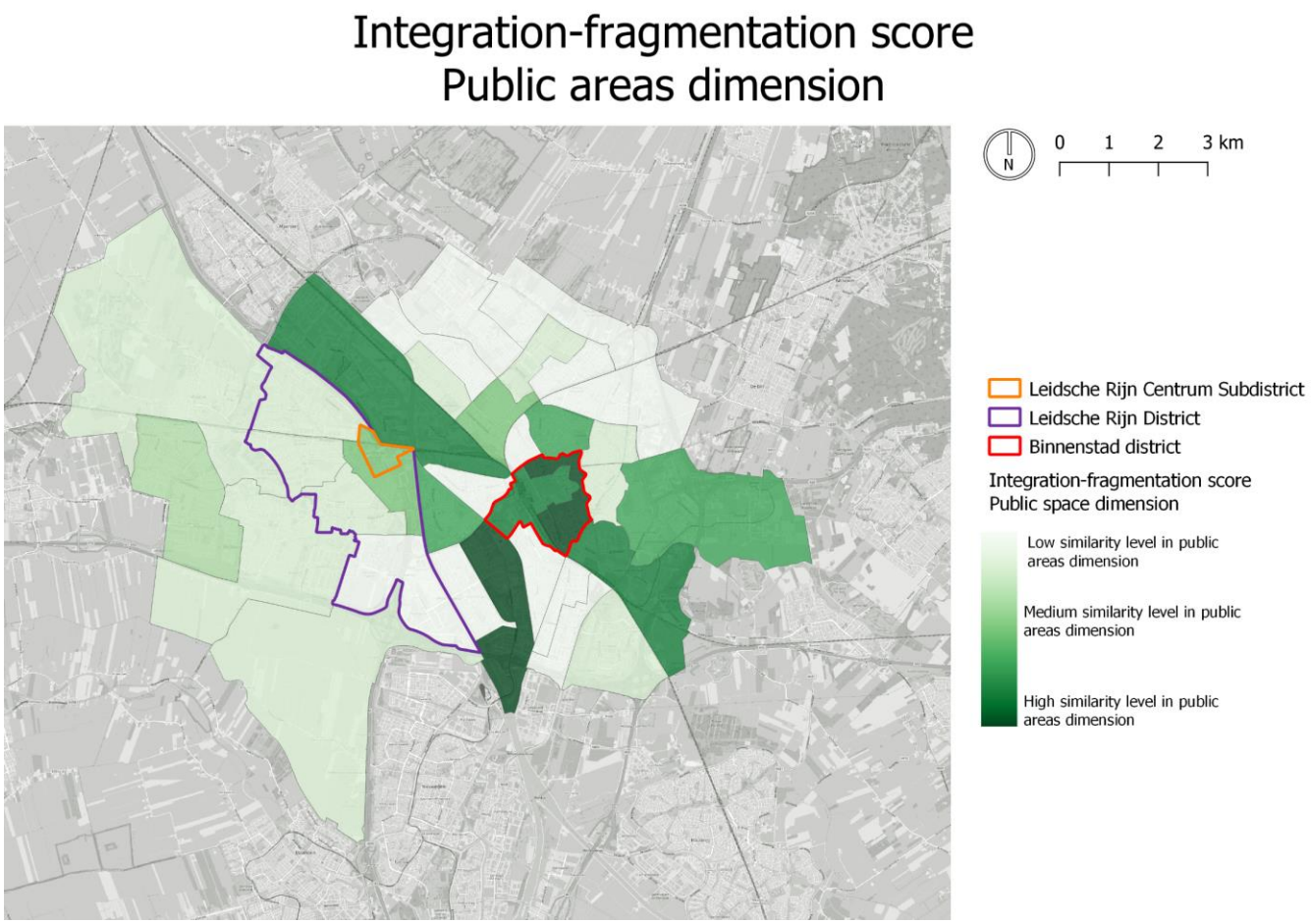

Figure 5-6 Integration - fragmentation score for public space dimension

Figure 5-6 illustrates the map for the integration – fragmentation score for public space dimension. From the map, the spatial distribution of the score is relatively random. It means that it is not necessary that subdistricts which are close to Binnenstad district have higher similarity level with Binnenstad district in the public spaces and public services areas. This map also highlights the difference between the two subdistricts of the Binnenstad district, as similar to the housing type dimension. This outcome suggests an interesting topic for future research for the integration and fragmentation between the two subdistricts in the Binnenstad district.

iii. House ownership

According to Leidsche Rijn database on WistUdata, there are four type of tenure status (woningen naar eigendom koop): 1) self-owning house (eigendom koop), 2) rental social housing (woningen naar eigendom sociale huur in corporatiebezit), 3) rental housing other than social housing (woningen naar eigendom huur overig) and 4) unknown ownership (woningen naar eigendom onbekend). The chart below presents the comparison of ratio between different tenure type in Binnenstad and Leidsche Rijn Centrum.

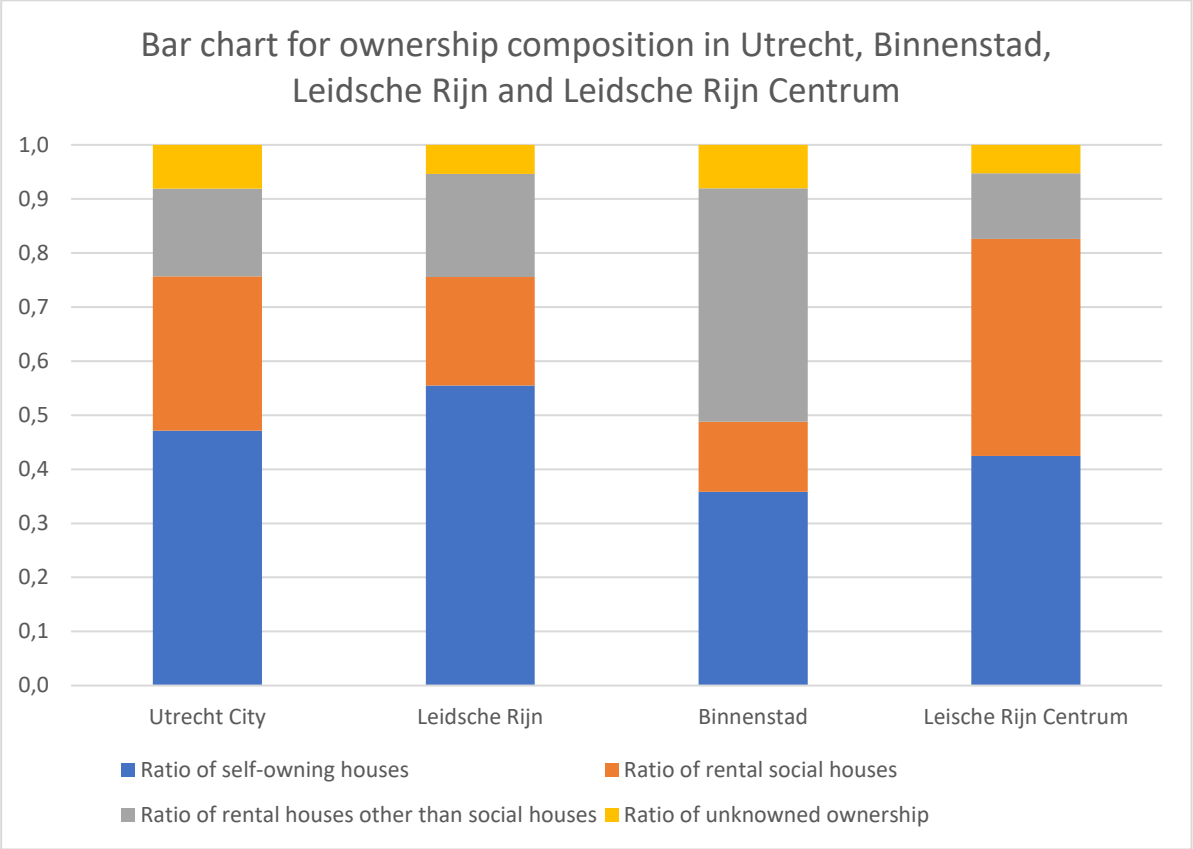

Figure 5-7 Bar chart for ownership composition in Utrecht, Binnenstad, Leidsche Rijn, Leidsche Rijn Centrum

The chart in figure 5-7 indicates that the ownership composition between the Binnenstad district and Leidsche Rijn Centrum subdistrict is relatively similar for the ratio of the self-owning houses, and unknown ownership. There is a major difference between the ratio of rental social houses and the ratio of rental houses other than social houses. In Leidsche Rijn Centrum subdistrict, the ratio of rental social houses dominates the ratio of rental houses other than social houses, which is the contrary situation in the Binnenstad district. As discussed in the previous chapter, tenure status is an element describing the social structure of an area. Tenure status can imply multiple characteristics of the population, such as the economic status or lifestyle. In the context of housing in The Netherlands, social houses are an important element in social structure because of the influence of social housing association in the community.

With the difference in house ownership presented in the chart 5-7, with high similarity level in self-owning houses and major difference in the ratio of rental social houses and rental houses other than social houses, it is reasonable to assert that the level of integration in social structure between Leidsche Rijn Centrum subdistrict and Binnenstad district is at the medium level, neither extremely high nor extremely low. Figure 5-8 below describes the integration-fragmentation score of house ownership dimension.

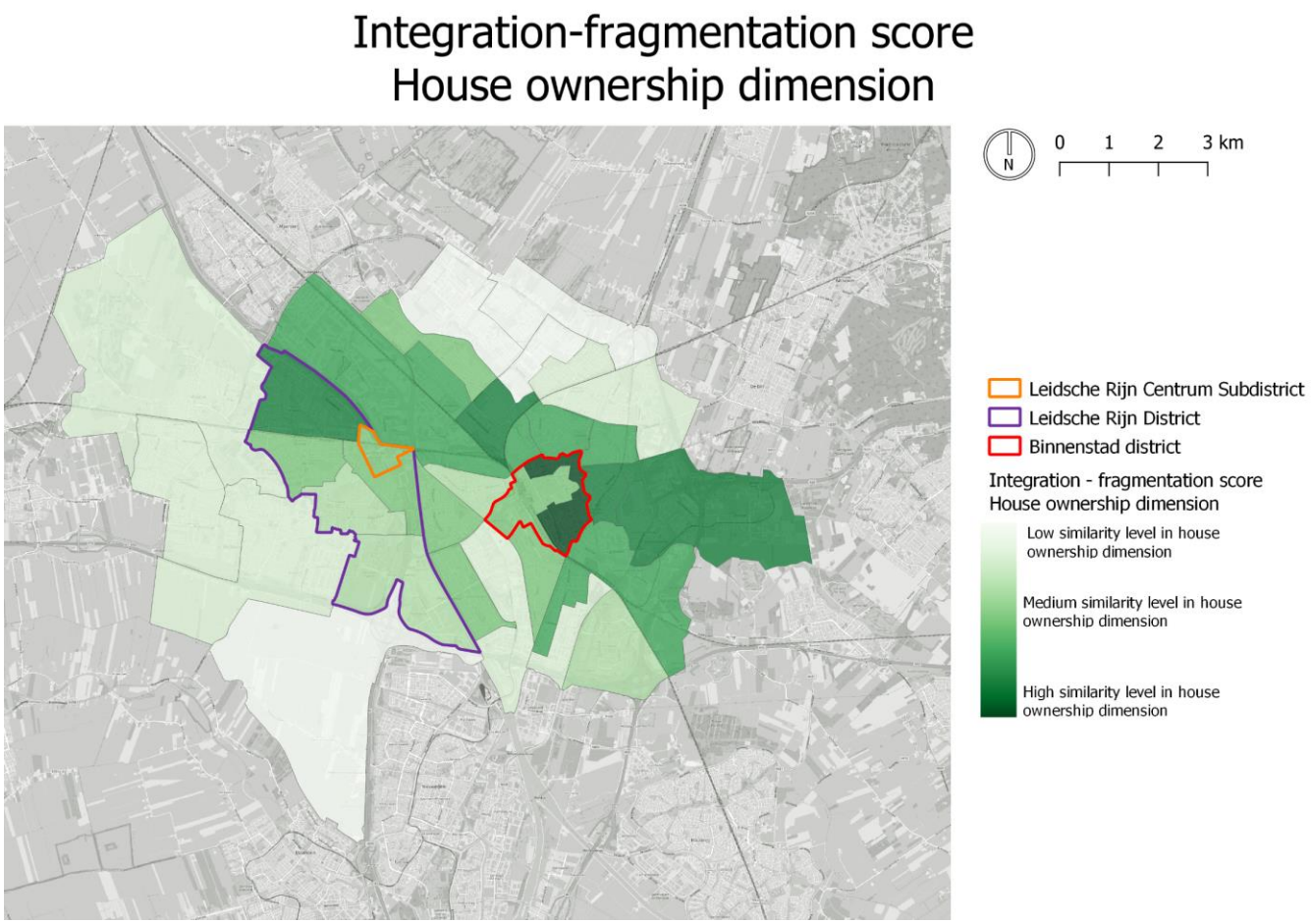

Figure 5-8 Integration - fragmentation score - house ownership dimension

In comparison with other dimensions, the spatial distribution of the integration – fragmentation score of house ownership dimension is relatively less random. From the map in figure 5-8, the subdistricts which are closer to Binnenstad district have a generally higher score.

iv. Family structure

According to Leidsche Rijn database on WistUdata, there are five type family structures: 1) living alone household, 2) couple without child(ren), 3) couple with child(ren), 4) single parent, and 5) other. The chart below presents the family structure of Utrecht city, Leidsche Rijn district, Binnenstad, and Leidsche Rijn Centrum.

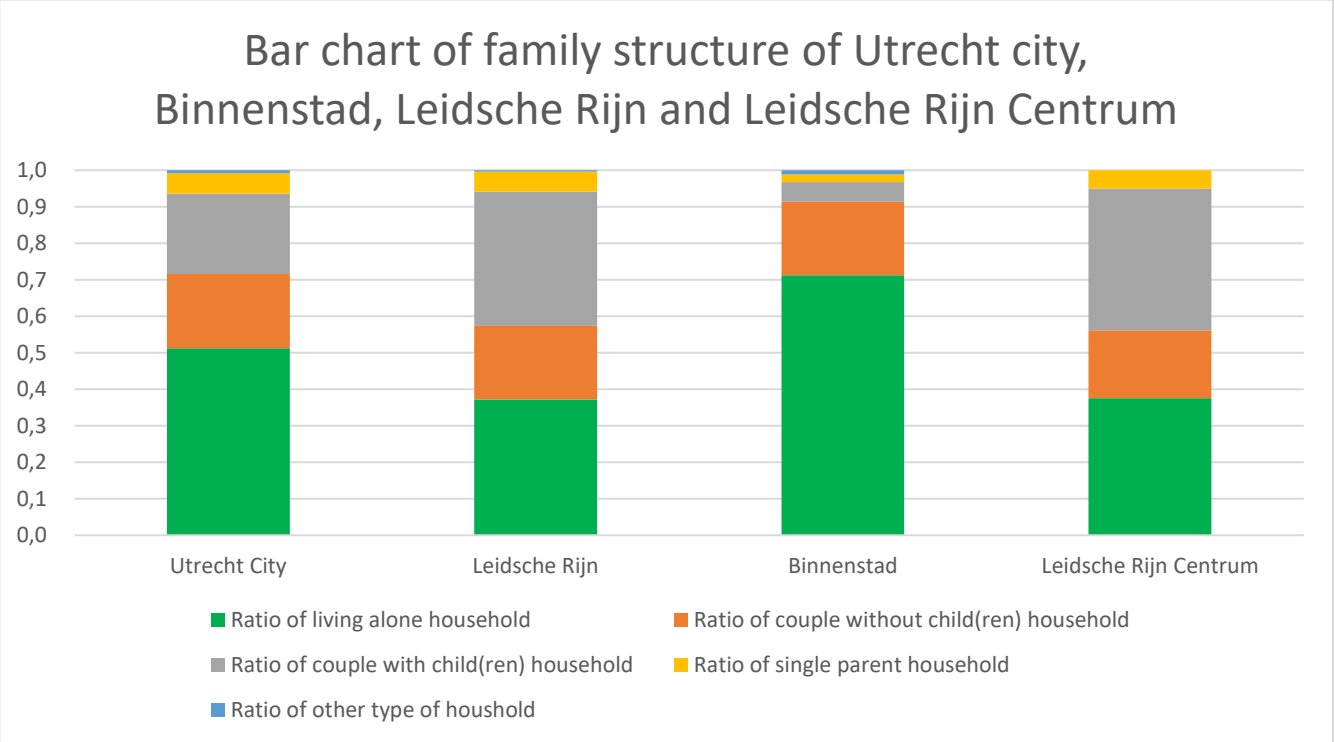

Figure 5-9 Bar chart illustrates the houshold composition in Utrecht, Binnenstad, Leidsche Rijn, Leidsche Rijn Centrum

The family structure of Leidsche Rijn Centrum, Binnenstad, Leidsche Rijn district and Utrecht city does not share much in common. Considering the figures of Binnenstad and Leidsche Rijn Centrum, while the ratio of living alone household dominant significantly in the family structure in Binnendstad, the respective ratio in Leidsche Rijn Centrum is slightly lower than the ratio of the couple with child(ren) household. The ratio of the couple without child(ren) in Binnenstad and Leidsche Rijn Centrum is quite similar to each other and also with the respective number of Utrecht City and Leidsche Rijn district. The chart shows a major difference in the ratio of the couple with child(ren) household between Binnenstad and Leidsche Rijn Centrum. In Binnenstad the proportion of couple with child(ren) household is relatively small, meanwhile, in Leidsche Rijn Centrum, this figure is the most dominant. In comparison with Binnenstad and the Utrecht city, the chart shows that although the ratio of the couple with child(ren) and the ratio of the couple without child(ren) is Utrecht city is not relatively similar, the difference between those figures in Binnenstad is almost fourfold. In comparison with Leidsche Rijn Centrum and Leidsche Rijn District, the family structure is relatively similar.

In short, the social structure in term of family structure between the Binnenstad district and Leidsche Rijn Centrum subdistrict has a major difference. It implies that the level of integration in the aspect of family structure between the two areas is relatively low. Since different family structure have different requirements in facilities (Utrecht Municipality, interview, 2019) and lifestyle, family structure partially describe the non-physical structure of the area and might influence the physical structure of the area. For example, family-type households might need bigger houses (because there are more people in the houses), couple with children might need more playgrounds, child-care centres, elementary schools, which might not be very important for residents living alone. The areas where family-type households dominate might eventually have different land use structure than the areas where living alone household dominate. Figure 5-9 reflects only the data in 2018, and the figure shows that most of family type household (couple with children and couple without children household) do not live in Binnenstad. If this trend continues or intensify, the social structure between the two areas might distinct from each other. In the extreme situation, Leidsche Rijn Centrum subdistrict might attract all family type households from the Binnenstad. Eventually, there could be only one particular group of people that live primarily in one area, which is considered as a fragmented city (Utrecht Municipality, interview, 2019).

The map in figure 5-10 below describes the integration – fragmentation score in family structure dimension. The map shows that the subdistricts which are closer to the centre have a relatively higher score, implying that the location of subdistrict closer to the city centre has higher similarity level of family structure with the Binnenstad district.

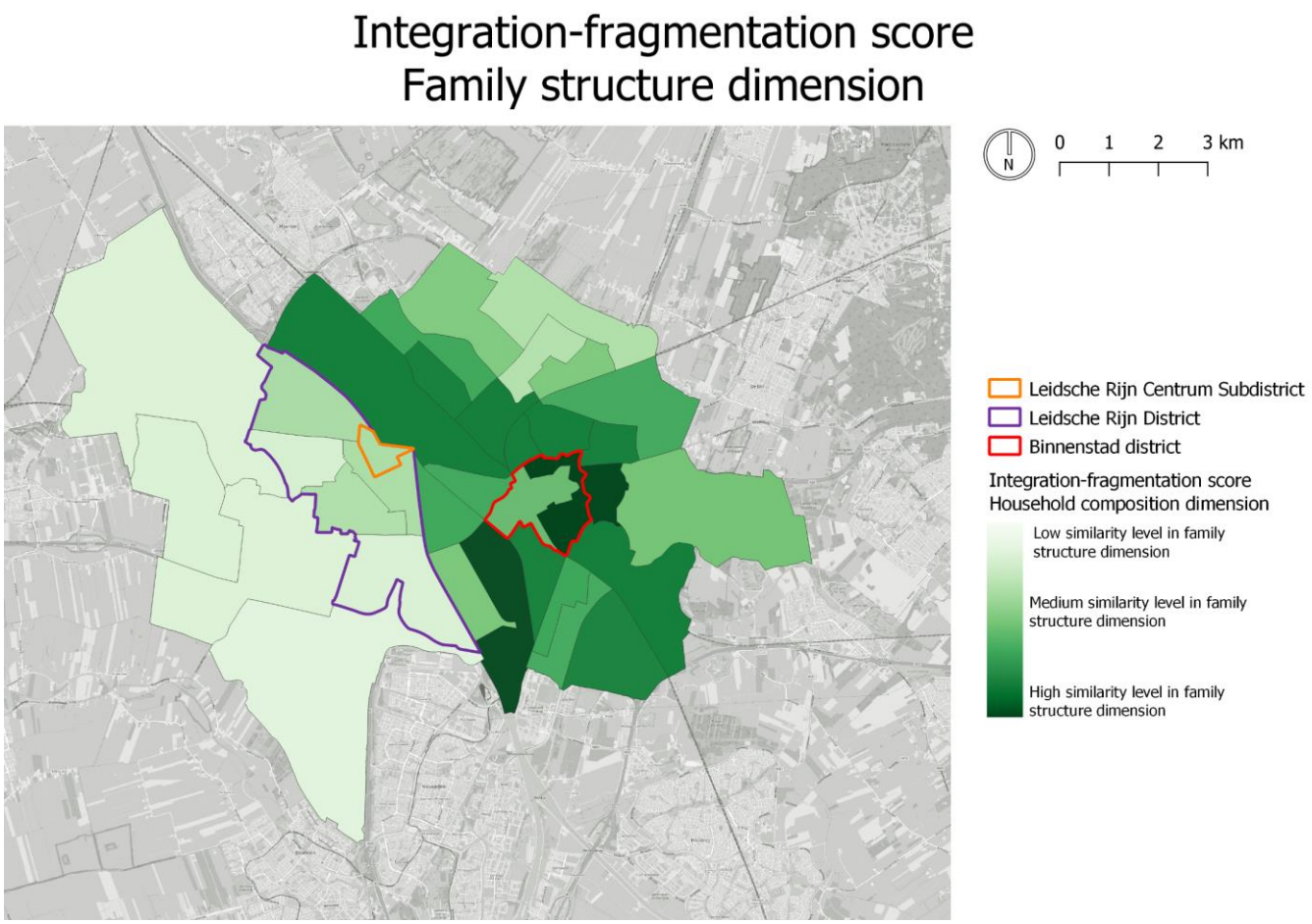

Figure 5-10 Integration - fragmentation score, family structure dimension

v. Income

The income level of a neighbourhood connects with various factors influencing the integration and fragmentation level, such as rental price, housing types, and lifestyle. For example, in the study of gated communities, exclusive neighbourhoods normally have a noticeable higher income than the surrounding area. Figure 5-7 describes the total income of all subdistricts in Utrecht city.

Figure 5-11 shows that Vleuten – Haaruillens subdistrict has the highest income and Zambesidreff – Tigrisdreef subdistrict has the lowest income. Figure 5-8 indicates the difference in income between each subdistrict with the average income of Binnenstad. From the graph, the number of subdistrict with higher income. The two graphs indicate that Binnenstad district has an average income in comparison with other subdistricts in Utrecht city. Figure 5-8 shows that the difference between Leidsche Rijn Centrum subdistrict and Binnenstad district belongs to the average range. Votulast subdistrict and Nieuw Engeland-Schepenbuurt subdistrict has the lowest difference with Binnenstad district's income. Vleuten-Haarzuilens subdistrict has the highest difference with 18,52 thousand euro. This is also the subdistrict with the highest income.

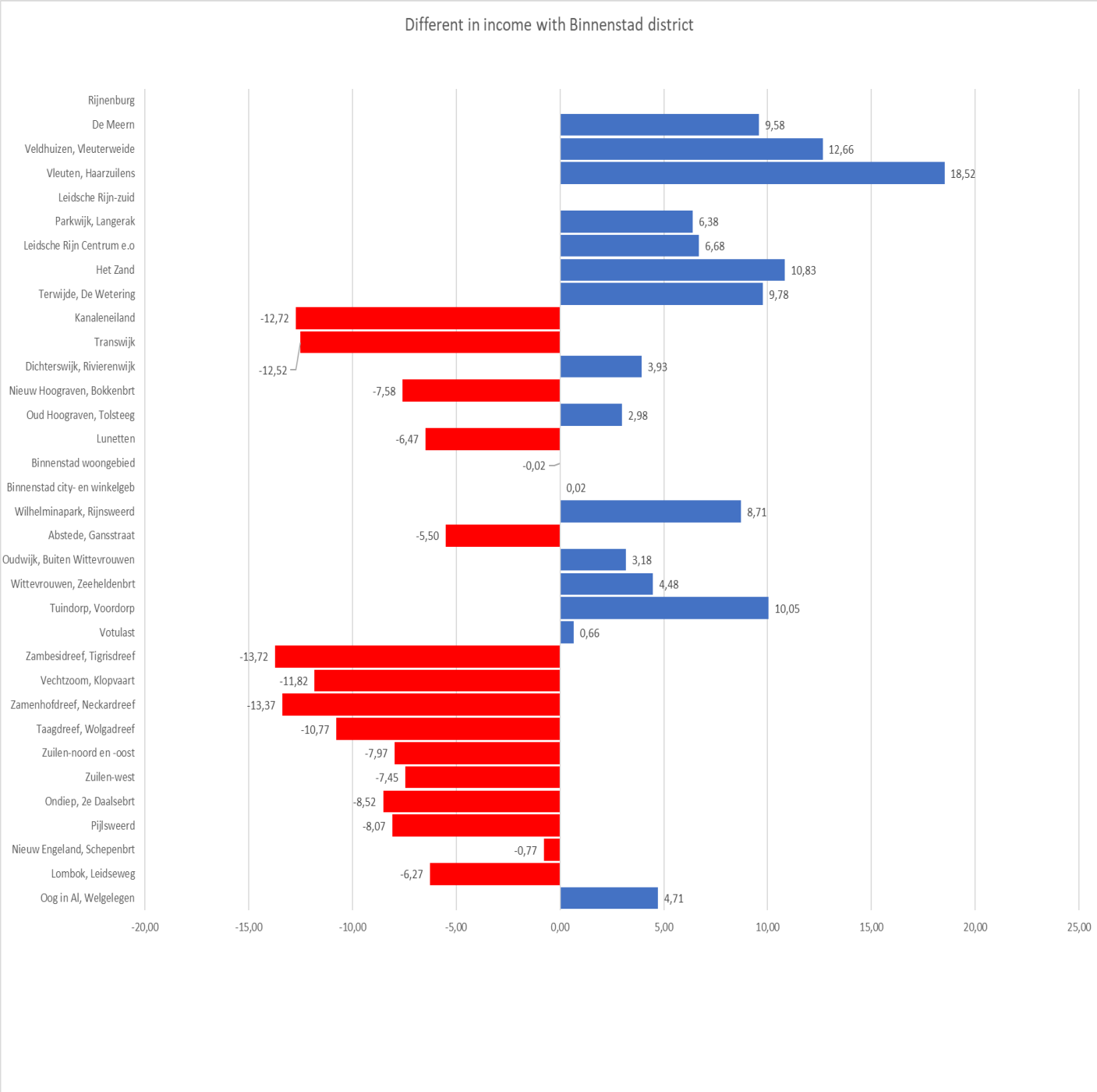

Figure 5-11 Difference of income between subdistrict and the average income of Binnenstad district (x1000e), 2016

In general, most of the integration – fragmentation scores of the indicators describing the similarity level in urban structure between Leidsche Rijn Centrum subdistrict and Binnenstad are in the medium level. It implies that in term of urban structure, the two areas are relatively different from each other. However, since the integration – fragmentation level is measured by two aspects, and the similarity level in urban structure is only one of the two, this outcome alone cannot conclude the overall integration – fragmentation level of Leidsche Rijn Centrum subdistrict. The next section discusses the outcome from the measurement of urban integration – fragmentation level in considering the connectivity between the two areas.

b) Dimensions and indicators describing the integration and fragmentation as in the level of connectivity

As mentioned in chapter 4, the level of connectivity between the Leidsche Rijn Centrum subdistrict and the Binnenstad district is measured by the accessibility to the public areas. In this thesis, the accessibility between the two areas consists two elements: 1) the measurement of the average distance between residential areas and public areas in the Binnenstad area, and 2) bicycle and pedestrian accessibility, measured by the ratio of the population choosing cycling and walking as the option to come to the Binnenstad district.

The first part of this section presents the outcome from the network analysis for road network distance between public facilities and residential areas. The public facilities selected for measurement of the distance to public facilities dimension includes ten places ranging in three themes: commercial activities, culture and entertainment, and educational buildings:

1) Hoog Catherijne,

2) Steenweg (shopping street),

3) de Bijenkorf Utrecht,

4) TivoliVredenburg,

5) Dom Tower,

6) Museum Catharijneconvent,

7) Universiteitsmuseum,

8) Nijntje Museum,

9) Central Museum,

10) Universiteitsbibliotheek Utrecht Binnenstad.

The residential buildings are selected randomly throughout the subdistrict. The second part of this section presents the analysis for the ratio of the population choosing cycling and walking as the option to come to the Binnenstad district.

i. Distance to public facilities

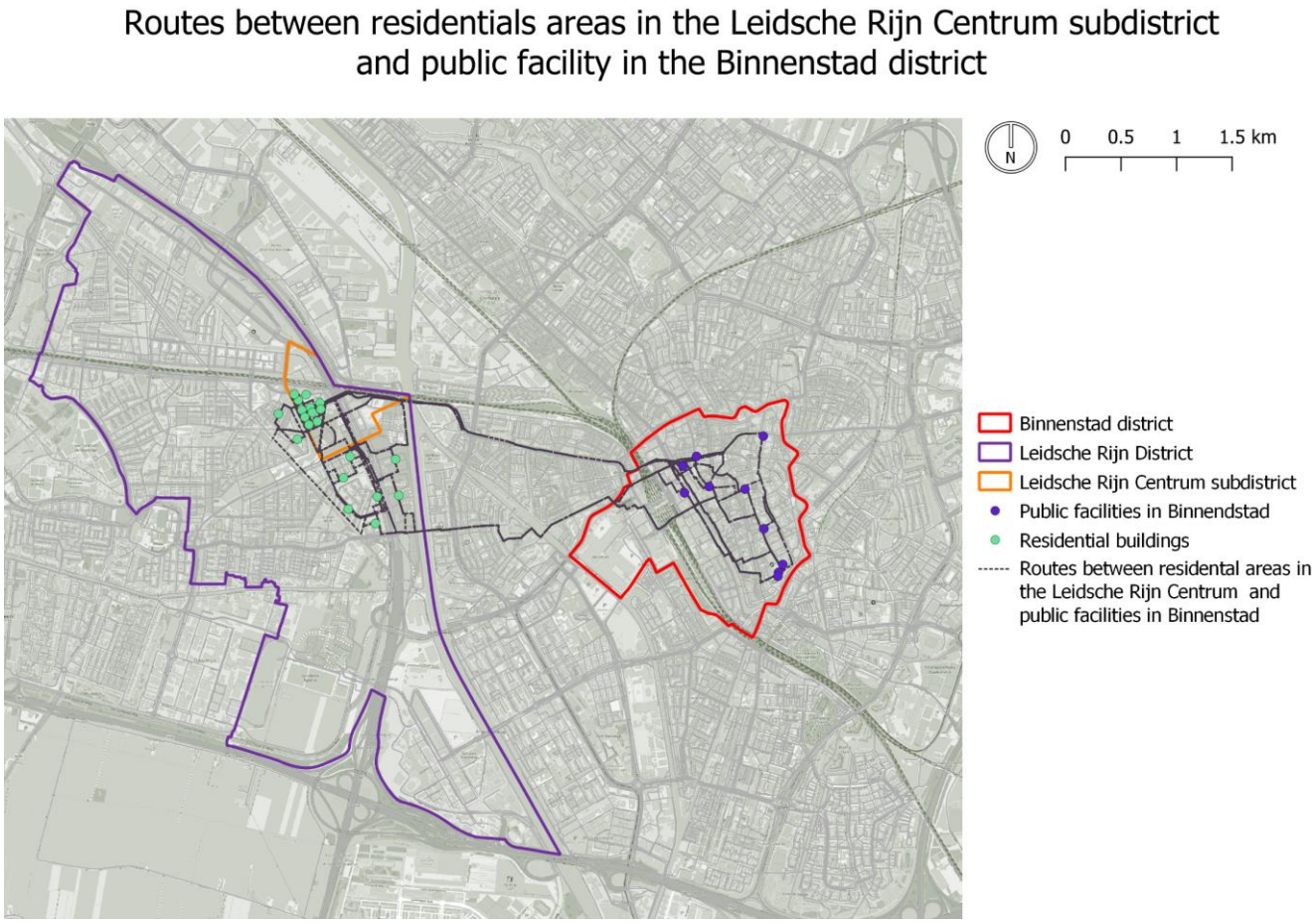

Figure 5-12 The routes between residential areas in the Leidsche Rijn Centrum subdistrict and public facilities in the Binnenstad district

The map in figure 5-12 shows that one of the two main routes connecting Leidsche Rijn Centrum's residential neighbourhood crossed Parijsboulevard, which is built on top of the A2 highway. This reflects the intention mentioned in the planning document of the Leidsche Rijn project about covering the A2 highway to improve the connectivity between the area and the existing city centre.

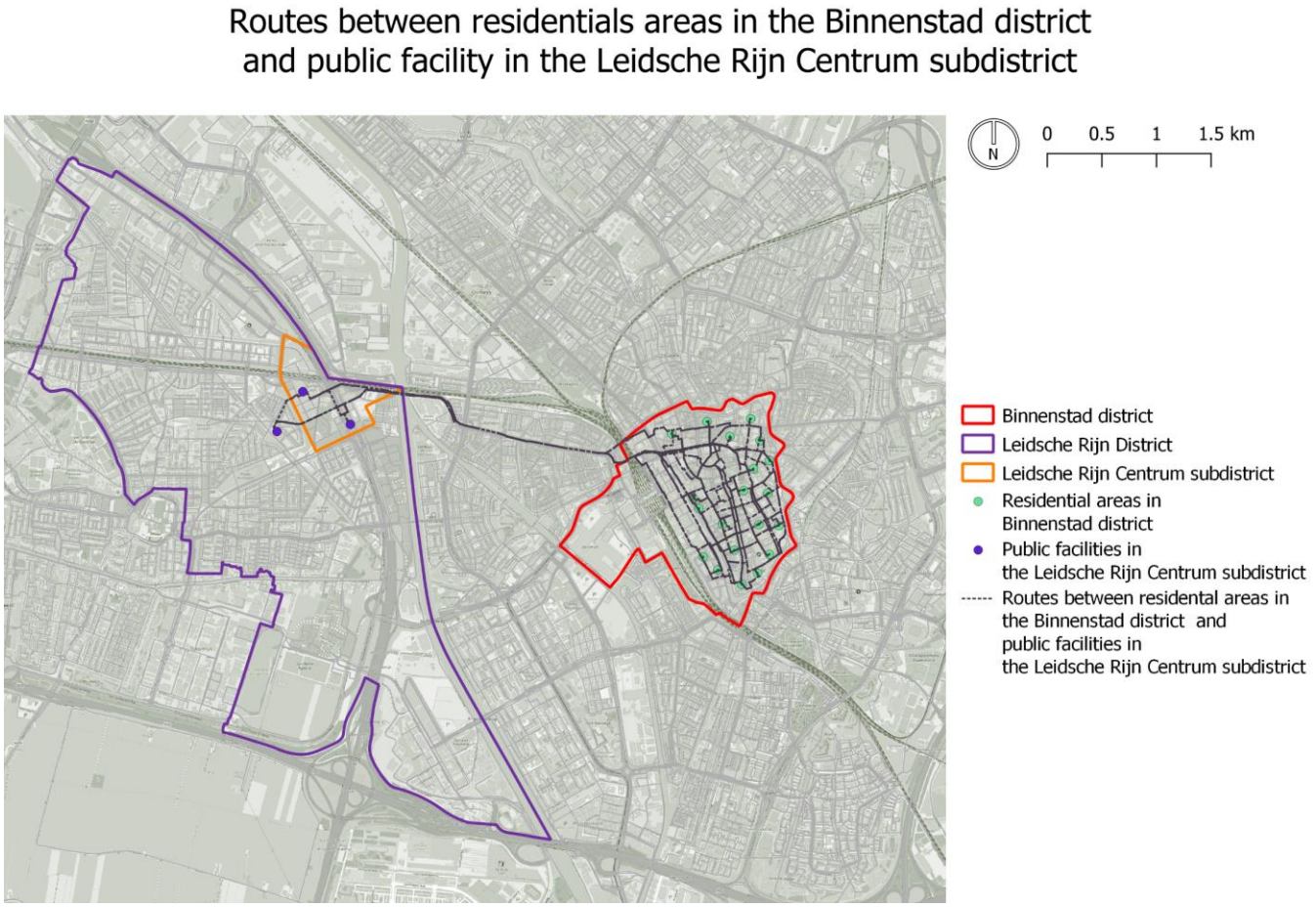

Figure 5-13 The routes between residential areas in the Binnenstad district and public facilities in the Leidsche Rijn Centrum subdistrict

Consider the accessibility between public facilities in the Leidshce Rijn Centrum subdistrict and Binnenstad, the map in figure 5-13 highlights the role of the cover above A2 Highway, particularly the Parijsboulevard, in the effort promoting the connection between the two areas. Since most of the important public facilities in Leidsche Rijn Centrum subdistricts locates in the northern part of the subdistrict, the road network at this area has a bigger influence to the connectivity between residential areas in Binnenstad district and the public facilities in Leidsche Rijn Centrum subdistrict.

The score is calculated by normalising the average distance from each point in the residential areas to each point of public facilities. The map in figure 5-13 describes the score of network distance from public facilities in Binnenstad district to other subdistricts in Utrecht. In general, it is expectable that the score decrease according to the Euclidean distance. However, the map highlighted that the subdistrict on the other side of the highway has a lower score in network distance in comparison with the subdistricts on the same side of the highway with Binnenstad district regardless the Euclidean distance. It means that the A2 highway obviously has a strong influence on the connectivity between Binnenstad district and other subdistricts.

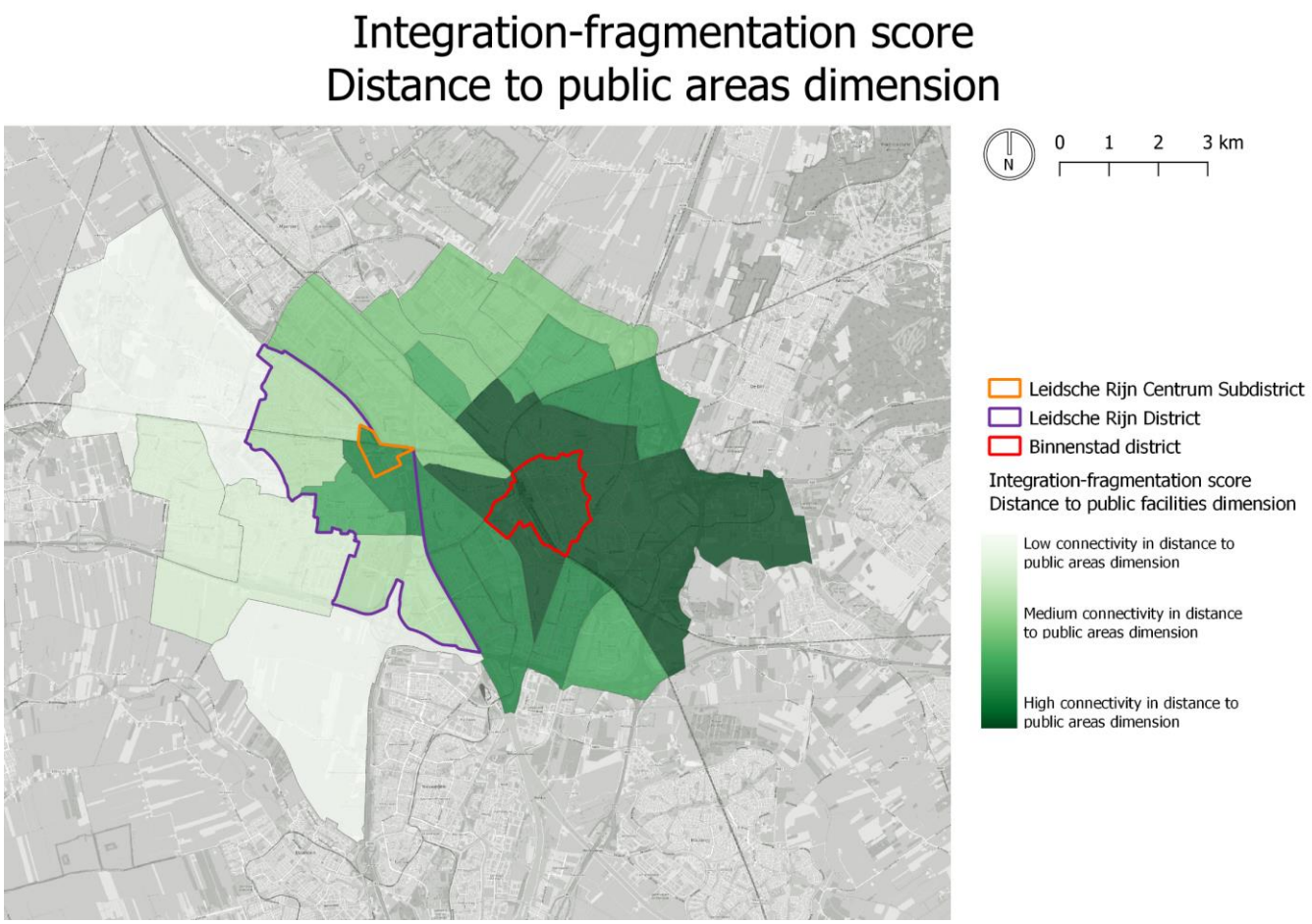

Figure 5-14 Integration – fragmentation score for indicator describing network distance to public facilities in Binnenstad district

In short, the results from the network analysis above supports the argument that the transport network could curtail the disadvantage caused by visual proximity. With the A2 highway highlighted as the shortest options connecting the two areas, the results also support the positive consequence of planning strategy covering A2 highway for improving the connectivity between LRC and Binnenstad.

ii. Bicycle and pedestrian accessibility

Bicycle and pedestrian accessibility plays an important role in evaluating the accessibility to an area (Yassin, 2019). In the planning documents of Leidsche Rijn project, bicycle and pedestrian accessibility to the neighbourhood has an important role in the level of connectivity of the district. This thesis accesses the bicycle and pedestrian connectivity between Leidsche Rijn Centrum subdistrict and Binnenstad district by measuring the ratio population choosing walking and cycling as a mean to Binnenstad from different subdistricts. As a general assumption, the two subdistricts of Binnenstad subdistrict should have the highest ratio of population choosing walking and cycling to commute to Binnenstad district. Meanwhile, subdistricts in the further distance might prefer other means of transport, for example, train or car, to commute to Binnenstad district, which leads to a lower ratio of choice choosing walking and cycling to Binnenstad district.

From the road network analysis in the previous section, the average distance from Leische Rijn Centrum subdistrict's residential areas to public facilities in Binnenstad district is approximately 2,7km. With that figure, it is expected that the ratio of cycling and walking as options to Binnenstad in LRC is not among the highest. The map in figure 5-15 below points out that for subdistricts on the other side of the highway, LRC has the highest ratio of choosing cycling and walking to Binnenstad. In general, subdistricts locate on the same side of A2 highway Binnenstad has a higher ratio of having cycling and walking as options to commute to Binnenstad.

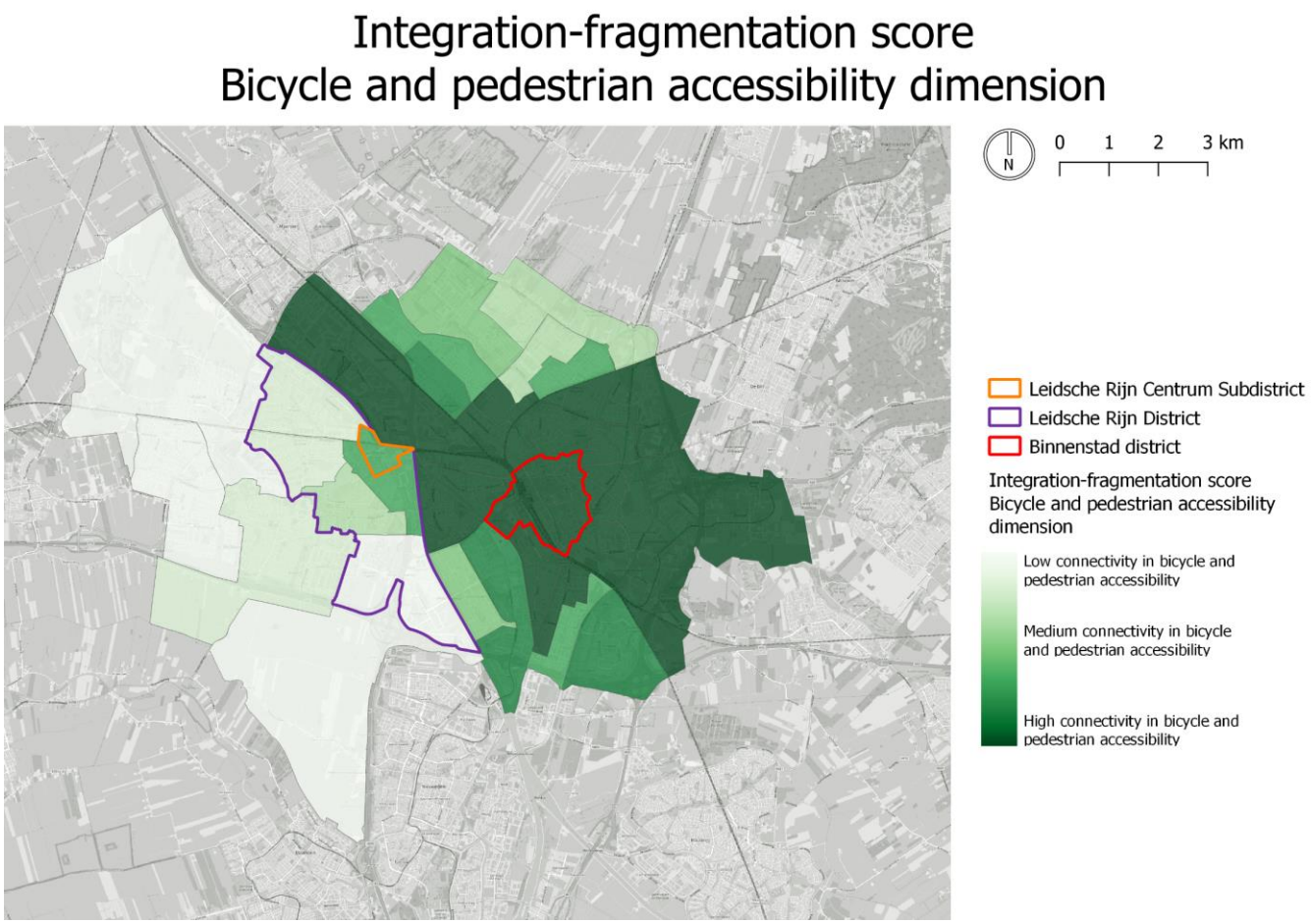

Figure 5-15 The ratio of cycling and walking to Binnenstad as options according to subdistricts in Utrecht city

5.2. Overall integration-fragmentation score

The previous sections discuss the calculation of individual indicators and the respective relationship with the level of integration and fragmentation of an area. That calculation is interpreted into integration/ fragmentation score by normalising the dataset with reference to the value of Binnenstad district. Translating the value of the indicators into score provide inputs for the discussion about the situation of the study area, which is Leidsche Rijn Centrum subdistrict, on the continuum framework of integration and fragmentation. The aggregated integration/ fragmentation is the average of the score of the individual dimensions. The score of each dimension is the average of the score of individual indicators of the respective dimension. The maximum score is 1, which indicates a fully integrated situation. The minimum score is 0, which indicates full fragmented situation. The first part of this section presents the aggregated score with equal weight for all dimensions. The later part of this section presents the aggregated score with different weights. The weight of the dimensions is from the survey with three members in the Leidsche Rijn project in Utrecht municipality.

a) The overall score without consideration of weight

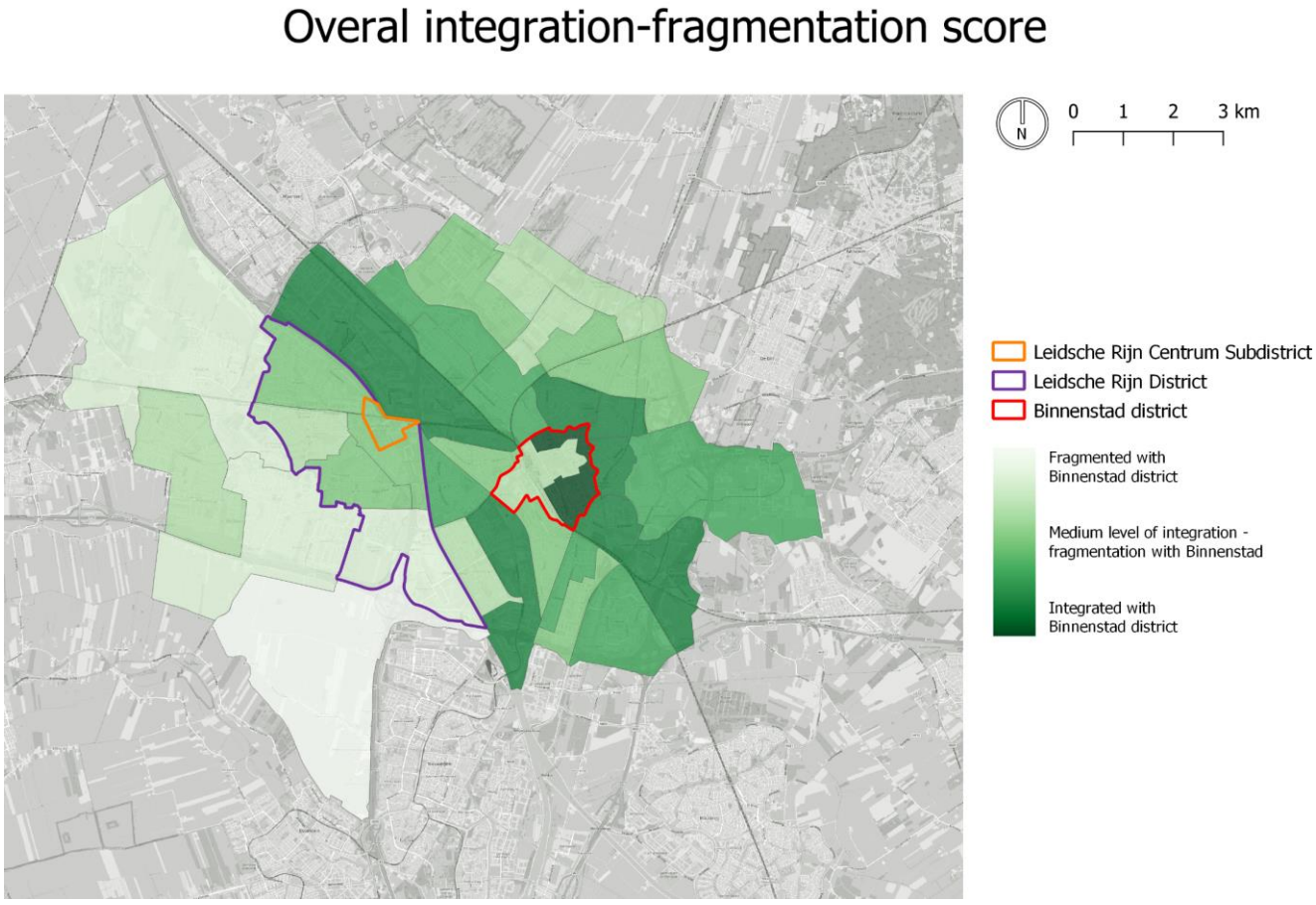

Figure 5-16 Overal integration - fragmentation score

The overall score of each dimension is the average score of indicators in the respective dimension. The data used to calculate public areas is from land use map in 2010. The thesis assumes that there is no major change in land use for public areas in Utrecht from 2010 to 2018. The road network used to calculate the score for distance to public facilities indicator based on Openstreetmap in 2020. The thesis assumes that there was no major change in the road network from 2018 to 2020. The overall score does not consist of the score for income because the data used for the income indicator analysis is from 2016. From 2016 to 2018, the overall GDP growth of the Netherland increase from 2,19% to 2,6% (Plecher, 2021). It is uncertain that the average income of the subdistricts would remain so that the thesis excluded the score of income indicator from the overall integration – fragmentation score. Figure 5-17 presents the integration – fragmentation score according to dimensions in the integration – fragmentation framework in equal weight.

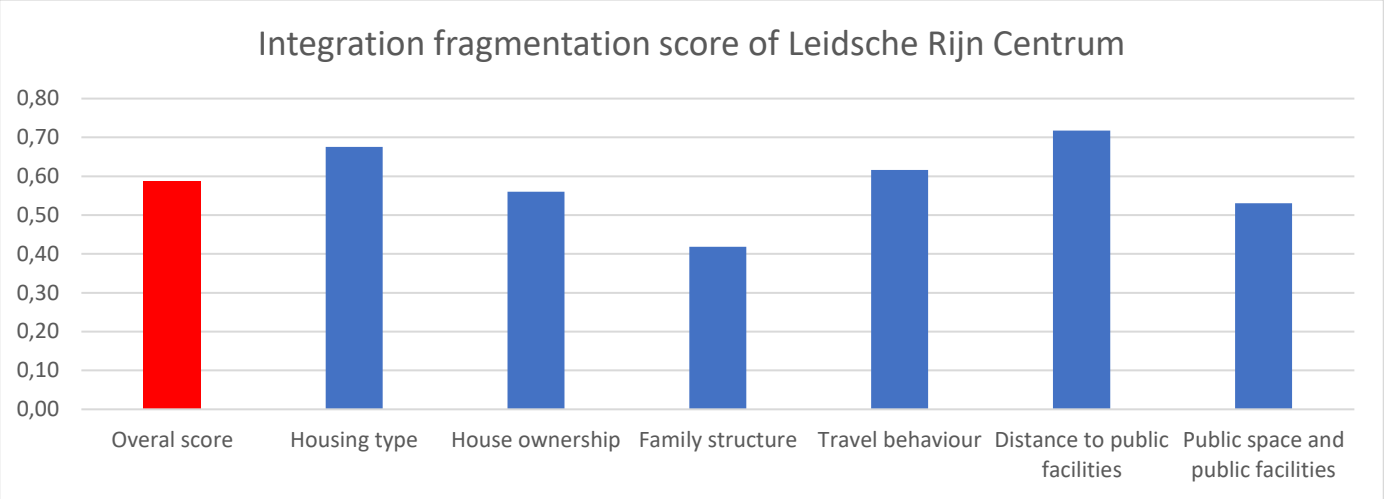

Figure 5-17 Integration/ fragmentation scores of Leidsche Rijn Centrum subdistrict according to dimensions

The chart in figure 5-17 shows that the overall score is 0,59. The score for family structure dimension is the lowest with the value of 0,42. The score of distance to public facilities is the highest with the value of 0,72. Given that value 1 indicates the fully integrated situation and value 0 indicates a fully fragmented situation, Leidsche Rijn Centrum subdistrict's level of integration to Binnenstad district is slightly above the medium level. The most unexpected outcome is the score for distance to public facilities dimension since its value is among the highest.

The score for the ratio of public space and public service area is the lowest with the value of 0,35. From the calculation in the previous section, the ratio of public space and service area in Leidsche Rijn Centrum subdistrict is noticeably greater than the ratio of public space and service area in Binnenstad district. This could be due to the fact that the Leidsche Rijn project is the new project with the various possibility for adjustment, while Binnenstad is a historical site with restricted spaces for adjustment. Considering the composition of public space and service area indicator, the score of this indicator has the second-highest value. It implies that the similarity level of the structure of public functions between the two areas is relatively high. It suggests the high similarity level in public activities and social interaction between the two areas, which lead to a higher level of integration between Leidsche Rijn Centrum subdistrict and Binnenstad district.

Table 5-1 combines the score of individual scores and the average overall score for the level of integration of LRC with Binnenstad.

Table 5-1 Integration/ fragmentation scores of indicators with equal weight for all dimensions

Dimensions	**Indicators**	**Score**
Housing types	The ratio of the five different housing types:	*0,68*
	1) apartment (appartement)	0,53
	2) terrace houses (tussenwoning)	0,41
	3) corner houses (hoekwoning)	0,51
	4) two houses under one roof (2 onder 1 kap)	0,96
	5) free-standing houses (vrijstaande woning)	0,97
House ownership	The ratio of different house ownership status:	*0,56*
	1) self-owning (eigendom koop)	0,87
	2) rental social housing (eigendom sociale huur in corporatiebezit)	0,55
	3) rental housing other than social social housing (eigendom huur overig)	0,2
	4) unknowned ownership (eigendom onbekend)	0,63
Family structure	The ratio of different household structure:	*0,42*
	1) living alone (alleenstaand)	0,33
	2) couple without child(ren) (paar zonder kind(en))	0,81
	3) couple with child(ren) (paar met kind(en))	0,22
	4) single parent (eenoudergezin)	0,73
	5) other (overig).	0
Public areas	The ratio of public spaces and public services, and the composition of the public areas	*0,53*
	Composition of public areas	0,71
	The ratio of public areas including	0,35
	water surface	0,66
	green	0,99
	social cultural	0,29
	recreation	0,93
Connectivity	Distance to public facilities measured by the average distance from residential buildings, and residential neighbourhood in Leidsche Rijn Centrum to public facilities in Binnenstad, including: 1) Hoog Catherijne 2) Steenweg (shopping street) 3) de Bijenkorf Utrecht 4) TivoliVredenburg 5) Dom Tower 6) Museum Catharijneconvent 7) Universiteitsmuseum 8) Nijntje museum 9) Central museum 10) Universiteitsbibliotheek Utrecht Binnenstad	*0,72*
	Bicycle and pedestrian accessibility measured by the ratio of a bike and walking chosen as an option to go to Binnenstad (***)	0,62
Average score		**0,59**

b) Integration – fragmentation score with weighted dimensions

Regarding the missing weight for the bicycle and pedestrian accessibility dimension, the thesis considered four scenarios for the weights of dimension Bicycle and pedestrian accessibility: weight 1, weight 2, weight 3, and weight 4. The overall score remains 0,59 in all scenario. The change of weight does not have a major influence on the overall score.

In compare with the overall score for an equally weighted dimension, there is no major change in the overall score. Given that value 1 indicates a fully integrated situation, value 0 indicates a fully fragmented situation, Leidsche Rijn Centrum subdistrict is slightly higher than the middle value in the continuum scale of integration – fragmentation.

In overall, weighted according to the survey's results and equally weighted score both point out that the level of integration of Leidsche Rijn Centrum with Binnenstad places is in the middle of the scale. The most noticeable outcome is the score of dimension distance to public facilities. At first, the visual location of Leidsche Rijn Centrum gives the impression that the score for this value might belong to the group of low score. Most of the scores of dimensions in urban nonphysical structure place in the middle of the scale. Since the area is still developing, those scores might subject to major changes in the future.

Table 5-2 Calculation of score for level of integration and fragmentation with consideration of weight

Aspect	**Dimensions**	**Score**	**Average weight from the survey**	**Score with weight from the survey and weight 1 for BP**	**Score with weight from the survey and weight 2 for BP**	**Score with weight from the survey and weight 3 for BP**	**Score with weight from the survey and weight 4 for BP**
The similarity in the urban structure	Housing types	**0,68**	4	2,72	2,72	2,72	2,72
	House ownership	**0,56**	3,33	1,8648	1,8648	1,8648	1,8648
	Family structure	**0,42**	3,33	1,3986	1,3986	1,3986	1,3986
	Public space and public servcies	**0,53**	3	1,59	1,59	1,59	1,59
Connectivity	Distance to public facilities	**0,72**	3,33	2,3976	2,3976	2,3976	2,3976
	Bicycle and pedestrian accessibility (BP)	0,62	-	0,62	1,24	1,86	2,48
Average overall score (*)	**0,59**			**0,59**	**0,59**	**0,59**	**0,59**

(*) Average overall score is calculated by dividing the total score to the total average weight. The average overall score of column "Score" equals to the scenario equal weight for all dimensions

5.3. Discussion and recommendation

This thesis presents an approach to quantify the urban integration – fragmentation level of an expansion area by comparing the similarity level and connectivity between the expansion area and the existing city. With the mentioned two aspects, the thesis uses different indicators to describe the characters and the relationship between the expansion area and the existing city. By considering urban integration and fragmentation as part of a continuum on different dimensions, the framework proposed in this thesis disentangle the phenomenon and highlight the most problematic elements in the integration – fragmentation progress of the expansion area. The results would be more accurate with additional dimensions and indicators which would provide more detailed pictures. The previous sections present the outcome from the analysis of urban integration – fragmentation level of the studied area with a brief discussion about the relationship among some indicators. This section present additional observation on the above results about the relationship among indicators and reflections on the selection of the indicator.

Regarding the similarity level of urban structure between Leidsche Rijn Centrum subdistrict and Binnenstad district, an analysis in the similarity level of demographic structure between the two areas would provide a more detailed picture in non-physical structure between the two areas. The analysis in demographic structure dimension could include the study on migration background structure, population density, the age structure of the population (such as the ratio of junior residents, the ratio of population in working age, the ratio of population in retired age) (Balbo, 1993; Schneider & Woodcock, 2008).

Regarding the connectivity between Leidsche Rijn Centrum subdistrict and Binnenstad district, this thesis consider all selected public areas at an equal level of importance. Since the characteristics of the selected public areas vary in different ways, such as functions and opening hours, the level of importance among them might vary accordingly. Therefore, a survey determining the level of importance of each public area would provide a more accurate outcome for the measurement of urban integration – fragmentation level of Leidsche Rijn Centrum subdistrict. In the same concern about residents' preference, an analysis about the residents' preferred public space would provide insights to evaluate the meaning of public spaces in the neighbourhood, and give a more detailed understanding on urban integration – fragmentation of the area (Balbo, 1993).

The connectivity between Leidsche Rijn Centrum subdistrict and Binnenstad district would have more accurate results by conducting more network analysis. For example, in addition to the measurement the network distance between public facilities and residential areas, an analysis measuring the time travelling between public facilities and residential areas in different modes of transports, such as by cars, walking, cycling, buses, trains, or the combination of multimodal transport, would provide a more detailed picture about the connectivity between Leidsche Rijn Centrum subdistrict and Binnenstad district. In addition to that, an analysis on the evaluation of public transport quality by conducting a survey with the residents using public transport to commute between the two areas would justify planning ambition of the subdistrict (Gemeente Utrecht, n.d.-c). The mentioned analysis would provide insights for measurement of connectivity between the expansion area and the existing city, which eventually contribute to the measurement of urban integration – fragmentation level (Schneider & Woodcock, 2008).

Another dimension that would contribute to the measurement of urban integration – the fragmentation level is safety and security (Coy, 2006). Fear of crime is among the common elements contributing to the fragmentation process of an area (Coy, 2006). In the context of Leidsche Rijn Centrum subdistrict, this dimension would be measured by two approaches. The first approach is conducting two surveys: one survey with the residents living in Leidsche Rijn Centrum subdistrict about their perception of safety in the Binnenstad; the other survey with the residents living in Binnenstad district about their perception of safety in Leidsche Rijn Centrum subdistrict. The second approach is to compare the safety index between the two areas.

The analysis could expand for the whole Utrecht city by using all the dimensions in the Leidsche Rijn Centrum subdistrict case study, the above-mentioned additional dimensions, and the new dimensions that might emerge in the planning documents of other subdistricts in Utrecht city.

Regarding the relationship among indicators, the observation from the overall results shows that the relationship among the indicators and dimensions in similarity level of urban structure is ambiguous and might require further analysis for clarification. For example:

According to the interview with Utrecht Municipality, director of spatial development and urban planning Leidsche Rijn, Vleuten-De Meern and manager of team Urban planning Leidsche Rijn, different family structures require different housing type, as well as public facilities (Utrecht Municipality, interview, 2019). According to figure 5-17, the integration –

fragmentation score of housing type indicator is noticeably higher than the other two indicators (0,68 for housing type dimension, 0,56 for house ownership dimension, and 0,42 for family structure dimension). That outcome implies that the housing type structure between the two areas is relatively similar; however, the family structure between the two areas is relatively different from each other. It might suggest that at the time of this thesis, the provision of housing type does not match with the family structure in the Leidsche Rijn Centrum subdistrict. This outcome aligned with the discussion in the interview with Utrecht Municipality that the population structure of an area involves through time:

> *"In those days, a lot of families went to neighbouring villages because they couldn't find a space to live in the city. So. In the 80s the VINEX locations were thought up, designed to prevent those families from moving out of the city to recreate a balance. Leidsche Rijn is naturally not completely at the city average. It takes about two generations before a neighbourhood or an area an urban development area will be almost equal to the average of the city where it was developed.*

However, if the analysis on different time series also gives a similar outcome, it might suggest a different relationship between the housing type and family structure. It could be that different family structures have the same preference in housing type, or there is a mismatch in the housing provision and the housing demand.

In compare with the results of dimensions in similarity level aspects, the results of dimension in connectivity aspects seems to have a clearer pattern. In general, the subdistricts which locate further from the Binnenstad district have a lower score. However, with a more detail observation, the result from Leidsche Rijn Centrum subdistrict suggests that Euclidian distance between the existing urban structure and the extension areas does not necessarily cause fragmentation for the areas. In other words, the result emphasised the role of traffic connectivity between the existing urban structure and the extension area in improving the level of integration of an urban area.

In summary, the urban integration - fragmentation framework considering the two phenomena as parts of a continuum would disentangle the problem into separate dimensions and highlight the problematic dimensions. The results of the analysis could be improved by adding dimensions and indicators which describe the characteristics influencing the integration – fragmentation level of the expansion area and the existing city. Additional analysis on the perspective of the residents would also improve the overall measurement of urban integration – fragmentation level of the study area. Although there are discussions about the relationship between indicators in literature and in the interview with Utrecht Municipality, the results from this thesis could not prove a solid relationship among the indicators. A more expended analysis, for example, the analysis on more time series, would provide a more solid foundation for the discussion about the relationship among the indicators and dimensions.

6. Conclusion

This thesis develops and applies an analytical framework for assessing integration and fragmentation of an urban area. By considering the two phenomena into one continuum, the proposed framework could problematise the phenomenon in multiple dimensions and recognise the critical elements influencing the urban integration – fragmentation level of an area. The dimensions developed in this thesis describe the two aspects of urban integration – fragmentation including 1) the similarity level of the urban structure between the expansion area and the existing urban structure, and 2) the connectivity between the two areas.

Since the drivers of urban integration and fragmentation vary according to different contexts, application of the urban integration – fragmentation framework requires justification according to the specific context of the study areas. The justification could refer to the cultural background, the historical development of the area, planning regimes, planning ambition, or the combination of all the mentioned elements. The level of importance of the indicators in the measurement of urban integration – fragmentation level also vary according to different contexts. Therefore, it is necessary to consider weighting those indicators in the measurement of urban integration – fragmentation level.

In the case study of Leidsche Rijn Centrum subdistrict, the urban integration – fragmentation level of the area is measured in two aspects including 1) the similarity level of the urban structure between Leidsche Rijn Centrum subdistrict and Binnenstad district, and 2) the connectivity between the two areas. The overall score implies that the study area is at the medium level in the framework, with a higher score in the connectivity aspects than in the similarity level of the urban structure aspects. This outcome supports one of the planning objectives for enhancing the connection between the two areas. The outcome also highlights the role of the traffic network in improving the level of integration between the new area and its existing urban structure. Since the data is from 2018, the result reflects the level of integration of the subdistrict in 2018.

The literature about urban integration – fragmentation and the interview with experts on the case study agreed on the connection between certain elements. However, the results from the thesis could not provide solid proof for the correlation or causal relationship among the indicators. The reason could be because of the nature of urban development: the development process of urban areas usually require observation in a long time period.

The framework proposed in this thesis could be improved by adding more indicators, especially indicators describing the non-physical structure between the study area and the existing urban structure. Other indicators describing the residents' perspectives on the urban integration – fragmentation level of the areas would also improve the accuracy of the measurement. Future research could focus on the development of additional indicators, on applying the framework for the other subdistricts in Utrecht to have an overall picture about the urban integration – fragmentation level of the city, or on the relationship among the indicators by more detailed social study, or by applying the proposed urban integration – fragmentation framework on the data of multiple time series to observe the pattern of the outcomes.

In summary, this thesis contributes to the literature on urban integration and fragmentation by proposing a framework to quantify the integration and fragmentation level of an area. The indicators introduced in this thesis are built on literature and the planning documents of the area. For different case study, the workflow and the methodology is applicable, but the indicators should alter according to the specific context of the case study. The thesis contributes to the understanding of the level of integration and fragmentation of Leidsche Rijn Centrum subdistrict in a specific time. For further study about the subdistrict, a study in a time series would provide the trend in the level of integration of the subdistrict. The results from this thesis do not identify the causes for the level of the integration of Leidsche Rijn Centrum subdistrict with the Binnenstad district. Future studies could focus on improving the accuracy of the framework or on studying the relationship between the dimensions and indicators.

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Appendix

Appendix 1: Extended tables of urban integration and fragmentation framework

Aspect	Dimensions	Subdimension/ *Indicator*	Scale	*Quotation*/ Reference to related research	Note
Structure of physical elements in the city	Settlement pattern	Visual shape of settlement pattern whether it is continuous or discontinuous		*"The city of the Third World is a city of fragments, where urbanisation takes place in leaps and bounds, creating a continuously discontinuous pattern." (Balbo, 1993)* *"[…] The most perceptible one is that of the built environment, and the different settlement patterns referred to above: the 'modern' centre, the historic city, the planned districts, the various types of illegal settlements, the slum areas" (Balbo, 1993).*	
	Settlement pattern	The similarity in characteristics of: - Service - Income - Cultural value - Institutional systems	The measurement could be at a different scale from neighbourhood to street level, but the elements should be on the same scale	*In the fragmented city, physical environment, services, income, cultural values and institutional systems can vary markedly from neighbourhood to neighbourhood, often from street to street." (Balbo, 1993).*	
	Settlement pattern	*- The ratio of population density in an urban area* *- The amount of land developed per person* - The spatial extent of urban areas *- The rates of land conversion*		*"To characterise the nature of changes and compare/contrast trends across cities and nations, we use a set of indicators that describe: (a) the spatial extent of urban areas; (b) the rates of land conversion; (c) the location and pattern of new urban land; (d) the amount of discontinuous growth; and, (e) the efficiency of land development, as suggested by population density."* (Schneider & Woodcock, 2008)	
	Characteristic of settlement	- Formation - Location - Size - Fitting - Construction typology	Neighbourhood level	*"Condomínios fechados (Brazil) or barrios cerrados (Argentina) can be typified following different criteria, such as formation, location, size, fittings, construction typology, as well as social structure." (Coy, 2006)*	
	Housing typology	- Aesthetic value		*"a series of dimensions are compared: 1) domestic architecture" (Low, 2007)* (example of domestic architecture: single-family houses, townhouses, apartments, extended family house around a patio, courtyard house, work-unit complexes) "Based on a national survey and regional focus groups, Edward Blakely and Mary Gail Synder (1997), identify three kinds of gated communities--lifestyle, elite, and security zone--each categorized by aesthetic control" (Low, 2007)	
Structure of non-physical element in the city	Meaning of public space	- Cultural meaning - Cultural pattern of social sanction/norm/authorisation	The measurement could be at a different scale from neighbourhood to street level, but the elements should be on the same scale	*"Within every fragment, the 'urban landscapes' vary. Urban structures where private, collective and public spaces have different meanings, give rise to a variable planned or fortuitous mix of built-up and empty plots, areas of concentration and areas of dispersal, connecting and dividing elements." (Balbo, 1993).* *"1) domestic architecture (for example: single family houses, townhouses, apartments, extended family house around patio, courtyard house, work-unit complexes), 2) urban/suburban settlement patterns (for example: urban street grid with houses facades open to the street, suburban houses with open yards, garden apartment, urban street grid with individual houses surrounded by walls, apartment complexes surrounded by walls, urban street grid with courtyard housing surrounded by wall), 3) the role of the state (for example: ambivalent, local governments use gated communities to reduce financial burden, federal government and citizens oppose gating as discriminatory, neoliberal governments' withdrawal of the state from provision of urban goods and services, state encourages the building of enclosed neighbourhoods as a strategy to maintain stability, reduce crime, and expand political control), 4) governance (community interest development, public law, state controlled governance groups), 5) citizenship (for example: succession from local citizenry, deteriorating sense of citizenship through demise of the state), 6) cultural meaning (community by contract, openness, confers Westernised modern status), 7) identity (individual, collective identity of lineage, work or lifestyle), 8) provision of goods and services, 9) taxation, 10) degree of privatization, 11) cultural pattern of social sanction (for example: moral minimalism, niceness, gossip, internal organisations provide social controls, residents' committees), and 12) fear of crime and others." (Low, 2007)*	Quotation from Low (2007)'s works would refer to many other dimensions
	House ownership composition	*- The ratio of different tenure structure (for example ratio of rental houses, ration of self-own houses depending on the specific context)*	The measurement could be at a different scale from neighbourhood to street level, but the elements should be on the same scale	*"A third essential way to look at spatial fragmentation is to consider the wide variety of tenure conditions." (Balbo, 1993)*	

	Characteristic of population	- *Rate of urban population growth* - Components of the population, including: + Migration background + Population density + Ratio of the population not urban area + Amount of land developed per person + Citizenship - The working population - Population with high education	+ Between neighbourhoods *(Balbo, 1993)* + Varied: per country, census block (Schneider & Woodcock, 2008)	*"Aside from the rate of urban population growth, its components also play an important role: mainly the natural increase in Latin America, migration in several African countries (though the number is dismissing), and foreign refugees in a significant and increasing number of cities. Natural growth and migration flows shape the city structure differently: house-sharing and overcrowding is more common in Latin America where the population is already mostly urban, while in Africa rural migrants often settle on the urban fringe, creating vast low-density semi-rural settlements" (Balbo, 1993)* *"Quantifying sprawl has appeared as a topic of research in just the past few years, and different approaches have emerged to evaluate a variety of spatial, demographic or social characteristics associated with different urban patterns. The most popular of these measures are routinely based on population information (often the most readily available data), used either alone as population density per county, census block, etc. (El-Nasser and Overberg, 2001; Lopez and Hynes, 2003; Hammer et al., 2004) or in conjunction with land cover information, such as the ratio of population to the urban area or the amount of land developed per person (Webster, 2002; Hasse and Lathrop, 2003; Wolman et al., 2005)"* (Schneider & Woodcock, 2008)	
	Safety and security	- Fear of crime		*"Condomínios fechados (Brazil) or barrios cerrados (Argentina) can be typified following different criteria, such as formation, location, size, fittings, construction typology, as well as social structure." (Coy, 2006)* *"These data show that urban violence affects social groups in very different ways and also corresponds to the increasing social disparities that result from urban fragmentation." (Coy, 2006)*	
	Household characteristic	- Household size - Household type - Age and sex of the head of the household		"Other variables (household type, age and sex of the head of the household, working population) show a substantially more homogenous distribution with no particular concentration pattern or hierarchy among the fragments, with the notable exception of two variables: level of education and, in particular, income distribution." (Balbo & Navez-Bouchanine, 1995)	
	Socio-economic characteristics and social structure	- Lifestyle - Status - The expansion of informal settlement and economy - Self-segregation of the privileges - Increase of socio-economic and ecological potential - *Level of vulnerability* - Loss of governability - Level of urban-suburban conflicts and socioeconomic disparities - Identity - Income - Taxation - *Degree of privatisation*		- *"As living in gated housing areas continues to be largely a privilege of the wealthier urban dwellers, the emergence of gated communities has to be interpreted as the product of increased socioeconomic disparities in urban society." (Coy, 2006)* - *"Concerning these urban places of action and representation of the wealthy, three factors should be taken into consideration in order to understand the rationality of the resulting urban fragments: status, lifestyle and security." (Coy, 2006)* - *"The first scenario is that of a fragmented city. In this scenario disintegration between the formal and the informal city deepens, the self-segregation of the wealthier urban dwellers increases and conflict potentials of varying scales and qualities are aggravated. Public authorities are more and more powerless in view of increasing disparities and market controlled urban transformation processes." (Coy, 2006)* - Figure6 Scenarios of urban development by Coy (2006) - *"Besides the traditional variables defining the population socio-economic profile of the different fragments, the survey considered a number of other quantitative variables intended to define the relationship between a fragment of residence and use of the city. In this view, the following issues have been taken into consideration:* *- the places of reference and the accessibility to infrastructure and services;* *- the household's residential trajectory within the agglomeration;* *- the family network and its spatial location." (Balbo & Navez-Bouchanine, 1995)* *"The expansion and consolidation of gated and exclusive residential areas (physically or symbolically closed). This new form of urbanization, dominant among the upper and upper-middle classes, is accompanied by the more recent gentrification of some central areas." (Bayón & Saraví, 2013)* - *"Based on a national survey and regional focus groups, Edward Blakely and Mary Gail Synder (1997), identify three kinds of gated communities--lifestyle, elite, and security zone--each categorized by income level" (Low, 2007)* "Other variables (household type, age and sex of the head of the household, working population) show a substantially more homogenous distribution with no particular concentration pattern or hierarchy among the fragments, with the notable exception of two variables: level of education and, in particular, income distribution." (Balbo & Navez-Bouchanine, 1995)	
	Governance and organisation	- Level of disorganisation and destabilisation - Role of the state		- Refer to Fig.6 Scenarios of urban development by Coy (2006) - *"This paper expands the original argument by adding the Latin American case and employs a multidimensional, cross-cultural analysis to explore regional and national variation as another step in generating an integrated theory of urban fragmentation. Utilizing data from the urban and suburban United States, Latin America and China, a series of dimensions are compared: 1) domestic architecture, 2) urban/suburban settlement patterns, 3) the role of the state, 4) governance, 5) citizenship, 6) cultural meaning, 7) identity, 8) provision of goods and services, 9) taxation, 10) degree of privatization, 11) cultural pattern of social sanction and 12) fear of crime and others." (Low, 2007)*	
	Relationship between residents and the place	*Percentage of population living and working in the same neighbourhood*		"Other variables (household type, age and sex of the head of the household, working population) show a substantially more homogenous distribution with no particular concentration pattern or hierarchy among the	

				fragments, with the notable exception of two variables: level of education and, in particular, income distribution." (Balbo & Navez-Bouchanine, 1995)	
	Choice of place to live and work	*Percentage of the population choosing a place to live according to the workplace of the head of the household*		*"Besides the traditional variables defining the population socio-economic profile of the different fragments, the survey considered a number of other quantitative variables intended to define the relationship between a fragment of residence and use of the city. In this view, the following issues have been taken into consideration:* *- the places of reference and the accessibility to infrastructure and services;* *- the household's residential trajectory within the agglomeration;* *- the family network and its spatial location." (Balbo & Navez-Bouchanine, 1995)*	
	Household's residential trajectory	*- Percentage of families living in a different neighbourhood before the time of the survey*		*"Besides the traditional variables defining the population socio-economic profile of the different fragments, the survey considered a number of other quantitative variables intended to define the relationship between a fragment of residence and use of the city. In this view, the following issues have been taken into consideration:* *- the places of reference and the accessibility to infrastructure and services;* *- the household's residential trajectory within the agglomeration;* *- the family network and its spatial location." (Balbo & Navez-Bouchanine, 1995)*	
	Family network	*- The ratio of families, of which members having relatives living in the same neighbourhood*		*"Besides the traditional variables defining the population socio-economic profile of the different fragments, the survey considered a number of other quantitative variables intended to define the relationship between a fragment of residence and use of the city. In this view, the following issues have been taken into consideration:* *- the places of reference and the accessibility to infrastructure and services;* *- the household's residential trajectory within the agglomeration;* *- the family network and its spatial location." (Balbo & Navez-Bouchanine, 1995)*	
connectivity	Accessibility to services and infrastructure	- Auto dependence - Road network accessibility *- Distance to jobs or commercial areas* *- Distance to public facilities* *- The ratio of choosing a car as a key means of transport instead of public transport* - Provision of goods and services - Place of preference for public facilities *- Existing of restriction to access public space*		*The second symptom of fragmentation is represented by the differences in services and infrastructure levels and their accessibility. (Balbo, 1993).* *"A few studies have included measures of accessibility and proximity, such as auto dependence, road network accessibility or even distance to jobs or commercial areas"* (Schneider & Woodcock, 2008) *"These developers, driven exclusively by market logic, have sought, on the one hand, to achieve economies of scale through the standardised construction of hundreds of thousands of (very) small houses and, on the other, to increase profitability by purchasing very cheap land, placing these complexes in peripheries that are increasingly distant from urban centres and even basic urban infrastructure (Moctezuma, 2012)." (Bayón & Saraví, 2013)* *"These fortified and self-referential spaces are autonomous from the surrounding urban space, given that they are directly linked to the car as a primary means of connection. This, in turn, requires expressways (without any consideration for urbanism, quality of urban social life, and sustainability) and leads to an abandonment of and total lack of interest in public pedestrian space." (Bayón & Saraví, 2013)* *"This paper expands the original argument by adding the Latin American case and employs a multidimensional, cross-cultural analysis to explore regional and national variation as another step in generating an integrated theory of urban fragmentation. Utilizing data from the urban and suburban United States, Latin America and China, a series of dimensions are compared: 1) domestic architecture, 2) urban/suburban settlement patterns, 3) the role of the state, 4) governance, 5) citizenship, 6) cultural meaning, 7) identity, 8) provision of goods and services, 9) taxation, 10) degree of privatization, 11) cultural pattern of social sanction and 12) fear of crime and others." (Low, 2007)* *"Based on a national survey and regional focus groups, Edward Blakely and Mary Gail Synder (1997), identify three kinds of gated communities--lifestyle, elite, and security zone--each categorized by […] amenities, […] and location in the region" (Low, 2007)*	
	The visual form of the neighbourhood	*- Having fences and/or other types of barrier to separate the neighbourhood from the rest of the city/ surrounding areas* *- Having fences and/or types of barrier to prevent outsiders from accessing the exclusive public facilities in the gated communities*	Neighbourhood level	*"The expansion and consolidation of gated and exclusive residential areas (physically or symbolically closed)." (Bayón & Saraví, 2013)* *"Gated communities have privatized the public space within their walls and have also contributed to large investments in real estate,[…]" (Bayón & Saraví, 2013)*	

Appendix 2 Table of all indicators mentioned in planning documents of Leidsche Rijn project

Aspect	Dimensions	Subdimentions/ *Indicator(s)*	Scale	Quotation/ Rationale	Note
The similarity in the urban structure	Housing types	*The ratio of the five different housing types:* *1) apartment (appartement)* *2) terraced houses (tussenwoning)* *3) corner houses (hoekwoning)* *4) 2 houses under 1 roof (2 onder 1 kap)* *5) free-standing houses (vrijstaande woning)*	Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*"Leidsche Rijn Centrum Zuid is daarnaast vestigingsplaats voor kantoren en heeft een gedifferentieerd woningaanbod."* (Gemeente Utrecht, 2009) Translation: Leidsche Rijn Center Zuid is also a location for offices and has a differentiated housing supply. Utrecht municipality database distinguishes five housing types: 1) apartment (appartement), 2) terraced houses (tussenwoning), 3) corner houses (hoekwoning), 4) 2 houses under 1 roof (2 onder 1 kap), 5) free-standing houses (vrijstaande woning)	
	Network of public spaces (including squares and other public areas)	*- The ratio of green spaces and water surface per capita* *- The ratio of public space per capita*	Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*"Het beoogde stedelijke karakter vindt zijn uitwerking in de hoge bebouwingsdichtheid, de sterke mate van functiemenging en de diversiteit en hoge kwaliteit van de openbare ruimten." (Gemeente Utrecht, 2009)* Translation: The intended urban character is reflected in the high density of buildings, the high degree of mix of functions and the diversity and high quality of public spaces. *"Een netwerk van pleinen en andere publieke ruimtes is dan ook één van de belangrijkste onderleggers voor het stedenbouwkundige ontwerp."*(Gemeente Utrecht, n.d.-b) Translation: A network of squares and other public spaces is, therefore, one of the most important foundations for urban design.	
	Mixed function land-use	*The ratio of:* *- Commercial and services (shops and hospitality)* *- Housing* *- Offices* *- Social and cultural facilities*	Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*"Met bovenstaande genoemde visie als uitgangspunt is het Masterplan Leidsche Rijn Centrum opgesteld. In het Masterplan zijn de genoemde ambities uitgewerkt in:* *• klassieke stedenbouw met veelal gesloten bouwblokken* *• omringd door singel en parken* *• een glooiend maaiveld* *• hoge bebouwingsdichtheid* *• sterke functiemenging* *• hoogbouw als landmark ten noorden van het spoor."* (Gemeente Utrecht, 2009) Translation: With the aforementioned vision as a starting point, the Leidsche Rijn Center Master Plan has been drawn up. The stated ambitions are elaborated in: • classic urban design with mostly closed building blocks • surrounded by canal and parks • a sloping surface • high building density • strong function mix • high-rise buildings as a landmark north of the track.	
Dis(connectivity)	Availability of public transport		Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*"De HOV (Hoogwaardig Openbaar Vervoer)-baan en Fietsboulevard lopen dwars door Leidsche Rijn Centrum Zuid en hebben een directe verbinding met andere delen van het centrum, Leidsche Rijn en de binnenstad van Utrecht."* (Gemeente Utrecht, 2009) Translation: The HOV (High-quality Public Transport) track and Fietsboulevard run straight through Leidsche Rijn Centrum Zuid and have a direct connection to other parts of the centre, Leidsche Rijn and the Binnenstad of Utrecht. "Bereikbaarheid van het centrum is cruciaal om het centrum goed te laten functioneren, zowel van buiten Leidsche Rijn als vanuit Leidsche Rijn zelf. Dat geldt voor de auto, de fiets, de voetganger, het openbaar vervoer en het laad- en losverkeer."(Gemeente Utrecht, n.d.-c) Translation: Accessibility of the centre is crucial for the centre to function properly, both from outside Leidsche Rijn and from Leidsche Rijn itself. This applies to the car, the bicycle, the pedestrian, public transport and the loading and unloading traffic.	
	Accessibility of bicycle lanes	- Availability of bicycle lanes *- Percentage of people choosing cycling as main mean of transport*	Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*"De HOV (Hoogwaardig Openbaar Vervoer)-baan en Fietsboulevard lopen dwars door Leidsche Rijn Centrum Zuid en hebben een directe verbinding met andere delen van het centrum, Leidsche Rijn en de binnenstad van Utrecht."* (Gemeente Utrecht, 2009) Translation: The HOV (High-quality Public Transport) track and Fietsboulevard run straight through Leidsche Rijn Centrum Zuid and have a direct connection to other parts of the center, Leidsche Rijn and the Binnenstad of Utrecht. "Bereikbaarheid van het centrum is cruciaal om het centrum goed te laten functioneren, zowel van buiten Leidsche Rijn als vanuit Leidsche Rijn zelf. Dat geldt voor de auto, de fiets, de voetganger, het openbaar vervoer en het laad- en losverkeer."(Gemeente Utrecht, n.d.-c) Translation: Accessibility of the centre is crucial for the centre to function properly, both from outside Leidsche Rijn and from Leidsche Rijn itself. This applies to the car, the bicycle, the pedestrian, public transport and the loading and unloading traffic.	
	Accessibility to car traffic		Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*"De Stadsweg is een belangrijke schakel in de totale ontsluitingsstructuur van Leidsche Rijn, waaronder dus ook Leidsche Rijn Centrum."* (Gemeente Utrecht, n.d.-c)	Car-traffic structure in Leidsche Rijn Centrum as well as in Leidsche Rijn has a

				Translation: The Stadsweg is an important link in the total access structure of Leidsche Rijn, including therefore Leidsche Rijn Center. *De opgave voor het centrum is om de Noordelijke Stadsas met 2x2 rijstroken in te passen. Deze weg loopt parallel aan het spoor en vormt één van de verbindingen tussen Leidsche Rijn en de bestaande stad.*(Gemeente Utrecht, n.d.-c) Translation: The task for the centre is to fit in the Northern City Axis with 2x2 lanes. This road runs parallel to the track and forms one of the connections between Leidsche Rijn and the existing city. *"In de verkeersstructuur van Leidsche Rijn is aangegeven dat er geen doorgaand verkeer vanaf de A2 door het centrum van en naar de bestaande stad mag rijden. Om dat tegen te gaan, moet het onaantrekkelijk worden gemaakt om, komende vanaf de Noordelijke Stadsas uit oostelijke richting, af te slaan naar de Verbindingsweg om vervolgens via de Soestwetering de A2 op te rijden en vice versa."* (Gemeente Utrecht, n.d.-c) Translation: The traffic structure of Leidsche Rijn states that no through traffic from the A2 is allowed to drive through the centre to and from the existing city. To counter that, it must be made unattractive to turn from the Northern City Axis from the eastern direction to the Verbindingsweg and then via the Soestwetering to the A2 and vice versa.	different approach for specific areas (for example there should be the connection to the existing city, yet there should be no drive-through traffic to the Leidsche Rijn Centrum.
	Provision of parking space	*Ratio of parking lots per household*	Comparing between Leidsche Rijn Centrum subdistrict and Binnenstad district	*Als uitgangspunt is daarom gekozen om per woning 1 privé-parkeerplaats aan te leggen en de overige parkeerplaatsen (1500) op te vangen in de openbare voorzieningen* *Translation: The starting point was, therefore, to construct 1 private parking space per dwelling and to accommodate the remaining parking spaces (1500) in public facilities.*	

Appendix 3: Interview question template

Interview with manager of urban development for Leidsche Rijn project

Introduction

Thank you for accepting my interview invitation. My name is Mai. I am a master student in Faculty of Geo-information and earth observation science (ITC), University of Twente. As mentioned in the email, the main discussion is about the urban integration/fragmentation with Leidsche Rijn as the case study for the topic. Before the interview, I would like to ask for your permission to record this interview. The interview will be anonymised when being used in the thesis. Also, the information from the interview will be used only for the purpose of the thesis.

Could you introduce something about yourself?

My thesis topic is about developing a framework for accessing urban integration/fragmentation. The framework would be useful for urban planners in their practice or study about the urban development project. I am particularly interested in the project of Leidsche Rijn because, in one of the documents about the project, it stated that, together with the Binnenstad, Leidsche Rijn is expected to become a complementary centre of Utrecht city. Also, Leidsche Rijn falls in the definition of VINEX areas. Therefore, it is expected to integrate with the existing urban structure.

Interview question

Question 1: According to you, how would an integrated city look like? How would a fragmented city look like?

Question 2: Could you clarify further the meaning of "complementary centre" in one of the goals of the Leidsche Rijn project?

Question 2.2: In one of the planning document, it mentioned one of the element in for Leidsche Rijn (Leidsche Rijn centrum) is to have "strong mix-function". How exactly this "strong mix-function" should be defined? For example, is there any target such as there should be more than 2 or 3 functions integrated into one building; or the ratio of different functions should be equal, etc.?

Question 2.3: In some literature, the tenure status would have a certain influence on the social relationships in the community. In the context of the Dutch community, some literature also mentioned the role of social housing associations in social integration. According to you, would it be relevant to consider tenure status as an indicator to assess the urban integration and fragmentation in Leidsche Rijn Centrum?

Question 2.4: In the planning document of LRC, it explicitly describes one type of mix-building with commercial plinth and apartment above. This building type is also common in the Binnenstad. Does this imitation aim to increase the integration quality of LRC with the Binnenstad?

Question 3: What are the aspects that Leidsche Rijn project focus on to ensure the wijk is integrated with the Utrecht city?

Expected answer: Some aspects/dimension that the project focuses on to access the level of integration/fragmentation of Leidsche Rijn project, maybe 10.

Follow-up **question 3.1:** Would you also give the weight for the level of importance of those aspects in the Leidsche Rijn project? (Could you give the order of the mentioned aspects according to its importance).

Question 3.2: What are the social elements that Leidsche Rijn project would like to emphasis in term of social integration?

Question 4: What do you think about the role of connectivity in the assessment of urban integration/fragmentation?

Question 4.1: What do you think about the role of public transport in the assessment of urban integration/fragmentation?

Question 4.2: In the case of The Netherlands, cycling is a very important mean of transport. How do you think about the influence of having biking lanes in the urban integration/fragmentation assessment?

Question 4.3: What do you think about the role of accessibility to public squares, public parks and shopping crossing areas (meaning between Leidsche Rijn and the Binnenstad) in the assessment of urban integration/fragmentation?

Connecting sentence: Since we have discussed the connectivity, I would like to move on to another aspect in the urban integration/fragmentation framework, which is the urban structure.

Question 5: Do you think that it is reasonable to state that Leidsche Rijn is integrated with Utrecht city if it has a high similarity level with the existing urban structure? Maybe in term of demographic structure, tenure status, land-use components.

The term “urban structure” could be elaborated using an example from the answer given above.

Connecting sentence: We have discussed aspects to be considered for building the framework for urban integration/fragmentation. I would like to discuss the monitoring of the project. Leidsche Rijn is a very big and complicated project. I would expect that the project has to go through different phases.

Question 6: What are the elements to focus on to ensure that the area is in the direction of integrating with the existing city?

After the interview

Thank you for your time. I would like to summarize some main points in our discussion today.

[Summary]

Is there anything else that I should notice?

Thank you for your time.

Appendix 4: Survey template

Integration and fragmentation quantitative framework

This survey is part of my Master Thesis with the topic "Studying integration and fragmentation in the urban expansion area. The case study in Leidsche Rijn Centrum, Utrecht, The Netherlands". The survey aims to give weight to indicators used to measure the level of integration of the expansion area (Leidsche Rijn) with the existing city structure.

According to literature about the topic of urban integration and fragmentation, the thesis studies the phenomenon of urban integration and fragmentation of an area according to two main aspects:

1) The similarity in urban structure between the two area

2) The connectivity between the two area

Profession:

Email:

The following are the dimensions:

On the scale from 1 to 4 with 1 is least important/least relevant and 4 is most important/most relevant in measuring the level of urban integration of Leidsche Rijn and the existing city structure, which are the score for the following dimensions:

SQ	Dimensions	1	2	3	4
1	Residential types: The ratio of different housing types: apartment, terrace house, corner house, 2 house under 1 roof, free-standing house)				
2	House ownership composition: The ratio of different tenure status: self-owning, rental social housing, rental housing other than social housing, unknown ownership)				
3	Family structure: The ratio of different household structure: living alone, t**he** couple without child(ren), couple with child(ren), single parent, others				
4	Income group composition				
5	Accessibility to public facilities				