METROPOLITAN VIRUS

A strategic planning framework to improve the resilience of the Metropolitan Region Amsterdam in the aftermath of the COVID-19 pandemic

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Abstract

Metropolitan regions are the most urbanized and globalized areas as the concentration of population and economy in the world, which makes them exposed to various global emergency risks like pandemics. And the COVID-19 outbroke from Wuhan (China) at the end of 2019, offered an up-to-date perspective as an opportunity to investigate and improve the vulnerability of metropolitan regions in highly contagious global diseases. Metropolitan Region Amsterdam, is one of the most developed regions in the Netherlands and the world, who is playing a significant role in globalization. However, in this emerging public health crisis, MRA has been the most vulnerable region as the current epidemic hotspot. The concentration of corona cases in the region has resulted in various negative impacts, both directly and indirectly.

Considering these problems, this project is a research-oriented design in MRA for the post-pandemic vision. Firstly, through a series of theoretical, political, and spatial analysis, the main problem of MRA is that it is vulnerable to the direct and indirect effects of the pandemic due to a vicious cycle of urban vulnerability which has been exposed and intensified by the hazard of COVID-19. And the basic reason is related to its attachment to continuous economic growth. The government of MRA has also paid attention to this problem and attempted to transfer its development from a pro-financial model to a pro-well-being model with a theoretical underpinning called "Doughnut Economics". However, like many other experimental tests, this transformation follows the traditional planning method which is not suitable for dynamic risks like the pandemic. Therefore, this research is aiming at spatial and political strategies based on the methodology of dynamic planning to improve urban resilience facing the pandemic in the post-COVID MRA. And the final concrete outcomes will be on different scales. There will be a vision of post-COVID MRA through a set of strategies of municipalities and institutions to improve urban resilience. And on a local scale, there will be a resilient design for different pandemic vulnerabilities for an equal and sustainable community.

Keywords: Globalization, Metropolitan Region Amsterdam, COVID-19, Urban vulnerability, Urban resilience

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1 PREFACE

This short preface expresses the acknowledgement and personal motivation of this project, followed by an introduction of the contexts developed in the report and the Planning Complex City studio.

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Fig. 1.1.1. Housing and canals in Amsterdam. Photographed by author.

1. ACKNOWLEDGMENTS

First of all, I would like to thank my mentors Rodrigo Cardoso and Claudiu Forgaci for their patient support and guidance of my research. The graduation research is difficult facing the challenge from the Corona, but my mentors still try their best to inspire me and figure out problems during the project.

Along with that, I would like to recognize the support from the Urbanism and Planning Complex Cities studio, particularly from Karlou Westerbeek and Christiaan Hanse. You all contribute in various aspects to keep the helpful environment, where we can communicate and discuss with each other even though we cannot meet in the faculty.

Last but not least, I also would like to acknowledge the people helped this research through their listening and opinions. I would like to thank my family and my friends from China for their support, advice and accompany about everything during the graduation year. I am also grateful to my boyfriend Xiaohu for his care and perfect advice to solve the problems both in my research and life.

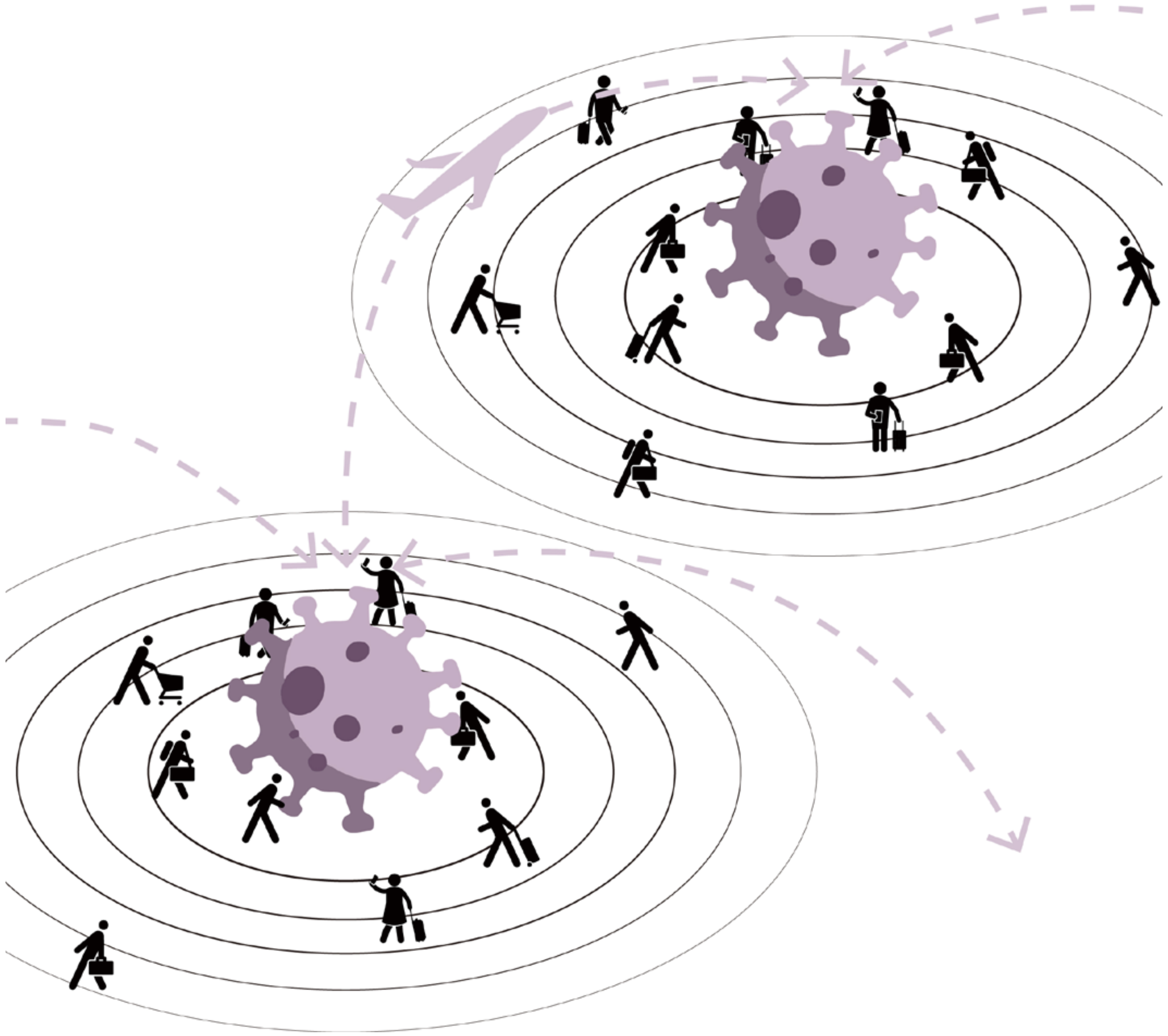

Fig. 1.2.1. Motivation diagram of the project. Made by author.

"Just as we have got used to the idea that metropolises are good for us, we find ourselves confronted by a global pandemic that exposes their inherent vulnerability." (Clark, 2020)

2. MOTIVATION

This research is derived from the interest in the impact of COVID-19 on metropolitan regions. A cluster of pneumonia cases from Wuhan, China, has grown into a pandemic that has ravaged many countries and cities in the whole world. The Netherlands, the current epicenter, has reached more than 180,000, a large number of whom are people living or working in the capital city Amsterdam (Michas, 2020). The coronavirus disease (COVID-19) also raises several social, economic, and environmental issues and severely affects metropolitan regions exposed to globalization. The number of people claiming unemployment benefits in the Netherlands in July was well over 15,000 as a result of lockdown to prevent the spread of the virus. And Amsterdam has been hit the hardest in the Netherlands, with a much more striking number of 50% increased than other cities (Séveno, 2020). Besides, many experts predicted that it will also lead to serious environmental degradation in the world (World Economic Forum, 2020). Although reduced traffic during the pandemic has led to the optimization in air quality, various regions may ignore or omit environmental controls as they gradually recover economically and socially.

Early research predictions attempt to explore the spread and impact of COVID-19 concern regarding the national medical conditions and global trade decrease, unconcerned about its spatial nature and social problems during the progress. However, this is a historic moment when cities can change course. It was used to be regarded as a radical method to reclaim urban space and development focus from a globalized economy to self-sustaining several years ago. Today, people-oriented development has been a proven best response to redress the glaring inequity exposed by the pandemic. The COVID-19 is striking at the heart of our closer world, with ties connected for commerce and the spread of the virus at the same time. If we don't focus enough on protecting the metropolitan areas from pandemics, the disadvantages of globalization and compact development may drive to a more fragmented world.

Therefore, I consider the pandemic as an opportunity for metropolitan regions, in this study Amsterdam, to improve their urban resilience for the global immediate crisis. I am motivated to have a research-oriented project in this field, which focusing on the causes, influence, and current approaches for the COVID-19 and new theories for future metropolitan development. I will model in space and time the spread and socio-economic impact of COVID-19 in MRA and analysis policy responses in different stages. Then, various scenarios will be designed for the post-COVID region and neighborhoods, to discuss the strategy of recovery to improve urban resilience in MRA. And finally, urban emergency management can be established with the post-COVID economic development model transformed to improve the resilience of cities in the challenge of global pandemics.

Fig. 1.3.1. An open market in Amsterdam during corona. Photographed by author, 12/12/2020.

3. INTRODUCTION

Coronavirus outbroken from Wuhan, China since 2019, has grown into a pandemic that has infected millions of people in different countries and cities in the world (WHO, 2020). The Metropolitan Region Amsterdam has become one of the most seriously attacked regions in the Netherlands. Early research attempts to explore the spread and impact of COVID-19 regarding the national medical conditions and global trade decrease, unconcerned about its spatial nature and urban problems exposed during the progress. This studio of Planning Complex City is built for spatial expertise, including spatial planning, governance, and participation. The spatial manifestations of disparities and inequity are starting points to institutional planning frameworks. Therefore, this project model in space and time the spread and socio-economic impact of COVID-19 in MRA and analysis policy responses in different stages. Accordingly, policy responses can be proposed with the post-COVID development model transformed to improve the resilience of cities in the challenge of global pandemics.

To select appropriate methods for this project to address problems, it is necessary to fully understand the significant impact of the COVID-19 pandemic in metropolitan regions. The problem context firstly introduces the information of COVID-19 in the global to connect identified problems, research question, research aim, and expected concrete outcomes of the project. Then, the methodological chapter will clarify the relation and connection of different frameworks regarding the problem, theories, and methods to reach the final project goal. The theoretical framework will be developed to discover the definition and indicators for metropolitan vulnerability and the territorial impact in MRA. Furthermore, focusing on this site of Metropolitan Region Amsterdam (MRA), spatial analysis is developed in different scales of regional sensitivity combing in the analytical framework. And finally, this project will propose a set of planning strategies to solve the problem and answer the research questions with a post-pandemic vision of Metropolitan Region Amsterdam.

2 PROBLEM CONTEXT

This chapter contains the problem, potential, and urgency priority of metropolitan areas facing pandemics, focusing on the Metropolitan Region Amsterdam. It leads to the research questions and aims of this project.

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1. METRO AREAS AND PANDEMICS

1.1 PANDEMICS IN HISTORY

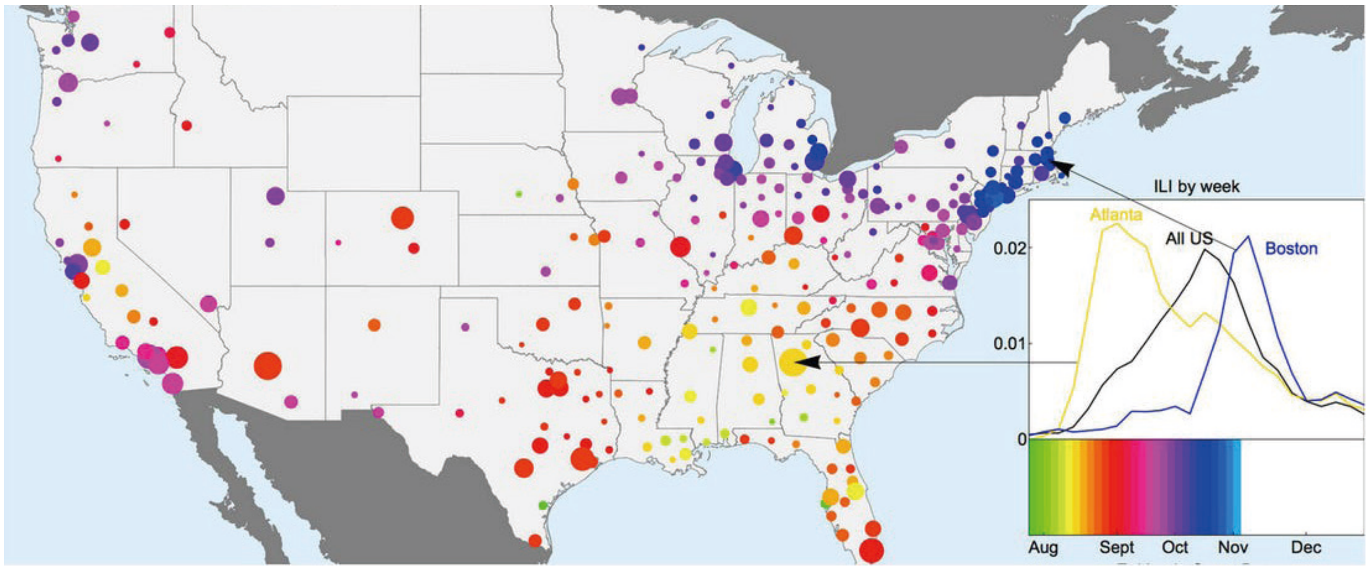
There has been a clear consensus emerged about the wonderful things that monopolization accomplished. They provide people with opportunities to connect, communicate, and exchange their goods and services in the world. The WTO has celebrated the power of metropolitan areas as junction boxes of global trade to increase productivity and social mobility (WTO, 2017). According to the United Nations, at least one-third of the global population is living in 1934 metropolises, and there will be 429 new metropolises until 2035 with a new one formed every two weeks (UNHSP, 2020). It has become the fastest-growing type of human settlement with the largest population but, as a result, metropolitan areas are fertile ground for pandemics as they are serving as intermediaries between international networks, municipalities, and people. The last three pandemics before COVID-19 in world history similarly begun and attacked mostly in metropolitan areas since the 21st century: SARS in 2003, H1N1 in 2009, Zika virus in 2015. These pandemics had shed light on the problems of the existing metropolitan model, showing a heightened sensitivity of these areas in the global network to the pandemic.

The outbreak of Severe Acute Respiratory Syndrome (SARS) was a deadly epidemic caused by SARS-CoV, which killed at least 774 people worldwide from 29 countries and territories in 2003 (Business Insider, 2020). It was first identified in Guangdong with an epicenter in Hong Kong, which are both amongst the most globalized and densely populated metropolises in China (Fig. 2.1.1). And the same as COVID-19, the SARS epidemic not only affected public health but also led to social, economic, and humanitarian repercussions in metropolitan areas. The economic impact, mostly on tourism and agriculture exports was estimated to be substantial at US$ 1.3 in Hong Kong (Keogn-Brown & Smith, 2008). And the immediate-direct economic effects and generated public fear have affected individual behavior, which potentially ranges widely in a long term (Smith, 2006).

Six years after the outbreak of SARS, H1N1 started in North America. The swine flu pandemic in 2009 was the second pandemic involving the H1N1 influenza virus after the Spanish flu pandemic in 1920. The 2009 H1N1 pandemic had the origin again from a metropolis, Mexico, firstly described in April 2009, and spread around the world at a high rate of speed, which was estimated to have about 284,00 deaths (CDC, 2009). And it has been approved from Fig. 2.1.2 that major cities in metropolitan areas played an outsized role in the transmission of the virus in the U.S. (Dalziel et al. 2018). Metropolitan areas with larger and more densely populated cities always had more diffuse pandemics, which presumably related to their more frequent cross-border people contact. And the 2009 H1N1 also had large macroeconomic effects on these highly affected regions. Like other pandemics, the initial economic impact occurred through falls of the industries with a high reliance on human contacts, such as tourism and hospitality. The pandemic in 2009 was estimated to cost the global economy decrease of about $360 billion within a year (McKibbin, 2009).

An outbreak of Zika virus began in April 2015 in Brazil and spread like a pandemic transmitted by mosquitoes at the start of 2016. It reached more than 1.5 million people infected in Brazil and intensified quickly in South America, Central America, North America, and the Caribbean (Boadle, 2016). The spread of this mosquito-borne disease established a similar landscape of risk with COVID-19: the densely populated and interconnected metropolitan areas are more vulnerable (Fig. 2.1.3.) The introductions by infectious travelers were more likely to initiate local transmission in a high human and mosquito density city (Manore et al. 2017). And according to the World Bank Group, "Initial estimates of the short-term economic impact of the Zika virus epidemic for 2016 in the Latin American and the Caribbean region (LCR) are a total of US$3.5 billion, or 0.06% of GDP" (Ulansky, 2016).

Fig. 2.1.1. SARS outbreaks in Guangdong Province, China. Source: Zhong et al. 2003.



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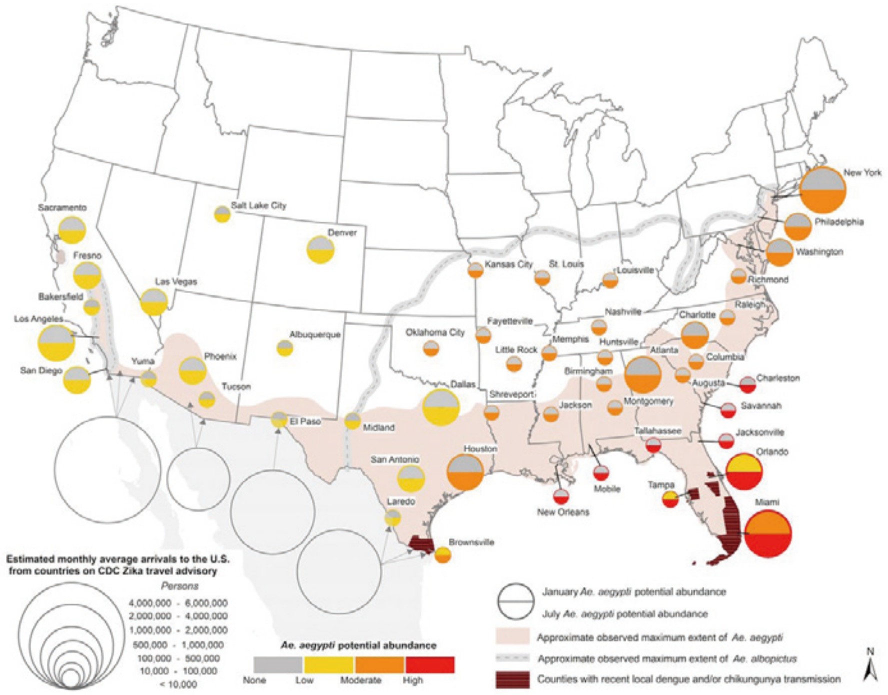
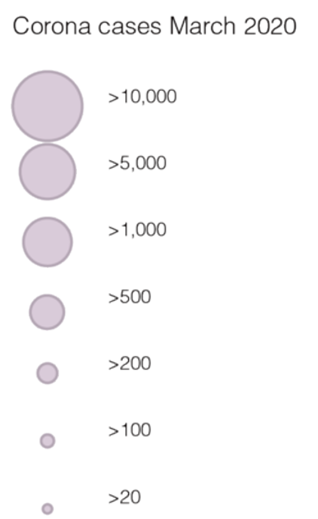


Fig. 2.1.3. The risk of US cities for getting Zika. Source: Joseph, 2016.

1.2 PANDEMIC OF COVID-19

COVID-19 is caused by a novel coronavirus, SARS-CoV-2, identified in Wuhan, China, 2019. It is a highly infectious virus in the large family of coronavirus from the common cold to more severe epidemics such as MERS and SARS (WHO, 2020). When a cluster of corona cases appeared in 2019 from Wuhan, China, it has mutated into a pandemic that has ravaged many countries and cities through the vast worldwide network in a short time. As of 11 May 2021, there have been 158,651,638 confirmed cases in 220 countries and territories, resulting in more than 3,299,764 deaths (CSSE, 2021). The first epicenter and the initial focus of the new coronavirus, Wuhan, is a metropolis of about 11 million, where more than 4,000 people have died. And the majority of corona cases also spread and concentrate in metropolitan areas in Europe like other pandemics in history (Fig. 2.1.4). For example, the Netherlands, the current pandemic hotspot, has reached more than 180,000, a large number of whom are people living or working in the capital city Amsterdam (Michas, 2020). And beyond physical-health impact, it has indirect impacts on social functioning and the urban economy. COVID-19 is having an eminently impact on metropolises, which has focused the attention of all on the role and vulnerability of interconnected metropolitan regions in the current increasingly globalized world.



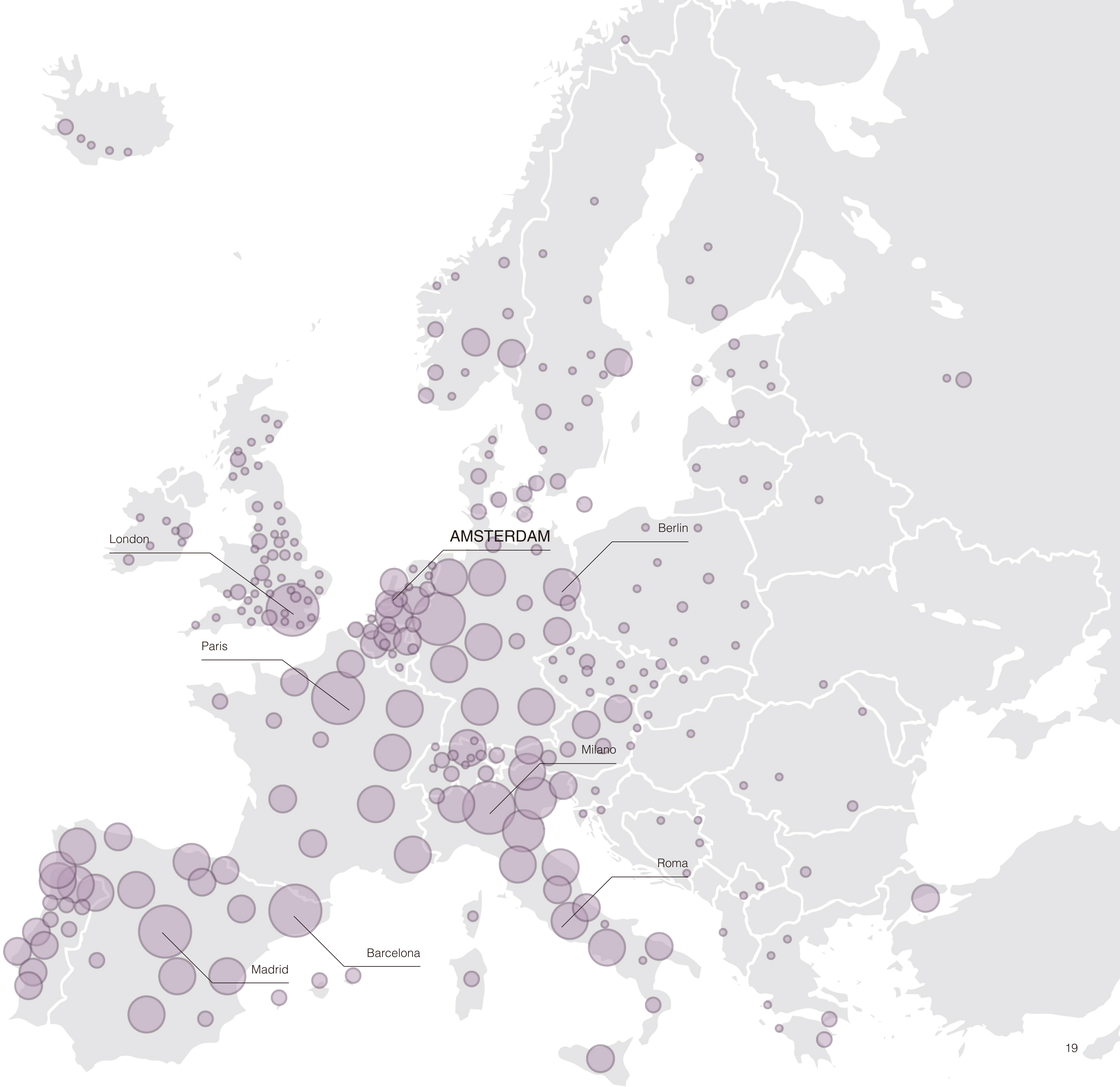


Fig. 2.1.4. Corona cases in European cities until March 2020. Made by author by data source from official municipalities.

The direct person-to-person transmission of COVID-19 is the main route of spread, which is related to the population concentration in cities. During the spread across the world, urban has become the epicenter of the pandemic, where 90% of reported cases are located (UN, 2020). And as the heart of urbanization and globalization, metropolitan areas are both the departure and destination of international and national exchange. At the same time, the agglomeration of such economic activities backfired as the reason for the interpersonal spread of COVID-19. Therefore, similar to other infectious diseases in history, the COVID-19 virus does not connect directly to poor environments. Rather, the epicenters of the most severe outbreaks until mid-May 2020 were the wealthiest metropolises of industrialized countries (Oakman, 2020). According to Fig. 2.2.1, the countries and areas with most corona cases are largely concentrated in central Europe, including the London metropolitan areas, Amsterdam, Brussels, and the Lombardy province in northern Italy. They are parts of the 'Blue Banana', which represents a cluster of regions with the highest per capita GDP in Europe.

Like many other pandemics, COVID-19 has ushered an indirect impact on the urban economy. Countries lockdown to protect their inhabitants away from the virus, which influenced not only cross-border communication but economic interactions. Capital regions and other metropolitan regions show a relatively higher risk of containment measures than small cities (Fig. 2.1.5). Besides unemployment and the closure of companies, the global pandemic is leading to a new climate of uncertainty, which is fueling national protectionism against globalization. It will be possible to destruct globalization and supply chains if governments decided to recover their vulnerable economy by limiting global flows of people and trade. Economists predicted that in the future of post-pandemic, it will be improbable to return quickly into a world as carefree as before (OCED, 2020).

Besides, COVID-19 has an indirect impact on the urban environment. Most of the studies estimated a positive impact on the environment. For example, greenhouse gas and air pollution have dropped dramatically in Europe due to the lockdown and social distancing policies (ESA, 2020, see Fig. 2.1.6). However, the coronavirus also has negative indirect effects on the environment. In some seriously affected countries, such as the U.S., sustainable waste management has been suspended because governments are concerned about the risk of the spread of the virus through recycling. And some industries seize the excuse to repeal single-use packaging, which has increased the domestic waste of inorganic (Bir, 2020). And ignoring sustainability criteria during economic and social recovery will give way to a vicious cycle back to the polluted-intensive global economy and the presence of infectious diseases.

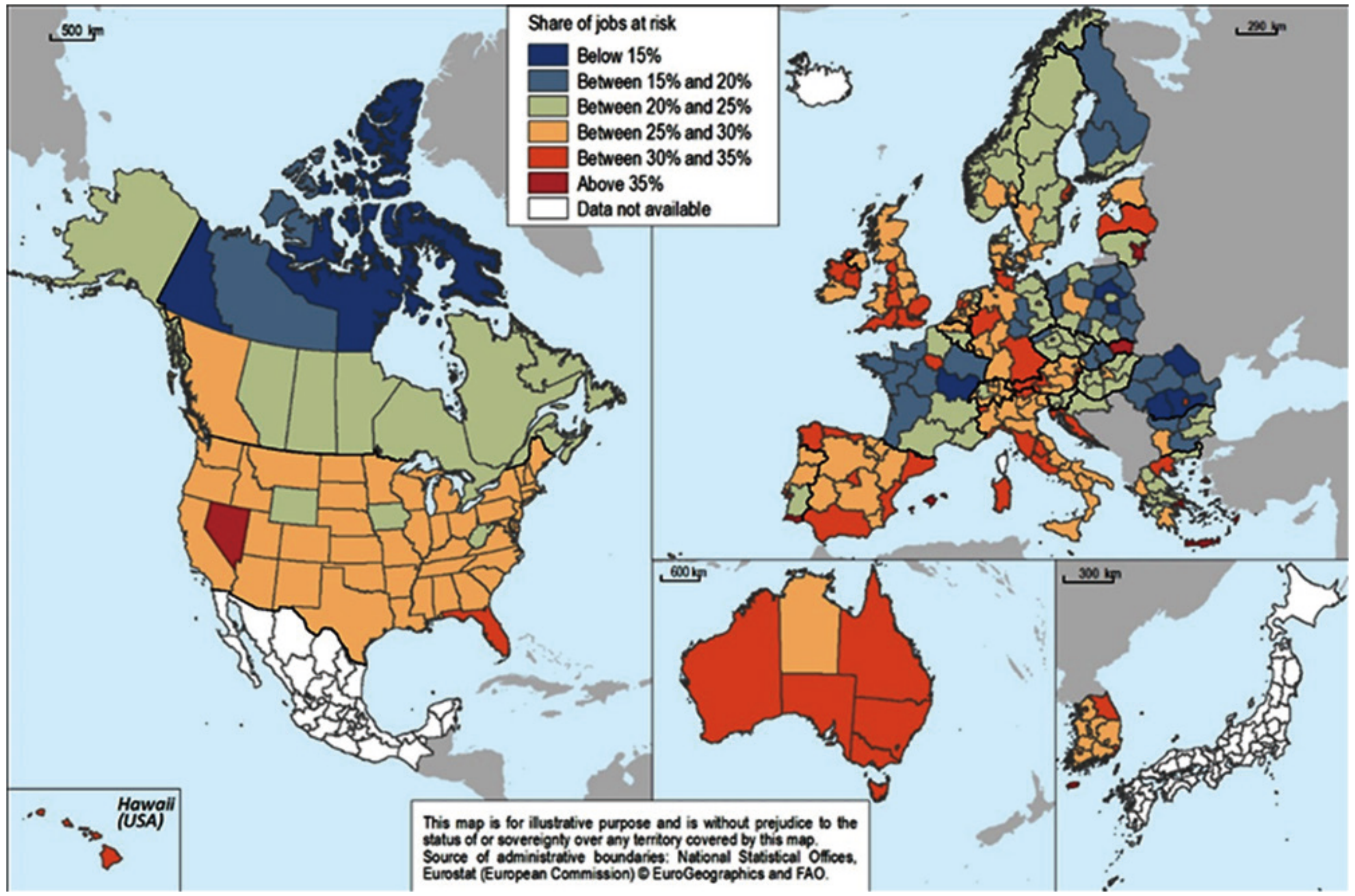
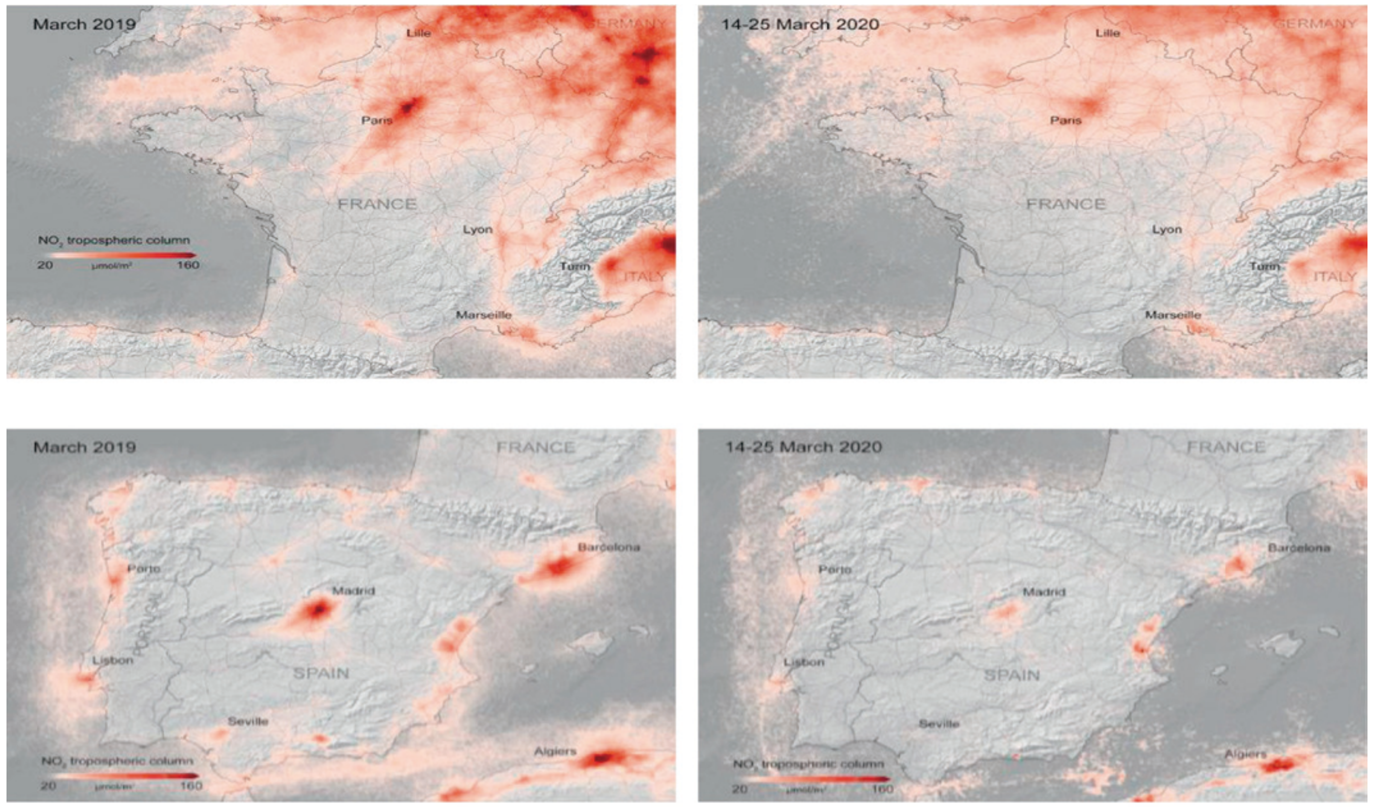


Fig. 2.1.5. Share of jobs potentially at risk from COVID-19. Source: OCED, 2020.



(a) (b)

Fig. 2.1.6. Evolution of NO2 concentrations in France and Spain. Source: ESA, 2020.

1.3 METROPOLISES ON THE FRONTLINE

This year, the COVID-19 has again focused the world's attention on the globalized world about metropolitan leadership of the pandemic on the frontline. Metropolitan areas provide interconnections across continents and municipalities, which enable travel, commerce, and also the risk of contagion. Although they are widely considered as engines of economic growth, they are centers of urban inequalities and environmental problems. And the pandemic has exposed these problems, while measures to control the spread probably exacerbate these problems. Therefore, an increasing number of governments and institutions start to rethink the role of metropolitan regions in emergency pandemic like COVID-19. The ongoing World Metropolitan Day 2020 campaign not only highlighted the importance of metropolitan areas but also provide an opportunity to consider the challenges facing to address the global crisis (Metropolis, 2020).

Milan and the region of Lombardy, as the capital and one of the richest areas in Italy, were the first epicenter of COVID-19 in Europe (Fig. 2.1.7- 2.1.8). It is the economic powerhouse of finance, fashion, tourism, but experienced a sharp slump since the outbreak of COVID-19 in February 2020. However, it already began planning its post-coronavirus recovery after two months of depression, considering its role of leadership for the country and the world. Mayor Sala identified three priorities in an interview in early April for Milan: the adaptation of digital and mobility infrastructures of social-distancing requirements; the creation of new rules for public spaces; and support for the local economy at risk that constitute the "soul" of the city (Giannattasio, 2020).

Barcelona, one of Europe's most densely populated cities responded to COVID-19 through a particularly innovative process of co-producing public goods and services. Civil society, experts, and local government corporate from the bottom up. The driving force behind this is the city's "maker" community, including a group of people experiment with technologies to address different sorts of problems (Abdullah & Garcés, 2020). It proved that the local response to repair deficiency of public protection was more efficient in Barcelona. And a supportive environment can facilitate the talent and experts in participated in urban governance to create a more resilient and sustainable city.

London was the UK's first concentration of corona cases in March. The COVID-19 infected rapidly in the vulnerable Greater London with 8.9 million inhabitants due to its international links, public transport network, and worst air quality. As the result, there were 4,781 coronavirus deaths in hospitals since the start of COVID-19, which reached the death rate 15 times higher than Berlin's (Fig. 2.1.9). And the economic shrink was estimated by 25% in the second quarter of the year (OBR, 2020). Considering the great impact and complex governments in Greater London, its response to COVID-19 is mostly dominated by the central and national government to consist of national conditions by completely aligned measures (Rode, 2020). And the citizens in London were overwhelmingly supportive and accepting of government measures.

And the measures taking into account the coronavirus pandemic in Metropolitan Region Amsterdam, Netherlands, are supported by a visual economic framework called "Doughnut Economics" for sustainable development (Boffey, 2020). It was developed by Kate Raworth in Oxford in 2012, consisting of environmental and social boundaries (Raworth, 2012). While struggling to protect public health in Amsterdam, the government is also exploring methods to rebuild the post-COVID world. Therefore, the doughnut economic model from Kate Raworth is embraced as the guide to recover the economy with balance among the planet and society. The municipality of Amsterdam tended to use the model to provide a "city portrait", where the public policy can guarantee the core social rights within the capacity of the environment.

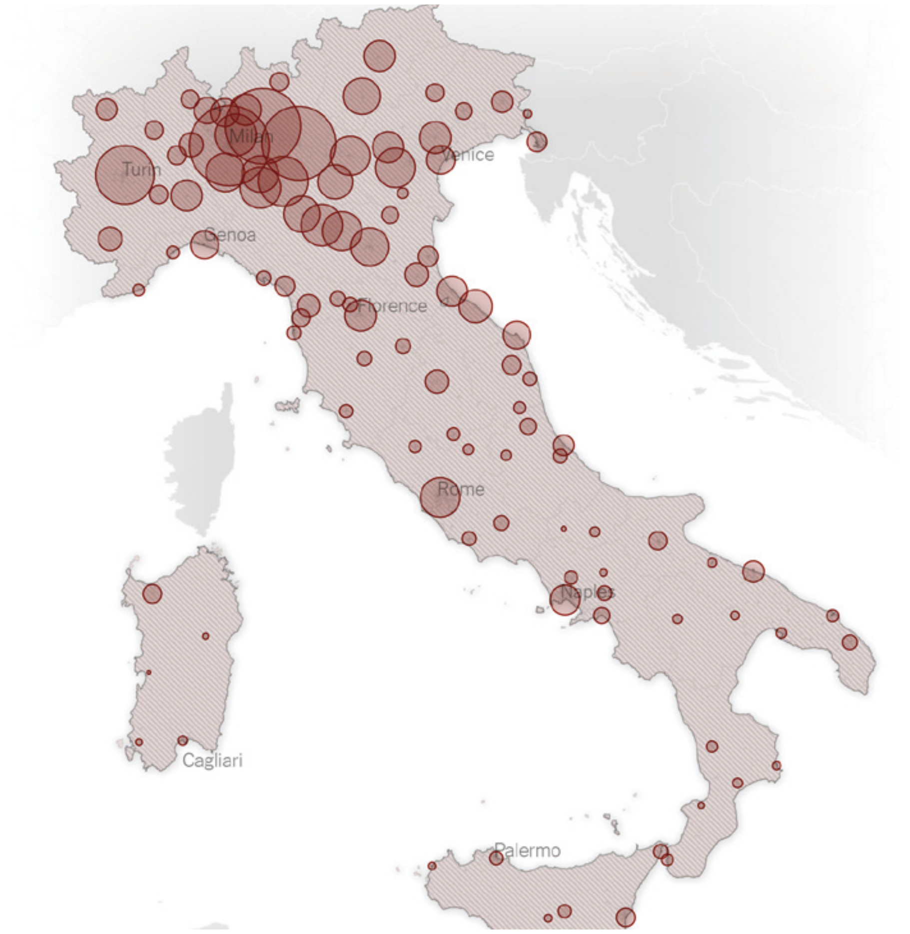


Fig. 2.1.7. Coronavirus impact across Italy. Source: McCann et al., 2020.

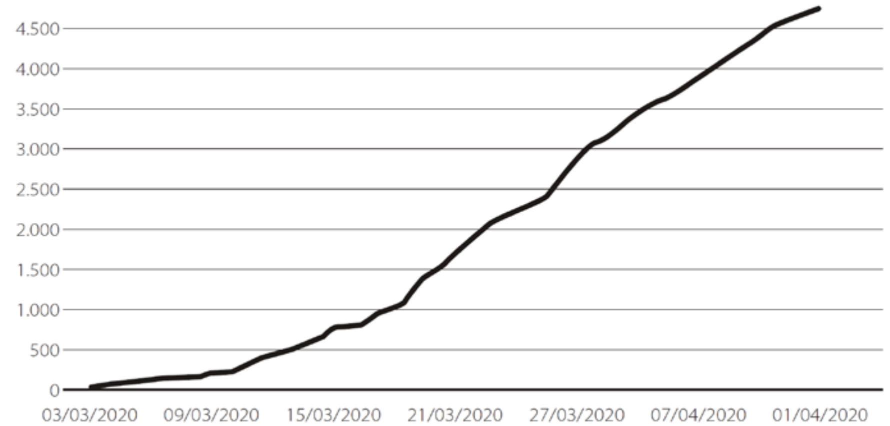


Fig. 2.1.8. Number of confirmed COVID-19 cases in Milan. Source: MilanoToday / Region of Lombardy, 2020.

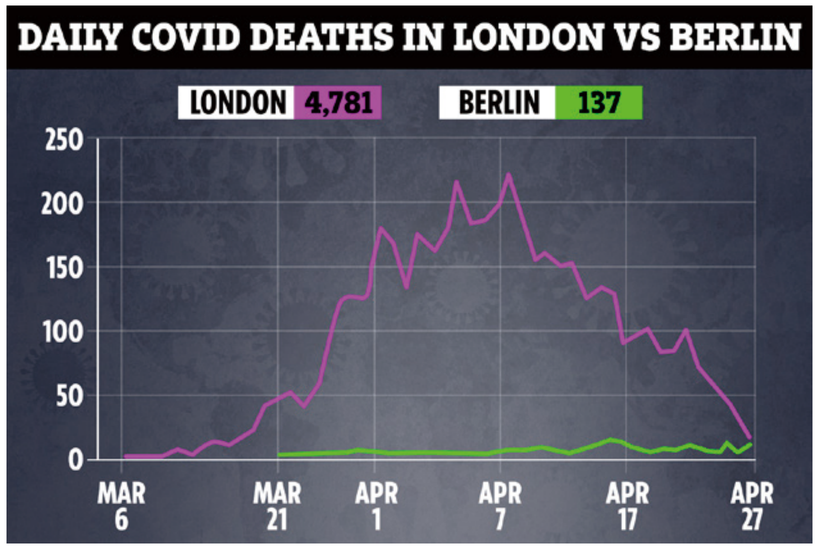


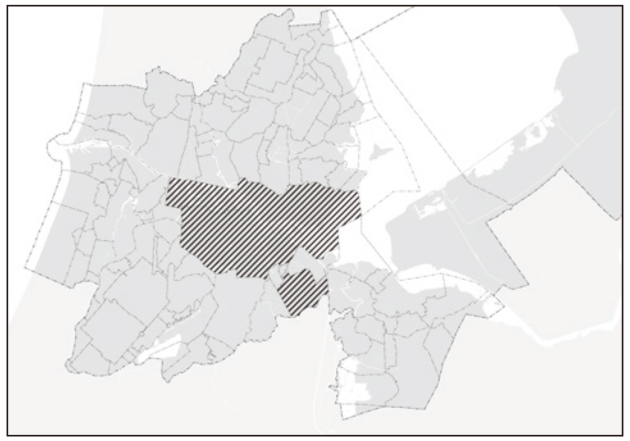
Fig. 2.1.9. Daily COVID deaths rate in London and Berlin in March and April. Source: Zeltmann, 2020.

2. METROPOLITAN REGION AMSTERDAM

2.1 BASIC INFORMATION

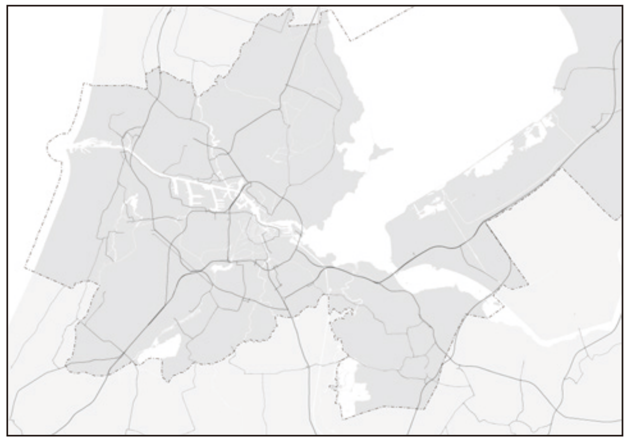
The Metropolitan Region Amsterdam (MRA) is the city region around the capital of the Netherlands (Fig. 2.2.1). It lies in the north of the Randstad, comprised of 32 municipalities within two provinces with around 2.5 million inhabitants (MA, 2018). This country's most developed economic region is home to more than 14% of the Dutch population. It is also a home and working place for diverse internal and external migrants, which makes it a broad palette of living and working environments. The MRA serves as an internationally connected region through compact cities, accessible railway, and a vast network of highways connecting MRA with the rest of the Netherland and the world (Fig. 2.2.2). Besides, it is also an important gateway to the Netherlands. Schiphol, the 12th international airports, experienced a passenger flow of 47.4 million passengers in 2008 (Schiphol Group, 2009). And the harbor of Amsterdam is the second largest port of the Netherlands, which transported 85 million tons of goods in 2007 (Port of Amsterdam, 2007). The economic function of MRA is mainly a core for international trade with 300,000 businesses and 1.5 million jobs (MA, 2018). The most important economic sector is financial and professional services, and over the last few years, the city developed more into international services like tourism and hospitality.

However, the MRA is vulnerable to facing the challenge of COVID-19 resulting in various negative influences. According to the different stages and reasons, they are divided into direct and indirect impacts.



Administration

Construction



Infrastructure

Fig. 2.2.1. Basic land information of MRA.
Fig. 2.2.2. Basic map in the north of Randstad.
Made by author by data source: OSM.

2.2 IMPACT OF COVID-19 ON MRA

2.2.1 Direct impact

The direct impact is mainly on public health. Due to its tightly physical and functional connection, MRA has become one of the most seriously attacked regions including around 10% confirmed cases of the Netherlands (GGD, 2020). During the second wave, the number of positive coronavirus cases increased by 20%, among which the most occurred in Amstelveen and Uithoorn (Fig. 2.2.3). The reported cases in MRA has reached 100 per 100,000 inhabitants since August and quickly spread to many counties (Fig. 2.2.4). The rapidly growing number of cases is reaching the saturation point of Amsterdam's medical system with a risk of collapse in the future.

The outbreak of COVID-19 has directly elevated the prevalence and death rate in MRA, mainly in the city of Amsterdam. Until 16th October 2020, there have been 2,404 confirmed cases per 100,000 residents in Amsterdam. The highly contagious disease increased employee illness-related absence in all sectors rapidly as the highest rate since 2003. And more people died than average because of the pandemic that may affect the life expectancy by excess mortality in 2020. In the worst scenario, life expectancy may drop by 1 year to the same level as 2010 due to twice as many deaths in the second wave (CBS, 2020). Moreover, the COVID-19 has occupied the majority of the public health resources. There was a decline in various general health care utilization, which is related to the fewer health services provided during the outbreak. According to the figures from the National Health Survey Monitor, many hospital appointments were postponed or canceled at the peak of COVID-19 (CBS, 2020).

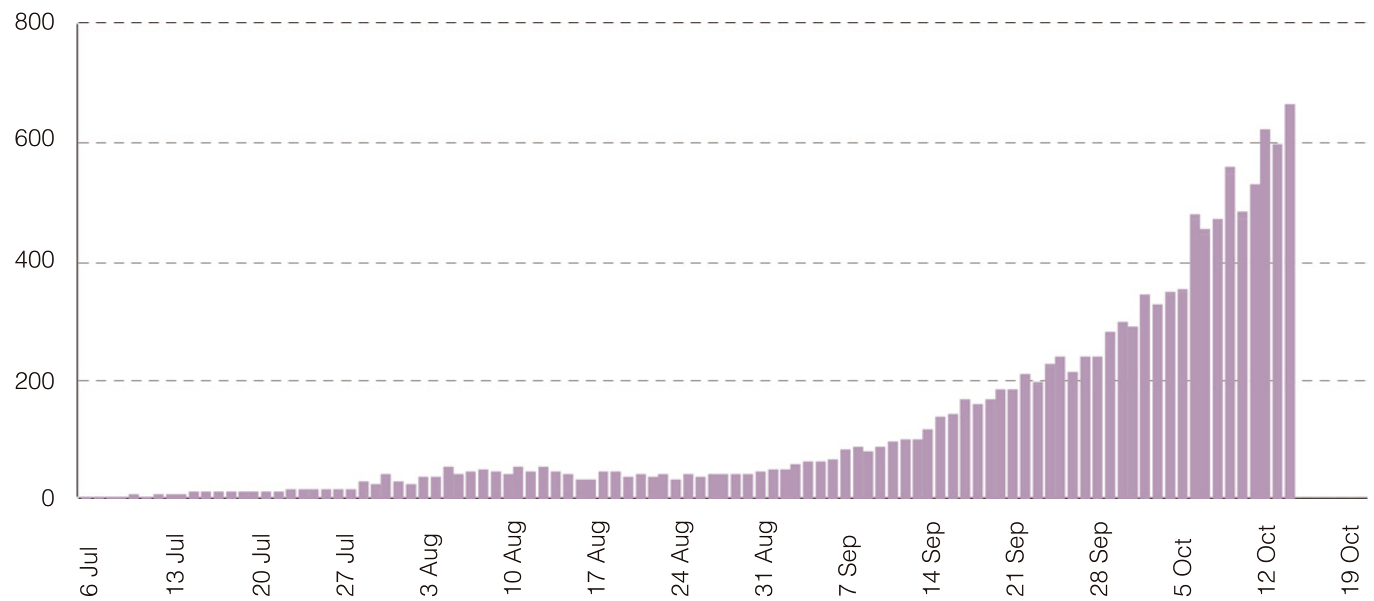


Fig. 2.2.4. Reported COVID-19 patients per 100,000 habitants in MRA. Made by author by data source: GGD, 24/10/2020.

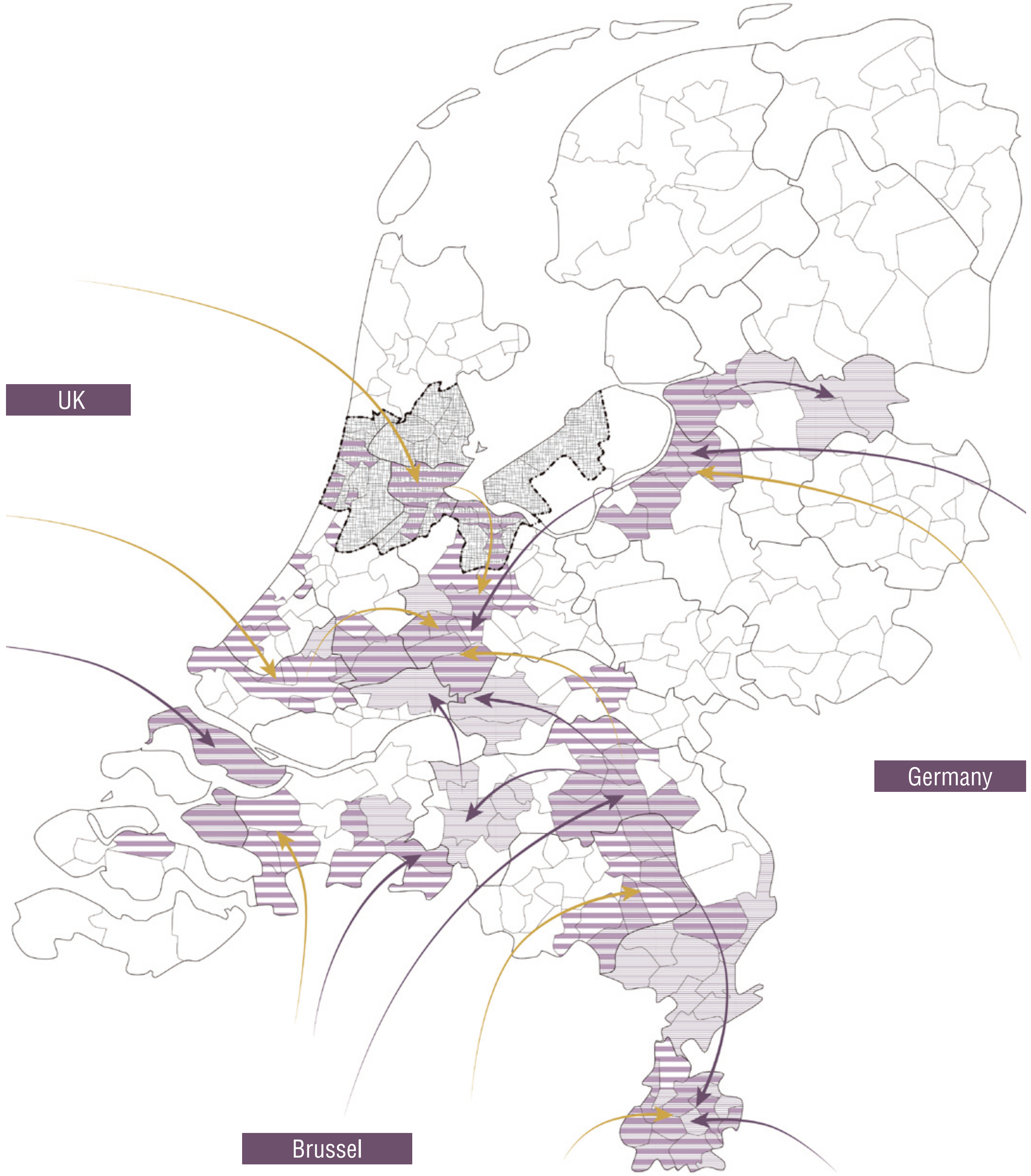


Fig. 2.2.3. Global trajectories of the coronavirus. Illustrated by author based on RIVM.

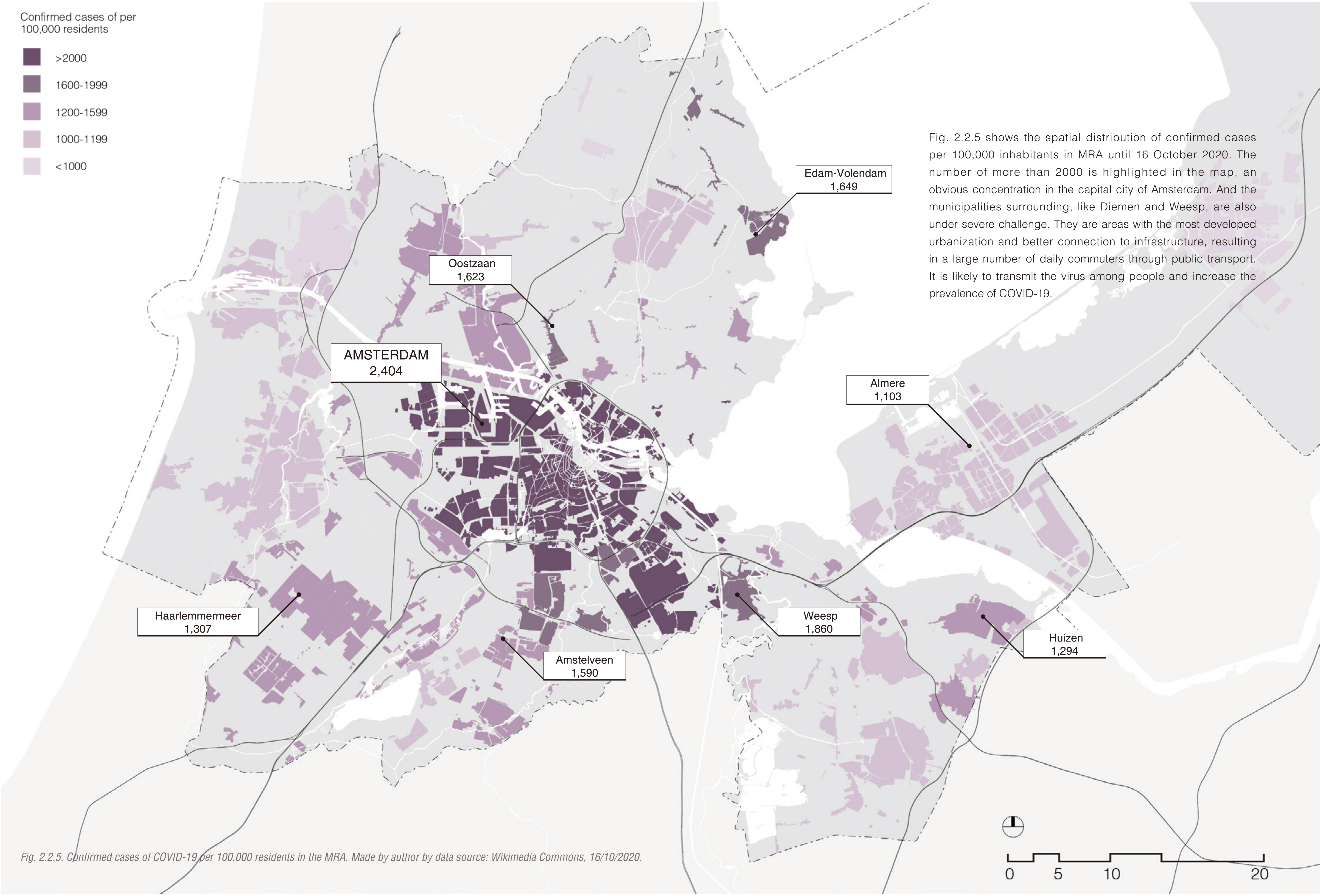


Fig. 2.2.5 shows the spatial distribution of confirmed cases per 100,000 inhabitants in MRA until 16 October 2020. The number of more than 2000 is highlighted in the map, an obvious concentration in the capital city of Amsterdam. And the municipalities surrounding, like Diemen and Weesp, are also under severe challenge. They are areas with the most developed urbanization and better connection to infrastructure, resulting in a large number of daily commuters through public transport. It is likely to transmit the virus among people and increase the prevalence of COVID-19.

Fig. 2.2.5. Confirmed cases of COVID-19 per 100,000 residents in the MRA. Made by author by data source: Wikimedia Commons, 16/10/2020.

2.2.2 Indirect impact

1) Economic impact

Firstly, the economic recession is the most fairly obvious impact of the coronavirus pandemic from closing restaurants, promoting social distance, and decreasing global trade and tourism. The impact of the pandemic on the economy is significant to MRA, giving the scale of the spread and its economic vulnerability. Gross domestic product (GDP) declined more than half in Q2 2020 with fewer investments and trade, which is attributable to the substantial reduction in consumption (CBS, 2020). There were only a quarter of entrepreneurs expected positively to exist at least one year, while most of them are pessimistic about the business activities in the future (CBS, 2020). And the percentage of business bankruptcies in MRA is increasing sharply since the outbreak of COVID-19 (Fig.2.2.6). Among them. hospitality industry and tourism are the first to be affected, whose occupancy rate can be 1% to 2%, and the percentage of overnight stays in MRA has become the lowest compared with others (Fig.2.2.7). And the coronavirus also cut the city's income through the loss of tax by 350 million Euros (European Commission, 2020).

2) Social impact

In addition to economic shifts, an emerging risk from social disruptions has become the second anxious impact. The business lockdown and economic recession have led to a soaring unemployment rate of 53% in March in Amsterdam, which is far above the national average (CBS, 2020). The strongest increases were the bottom and young workers. They are mostly people with the lowest income and health quality that is easy to be attacked, and also the group working hard in COVID-19 like health-care and retail workers.

The high structural unemployment for the pandemic and shutdowns is likely to exacerbate social inequality with long-lasting effects on people because the vulnerable groups are suffering the worst impacts. The loss of jobs and income increased their fear and insecurity, which led directly to social unrest and lack of confidence in municipal government. Besides, the policy measures for physical distancing also affected mental health and emotional loneliness, especially for older people (Tilburg et al., 2020). And MRA had the highest share of single elderly with 52 percent, which makes the problem more acute there (Fig. 2.2.8). And the technological fallout in COVID-19 has led to more data fraud, up 18 percent to 6,580 cases, like phishing scams (NL Times, 2020).

3) Ecological impact

COVID-19 could also have severe ecological effects during and after the crisis on the planet. Firstly, it is essential to mention that even though industrial and traffic emission and pollution have decreased during the pandemic, it could have little impact on the atmosphere for decades, which could return to an emissions-intensive future (Monserrate et al., 2020). Inappropriate measures for disease protection and development recovery are likely to have negative impacts on the environment. For example, the increasing demand for online shopping during the pandemic has increased organic and inorganic waste. And the restriction to waste recycle and a shortfall of investment in sustainable recovery can also emerge when municipalities start to reboot from the pandemic, which will increase pressure on the urban environment. Therefore, municipalities have to pay more for waste disposal with less recycling to prevent the virus from spreading through the waste. It is the reason that waste tax is up by a record 9.5% on average in municipal housing costs, which has increased the pressure on local poor residents and led to a two-day garbage strike in Amsterdam (Newmark, 2020). As a result, it would give way to a vicious cycle of aggravated vulnerability for further epidemic outbreaks.

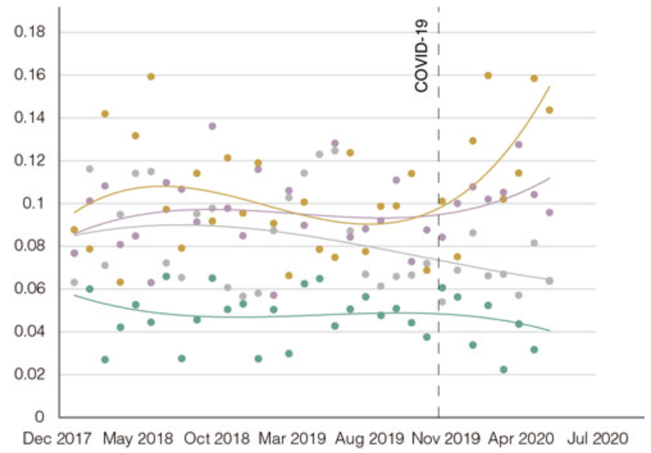


Fig. 2.2.6. Percentage of bankruptcies of the Netherlands from January 2018 to July 2020. Made by author based on data source: CBS, 2020.

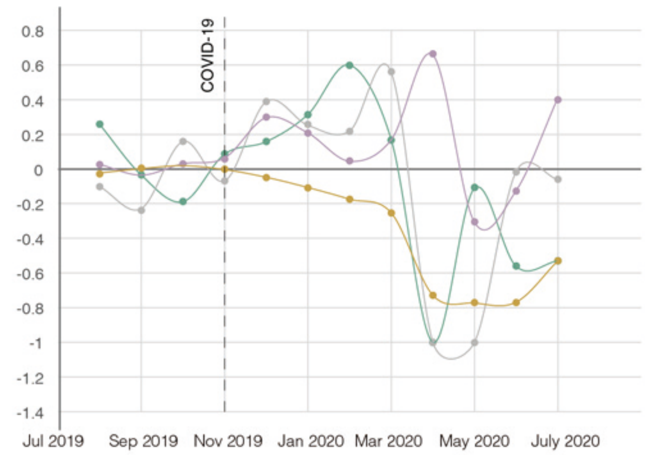


Fig. 2.2.7. Growth rates of overnight stays in hotels from August 2019 to July 2020. Made by author based on data source: CBS, 2020.

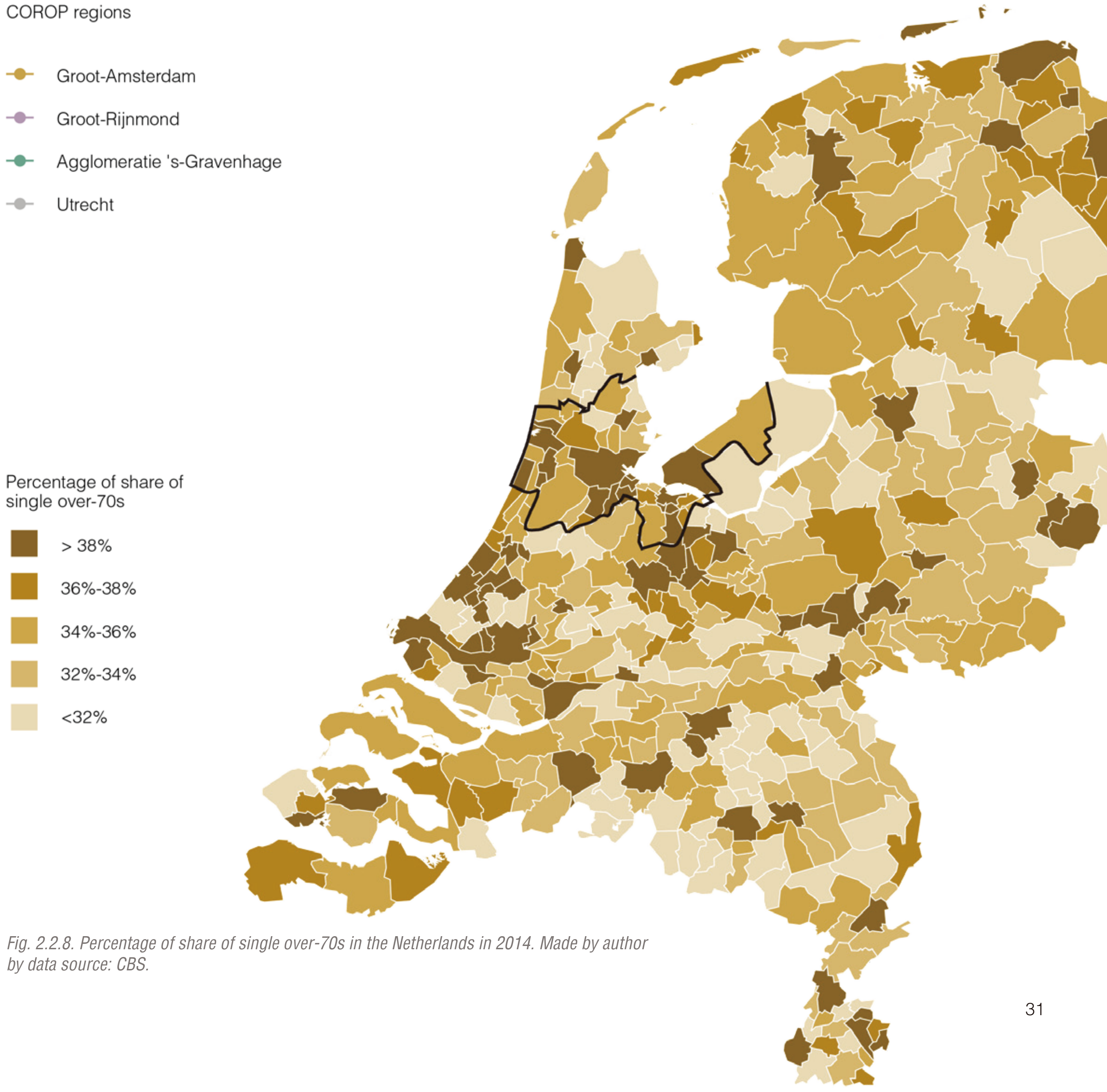


Fig. 2.2.8. Percentage of share of single over-70s in the Netherlands in 2014. Made by author by data source: CBS.

Fig. 2.2.9. Prosperous city of Amsterdam. Source: www.european-business.com, 2018.

Fig. 2.2.10. Quiet city of Amsterdam. Source: www.amsterdam.nl, 2020.

2.3 Administrative structure

At the global level, the European Medicines Agency (EMA) is a decentralized agency of the European Union (EMA, 2020). It has set up a dedicated group, to address the technological, legal, and regulatory challenges posed by the COVID-19 pandemic. This group aims to initiate several adaptive activities to maintain agency resources related to medical evaluation and surveillance during the pandemic, as well as emergency management related to COVID-19. It aims to promote close cooperation among regional networks in Europe to accelerate the development of vaccines and treatments. The COVID-19 Steering Group consists of four cross-agency workflows in four high-priority areas: therapeutic response, supply chain, business continuity and impact, human resources (EMA, 2020).

At the national level, the National Institute for Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu, RIVM) has always been committed to a healthy population and a healthy living environment. It plays a central role in infectious disease control and national prevention programs. It is a 'trusted advisor' to a society facing the challenge of COVID-19 supported by three main departments: Ministry of Foreign Affairs, Ministry of Health, Welfare and Sport, Ministry of Justice and Security (RIVM, 2020). In this way, RIVM supports citizens, professionals, and governments in the challenge of keeping residents and living environment healthy.

At the regional and municipal level, MRA is a complex region across borders. It consists of 32 municipalities, 2 provinces, and the Transport Authority Amsterdam in 7 sub-regions: Amsterdam, Amstelland-Meerlanden, Zaanstreek-Waterland, Almere-Lelystad, Zuid-Kennemerland, Gooi en Vechtstreek, and IJmond (Metropoolregio Amsterdam, 2018). The policy structure has outgrown its borders. Most of the regional development measures, including policy responses to the pandemic, have been taken in the whole region to ensure complete implementation and justice. It means managerial ownership, monitor progress, and adjust activities are almost at the same level throughout the region. Different actors in the region depend on and support each other. All parties need a contribution to resisting the disaster and disease during the COVID-19. From this perspective, the administrative structure in MRA is integrated enough to consider the context and solutions inside different cities.

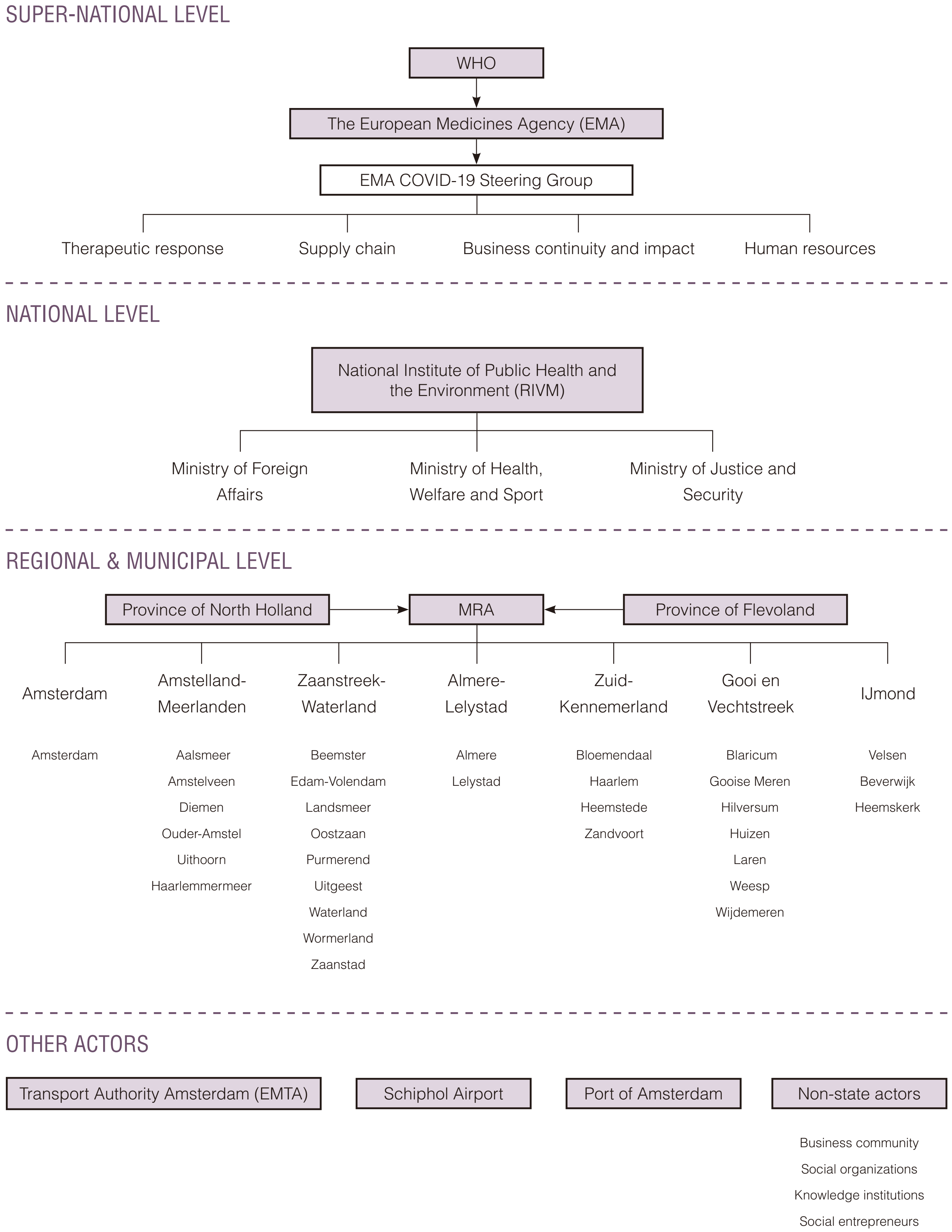


Fig. 2.2.11. Institutional mapping of the multi-level governance of the pandemic related policy sectors. Made by author based on EMA, RIVM, and City of Amsterdam, 2020.

2.4 Policy responses

Policy responses in MRA are proposed from national and regional levels. According to the issue these measures solved, they are divided into 3 aspects: decrease exposure, decrease sensitivity, and increase adaptive capacity (Fig. 2.2.12). Both measures at the national level and the regional level have been characterized by a major focus on improving adaptive capacity. It proves that adaptive capacity is the easiest component to improve quickly in the short term.

The Dutch government has implemented an 'intelligent lockdown'. It means the national economy can be affected as little as possible. Bars, restaurants, schools, gyms, and "contact professions" have been closed and people are urged to stay at home, but they can be free to move with a 1.5-meter social distance. The government hopes to ease the social, economic, and psychological costs of isolation and to make the eventual return manageable (Holligan, 2020). However, the strategy is perilous, leaving a big hole for the second or third wave (Choffnes, 2020). There has been a 60% rise in new cases in the second wave since the pandemic began (RIVM, 2020). As a result, more restrictive policies are emerging, such as several closed locations to reduce exposure, and a limited number of guests per day to reduce the risk of cross-infection.

Compared with national policies, Amsterdam institutions keep the measures for exposure and add a set of local policies to decrease sensitivity and increase adaptive capacity (City of Amsterdam, 2020). For example, the authorities and NGOs have organized many volunteer platforms to support residents and the elderly during the pandemic. They provide available laptops and internet connections to people who lack these basic facilities. Several campaigns have been organized to prevent social violence online to increase domestic safety. There is also special help for sex workers with income support. Besides, more emergency fund has been used for Corona crisis, including public markets, local entrepreneurs, food suppliers, etc. Besides, Amsterdam has provided major protection for its unique artistic and cultural atmosphere.

These measures have to some extent weakened the vulnerability of the region to the COVID-19, but some problems remain. Firstly, most of the measures emphasize the rapid improvement of adaptive capacity. Although it can mitigate the impact of the pandemic on cities to some extent in the short term, it is not sustainable and thus cannot improve regional resilience facing the next pandemic crisis. Secondly, most of the strategies are put forward at the national, regional, and urban levels. While these strategies have taken into account as comprehensively as possible the circumstances, problems, and characteristics of different populations and areas. These general strategies can hardly avoid some local situations that cannot be focused on completely.

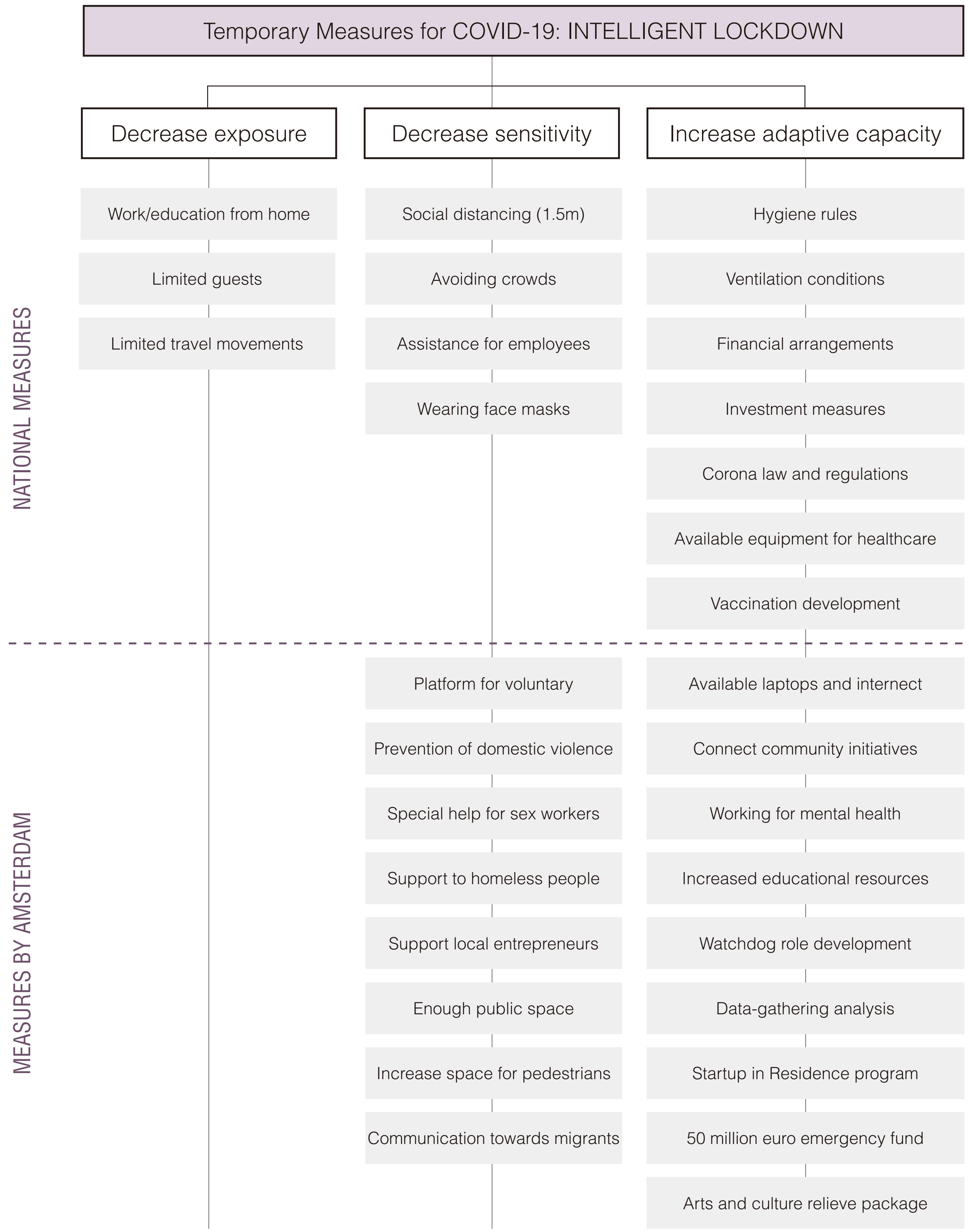


Fig. 2.2.12. Summary of city measures to COVID-19 in different levels. Made by author based on Rijksoverheid, and City of Amsterdam, 2020.12.07.

2.5 Doughnut Economy

The principle of post-pandemic planning strategies in Amsterdam is Doughnut Economics. Economists regard the global attachment to endless trade and permanent growth as the main reason for urban vulnerability, which is a characteristic of the 20th-century model (Fig. 2.2.13). The market economy and neoliberal economy are now the two most mainstream economic models in the world. The primary characteristics lie in the factors of production and the mechanisms for prices. The economic activities are always organized by the supply and demand of goods that maximize the value and efficiency, which on the other hand decreased the urban economic resilience to some extent. Due to the disadvantages of these two models, there is an increasing number of new models appearing for resilience. For example, people-centered economy and ecological economy are both partial models that focus on human rights and environmental protection during development.

Doughnut economy is a new holistic economic model, based on other transition models, to a thriving and resilient economy with diverse, redundant, and distributed networks. In Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist, Kate Raworth of Oxford University's Environmental Change Institute points out that the GDP cannot signify well-being. She argues that governments and companies should broaden their views beyond the financial profit to form a balance among economic growth, social demands, and planetary boundaries (Raworth, 2012). It developed based on the Sustainable Development Goals (SDGs) by the United Nations to a feasible framework for evaluation and measurement. The inner space of the doughnut highlights the sectors which we need to improve for a just space for human demands. If we overshoot, we will reach the outside of critical planetary degradation, like climate change and air pollution (Fig. 2.3.4). And the dough in the middle is a thriving and resilient space that we want to keep inside.

	THEORY	MODEL STRUCTURE	APPROACH	SECTORS INCLUDED	CORE	ECONOMIC GOAL	COORPERATION - COMPETITION	URBAN RESILIENCE
MARKET ECONOMY	Holistic	Private ownership, freedom of choice, self-interest, optimized buying and selling platforms, competition, and limited government intervention	From minimally regulated free-market and laissez-faire systems to interventionist forms	Supply includes natural resources, capital, and labor; demand includes purchases by consumers, businesses, and the government	The decisions regarding investment, production and distribution are guided by the price signals created by the forces of supply and demand	Goods and services are produced in the most efficient way possible	Competition drives the market economy as it optimizes efficiency and innovation	**Market economies marginalize those that are unable to compete, contributing to income inequality.**
NEOLIBERAL ECONOMY	Holistic	Privatization, deregulation, globalization, free trade, austerity, and reductions in government spending	Market-oriented reform policies such as "eliminating price controls, deregulating capital markets, lowering trade barriers"	Encompasses both politics and economics and seeks to transfer the control of economic factors from the public sector to the private sector	An intentionally imprecise stand-in term for free market economics - always more markets, always less government	Increase the role of the private sector in the economy and society	Commodity markets (competition, perfect information, rational behaviour)	**Despite the scale of the crisis neo-liberalism has remained resilient as an ideology and as a policy regime.**
PEOPLE-CENTERED ECONOMY	Partial	Principles and framework for analysis	No specific methodology, although in all cases, expert groups are used to assess needs, with no local participation.	people centred, territorial based, decentralization and capacity building, multisectoral economy, competitiveness and efficiency, multi-level, links rural-urban, and the consideration of cross-sectoral issues	At least fifty percent of profits go to stimulate a given local economy, instead of going to private hands	A people-centered economy aims to maximize the value of people	Emphasis simply on integration, and the importance of national government agencies in dispensing services	**New thinking to recognize vulnerable farmers as critical partners in delivering solutions is needed to increase their resilience and to enable them to help combat climate change.**
ECOLOGICAL ECONOMY	Partial	Nature, justice, and time	Acknowledges the ecological limits of the planet, that considers interactions between economic and ecological systems	Intergenerational equity, irreversibility of environmental change, uncertainty of long-term outcomes, and sustainable development	Explicitly advocating for an Earth-centered worldview and for bringing human activities within ecological limits	Strong sustainability and rejecting the proposition that physical (human-made) capital can substitute for natural capital	Reward cooperation, incentivize negatively „counter-petition" and (more softly) competition	**The Earth's carrying capacity is a central issue in ecological economics.**
DOUGHNUT ECONOMY	Holistic	7 ways to think like a 21st century economist	To set out new ways of thinking, rather than advocate specific policies or institutions	4 core forms of economic provisioning: household, commons, market, state.	The Doughnut as the 21st century goal: to meet the needs of all within the means of the planet; the economy becomes the means.	Human prosperity in a flourishing web of life – living in the Doughnut	We typically engage in conditional reciprocity, and both compete and collaborate	**Diversity, redundancy, distributed networks. Resilience through evolution: diversify – select – amplify.**

Fig. 2.2.13. Comparing different economic models of urban development. Made by author.

The Doughnut Economy has joined the Thriving Cities Initiative (TCI) cooperating with other cities for such a transformation. The vision in 2050 is to be a thriving, regenerative, and inclusive city for all citizens, while respecting planetary boundaries (Raworth, 2020). Therefore, the Amsterdam City Doughnut is a portrait for transformative action. It aims to stimulate cross-border collaboration between different institutions and connect an integrated network for actors in the process of development.

Amsterdam is the first city to adopt this model as the starting point of its post-pandemic policy-making (Guardian, 2020). Marieke can Doorninck, Amsterdam's deputy mayor took it as a tool for Amsterdam to overcome the effects of the crisis, which can help not to fall back on easy mechanisms (Fig. 2.2.15). They use them as the basis for a solution to model a 'new portrait for the city', incorporating the city's targets and SDGs to the post-pandemic Amsterdam Circular strategy (Fig. 2.2.16). Therefore, the development in MRA will take place within social and planetary boundaries.

However, there are some limitations to the Doughnut Economy as a tool to solve the problem of urban vulnerability. Firstly, it is a general evaluation model for political strategies without the big significance of spatial planning and design approaches. Secondly, it is a framework for regional and urban scales, and there is an increasing number of experts exploring methods to scale down for actionability. Last but not least, this theory, to some extent, ignores the role of technology, which could be a useful bridge of the gap between financial development and urban resilience. It is also regarded broadly as one of the possible development potentials from COVID-19. Therefore, design approaches in this project should take advantage of the Doughnut economic model and improve it to a more practical planning framework for urban resilience in MRA.

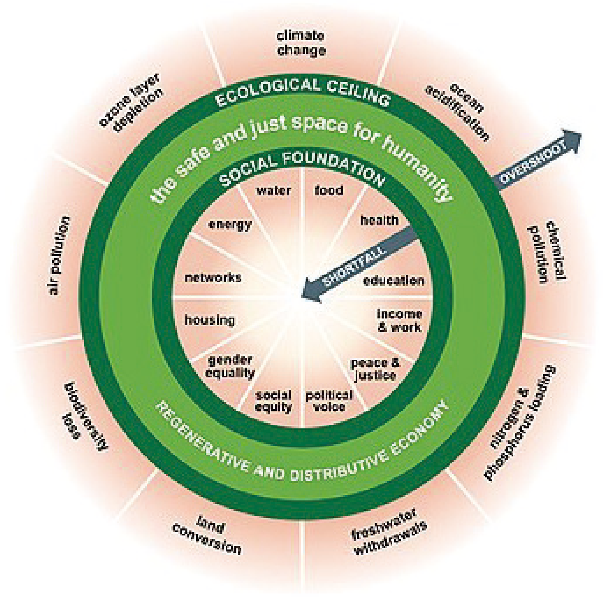


Fig. 2.2.14 The Doughnut economic model. Source: https://www.kateraworth.com/doughnut/

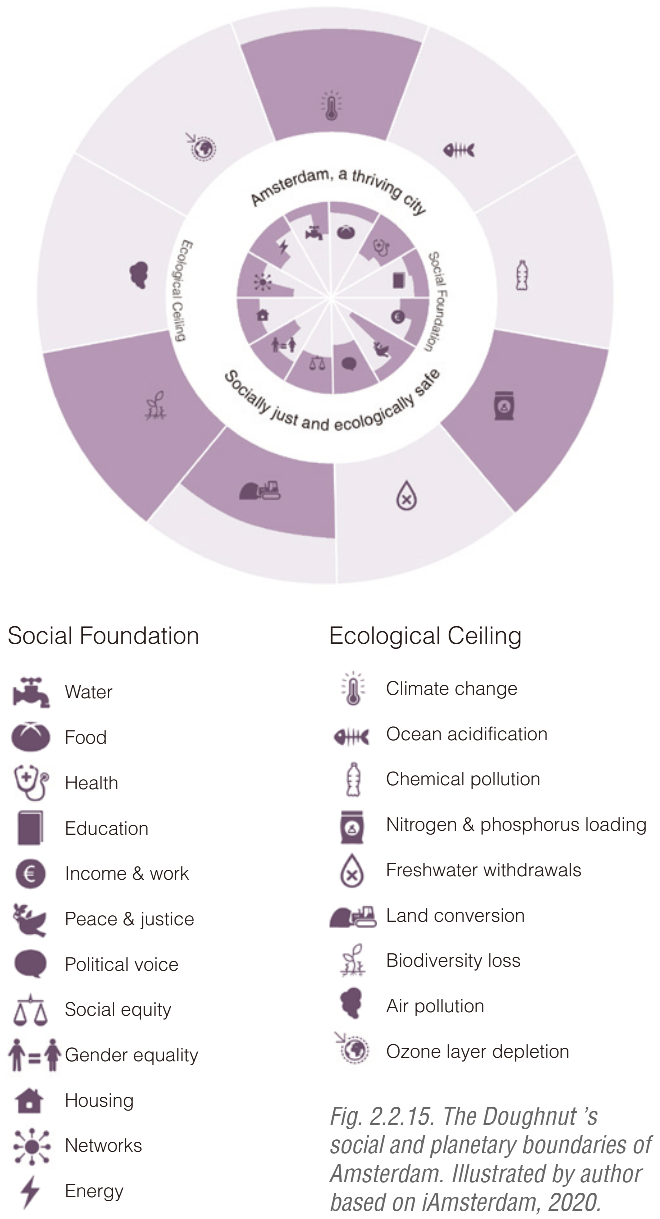


Fig. 2.2.15. The Doughnut 's social and planetary boundaries of Amsterdam. Illustrated by author based on iAmsterdam, 2020.

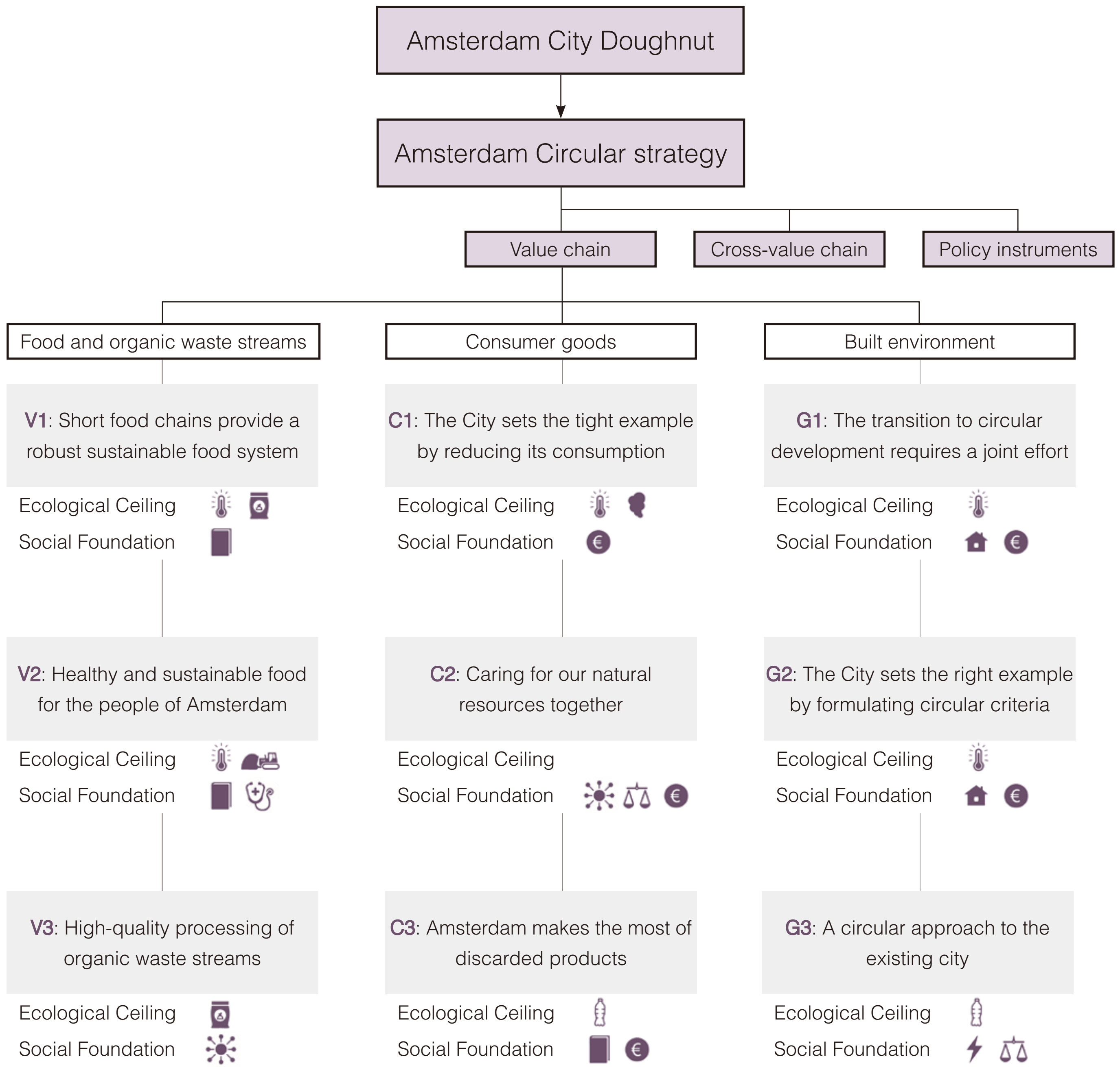


Fig. 2.2.16. Framework of Amsterdam Circular strategies and the position in the Doughnut. Made by author based on Circular Economy and the City of Amsterdam, 2020.

The Amsterdam City Doughnut drawn up by economist Kate Raworth works as a basis for Amsterdam Circular Strategy. The concrete measures focus on three value chains from the National Raw Materials Agreement due to the economic significance, environmental impact, and potentials for Amsterdam (Gemeente Amsterdam, 2020).

Firstly, the food and organic waste will be reused not only in households but in hotels and restaurants. It aims to decrease dependency on globally imported food. This value chain is closely linked with the national food strategy as the major ecological factor.

Secondly, consumer goods mainly focus on electronics, textiles, and furniture. The proposed strategy is to increase recovery and repair from corporations and professionals. It is chosen because of its contribution to the depletion of raw materials and pollution to climate change.

Thirdly, the built environment is emphasized to construct circularly and also use sustainable materials, especially in public space. The city will be designed in a climate-adaptive way, leading to a cleaner, livable, and gas-free neighborhood by 2040.

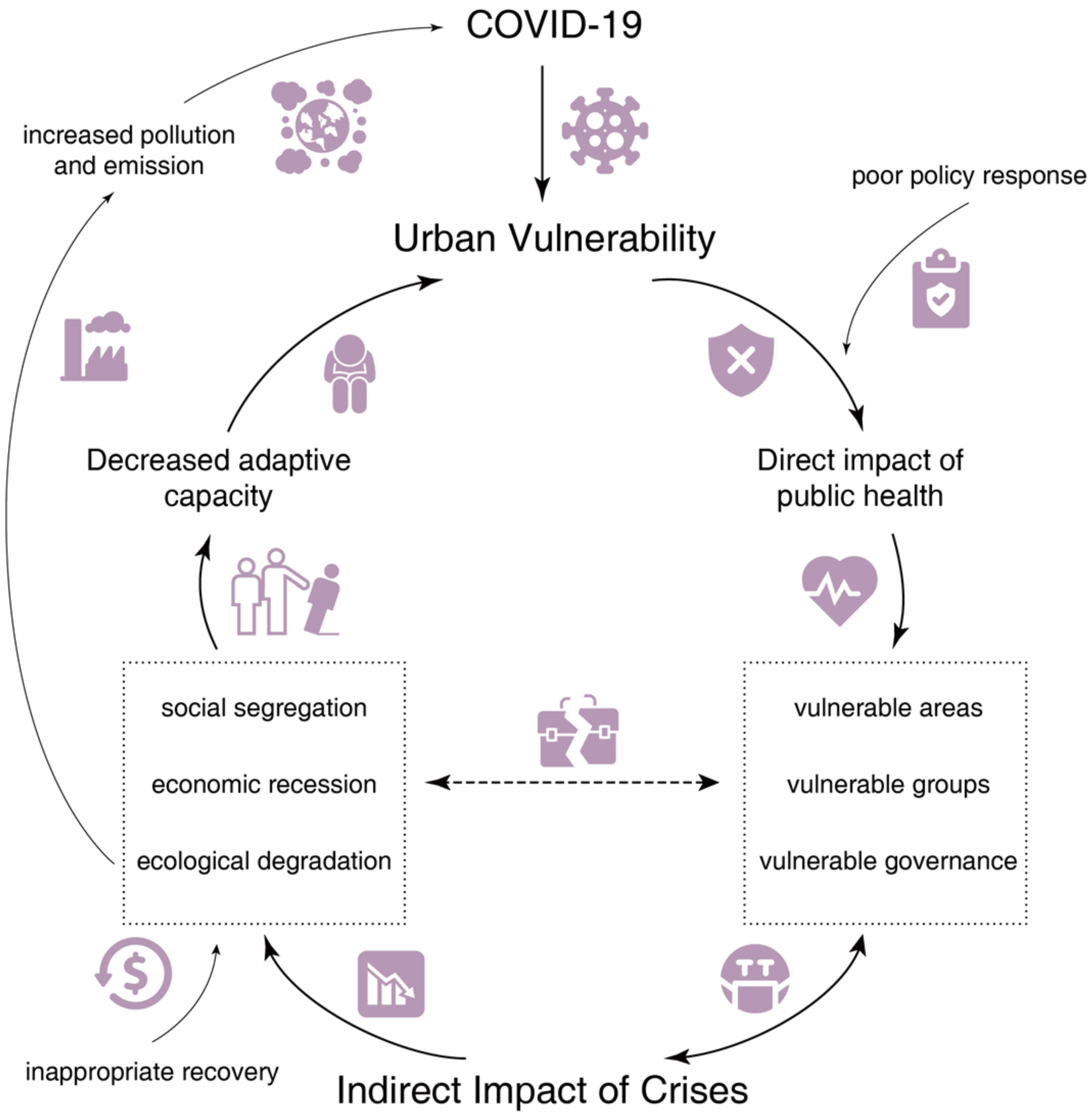


Fig. 2.3.1. A vicious cycle of urban pandemic vulnerability. Made by author.

3 PROBLEM STATEMENT

The COVID-19 has increasing impacts on MRA through a dynamic vicious cycle of urban pandemic vulnerability (Fig. 2.3.1). The direct impact of public health spread broadly across countries and regions due to its highly interpersonal contagious through globalization. And due to the gathering and cross-border flow of people, coronavirus has been spread and concentrated in the metropolitan region, which is playing a significant role in countries and the world. However, this impact has been intensified in vulnerable areas, groups, governance, and quickly developed into indirect impacts because of poor policy responses. The indirect impact of the crisis consists of social segregation, economic recession, and ecological degradation. Considering the urgency of recovery from these crises, inappropriate strategies proposed by different institutions will on the contrary decrease the adaptive capacity and return back to a pandemic vulnerable region. Besides, ecological degradation will also increase environmental pollution and emission to further malignant contagion like COVID-19.

The Metropolitan Region Amsterdam, the country's most developed and vulnerable region to the pandemic, is facing an overarching threat of COVID-19 with 10% confirmed cases of the Netherlands. And the measures to protect against the pandemic have led to 80% of industry bankrupt, a soaring unemployment rate of 42%, increasing domestic and medical waste, and so on. Poor living conditions of vulnerable areas, inequality of vulnerable groups, and marginalized development of vulnerable governance have decreased the capacity and increased vulnerability of MRA. The movement from one vulnerable cycle to another has trapped people with the lowest income, lowest health quality, highest immigrant, actually most live, in the most overcrowded neighborhoods in the city. And they are also workers who are always doing the most work, most notably health care, delivery, retail, construction, which are the most important ones in urban-resilient recovery but also the easiest ones to be unemployed during the COVID-19.

4 RESEARCH QUESTION AND AIM

4.1 RESEARCH QUESTION

How can a **multi-scale** planning strategy in MRA **reduce the vulnerability** of the region to **global pandemics** to **improve the regional resilience** of various areas, groups, and institutions to COVID-19?

SBQ1 How to define the urban vulnerability to pandemic from the perspective of urbanism and globalization?

SBQ2 What is a conceptual framework for qualitative and quantitative measurement of pandemic vulnerability?

SBQ3 What are the spatial strategic interventions to foster the improvement of urban resilience to pandemics?

SBQ4 What are the planning actions to contribute to the general urban resilience in MRA?

	SOCIO-ECONOMY	ECO-ECONOMY
REGIONAL	**01** The strategies that can facilitate the post-COVID economic recovery in MRA while respecting the well-being of residence with available social resources.	**03** The strategies that can balance the ecological stress of pollution, waste, and emission with the economic prosperity of MRA.
LOCAL	**02** A citizen-led community that is inclusive, equal, and localized to ensure their socio-economic resilience to a pandemic.	**04** An eco-friendly community based on the local landscape and spatial characteristics to improve their eco-economic resilience to a pandemic.

Fig. 2.4.1. Research focus. Made by author.

5.2 RESEARCH AIM

The research aims to investigate the **context, extent, and measurement of urban vulnerability** to
SBQ1 SBQ2
the pandemic in MRA. And further, it is dedicated to proposing **spatial and political strategies**
SBQ3 SBQ4
through the balance among economy, society and ecology to **improve metropolitan resilience** facing the pandemic and other risks in MRA after COVID-19 (Fig.2.4.2).

It is a planning project that aims to generate a strategic framework through the transformation of the urban economic model to accommodate the pandemic and its following risks to protect vulnerable areas and vulnerable groups on different scales.

It is a political research project as a theoretical addition to the governance of MRA for the pandemic. It aims to define the urban vulnerability of pandemic and further produce a guideline for collaborative management to ensure human rights at different levels.

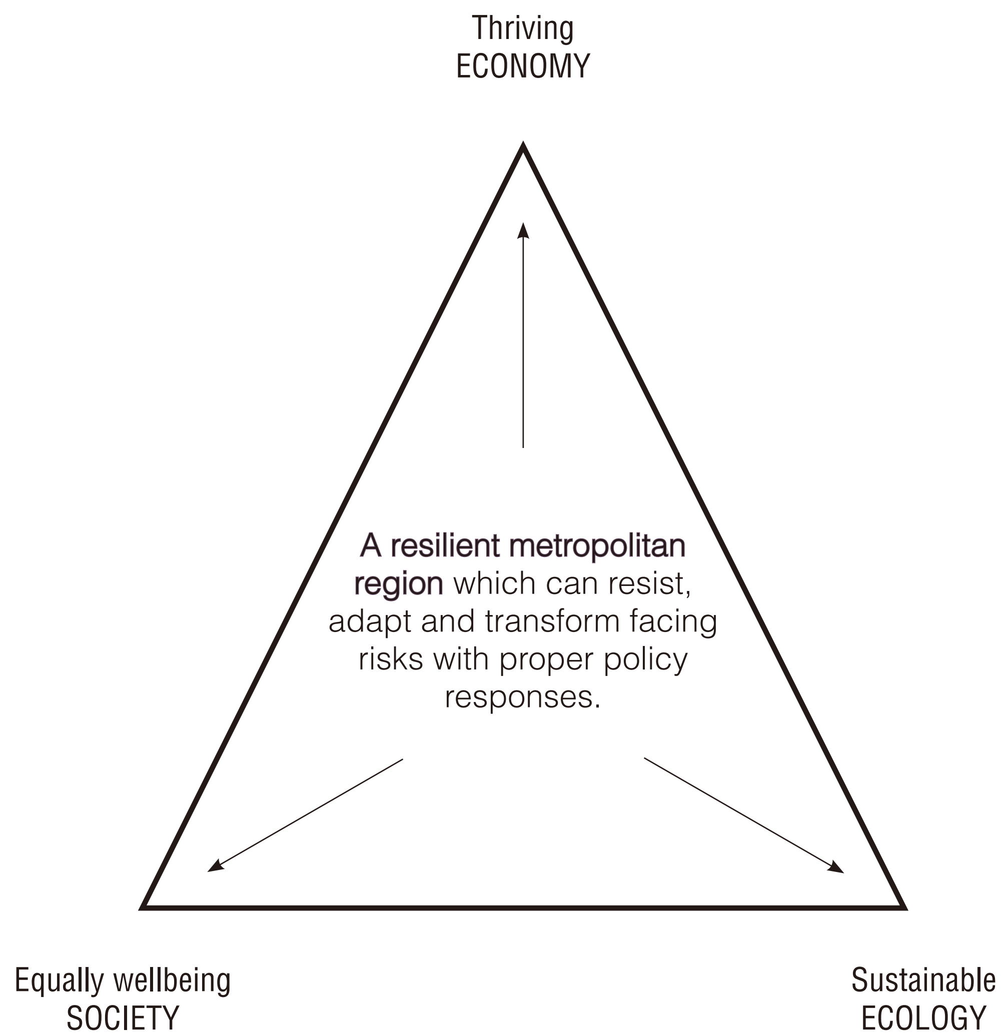


Fig. 2.4.2. Research aim. Made by author.

Fig. 2.5.1. The factory in Westpoort, Amsterdam, 2020. Photographed by author.

5. CONCLUSION

As the number of corona cases rises dramatically, the international governments and institutions are increasingly looking at ways to address the challenges of pandemic and the following crises. This contagious virus of COVID-19 in combination with the following global risk has triggered an unprecedented depression among different countries. And the metropolitan areas have become fertile grounds for pandemics as they are serving as intermediaries between international networks, municipalities, and people. Considering this, the Metropolitan Region of Amsterdam is one of the most urbanized and globalized regions, so this research firstly focuses on the direct impacts and indirect impacts of COVID-19 on it. The direct impact is related to public health, while the indirect impacts consist of three crises: economic recession, social segregation, and ecological regression. Although it is still too early to definite the magnitude and incidence of the influence, COVID-19 has been widely acknowledged to have a profound impact on metropolises in various aspects.

Then, the term "urban vulnerability" has been reconsidered as a conceptual framework and analytical approach to understand and address the marginality of the pandemic. The strategy in Amsterdam for the pandemic vulnerability is to reframe a Circular Amsterdam by economic transition based on Doughnut Economy from Kate Raworth. However, there are also some limitations of this economic model, so this research will propose a set of resilient strategies from that. It will be more suitable for problems of the pandemic in MRA.

Therefore, the research question is: How can a multi-scale planning strategy in MRA reduce the vulnerability of the region to global pandemics to improve the regional resilience of various areas, groups, and institutions to COVID-19? Accordingly, the aim of the research is to investigate the context, extent, and potential of urban vulnerability to the pandemic in MRA. And further, it is dedicated to proposing spatial and political strategies through the balance among economy, society and ecology to improve metropolitan resilience facing the pandemic in MRA after COVID-19

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3 METHODOLOGY

The purpose of this chapter is to clarify the relation and connection of different frameworks regarding to its problems, theories, and methods to reach the final project goal.

CONTENT

1. RESEARCH FRAMEWORK

The project starts with the motivation for the impact of COVID-19 on metropolitan regions. It has affected all the cities in the Netherlands for more than 100,000 people at an unprecedented speed, and the Metropolitan Region Amsterdam (MRA) is one of the most seriously attacked regions with the higher caseloads increasing almost 20% every week on average (GGD Amsterdam, 2020). Besides the direct public-health issue of the coronavirus, it is now widely recognized that the COVID-19 triggered a lot more crisis for the social, economic, and ecological development, which exposed the lack of urban resilience (OCED, 2020) utterly. The MRA, as the capital region and the most robust economic region playing a significant global role, can be on the frontline of crisis management in the Netherlands.

Therefore, the thesis firstly takes an in-depth look at the consequences of COVID-19 in MRA about direct and indirect ones. The danger of public health has become an outstanding direct problem since the outbreak of the epidemic due to the infectivity of the virus, which could also have long-lasting effects on indirect influence. Beyond the health impact, the economic recession dominates the risk of local employment by pro-longed lockdown and the confinement measures. It also leads to soaring social inequalities with mental health problems and loneliness. Furthermore, the increasing waste and recovery management approaches can be a risk perception as a shortfall of sustainability criteria. These indirect impacts are likely to increase the vulnerability of the region and damage the global environment for other pandemic crises. To sum up, MRA is vulnerable to direct and indirect effects of the pandemic due to the vicious cycle of urban vulnerability which has been exposed and intensified by the hazard of COVID-19.

Considering the Doughnut Economics used as a starting point by the Amsterdam government to a post-COVID transformation, it leads to the main question of my project. How can a multi-scale planning strategy be combined with the economic transition model of the MRA to reduce the vulnerability of the region to global pandemics?

This project is dedicated to proposing spatial and political strategies through the economic transition to improve urban resilience facing the pandemic in metropolitan regions after COVID-19. The project aims to discover the reason for the harmful effects of COVID-19 in MRA and to learn lessons from its experience to propose alternative approaches that can establish a resilient metropolitan region through a new economic model. Therefore, the expected outcomes are mainly in two different scales to approach the questions and to reach the goal. There will be a vision of post-pandemic MRA through a set of spatial and political strategies of municipalities and institutions to improve urban resilience. Besides, this project will come up with a resilient design for different pandemic vulnerabilities for an equal and sustainable community.

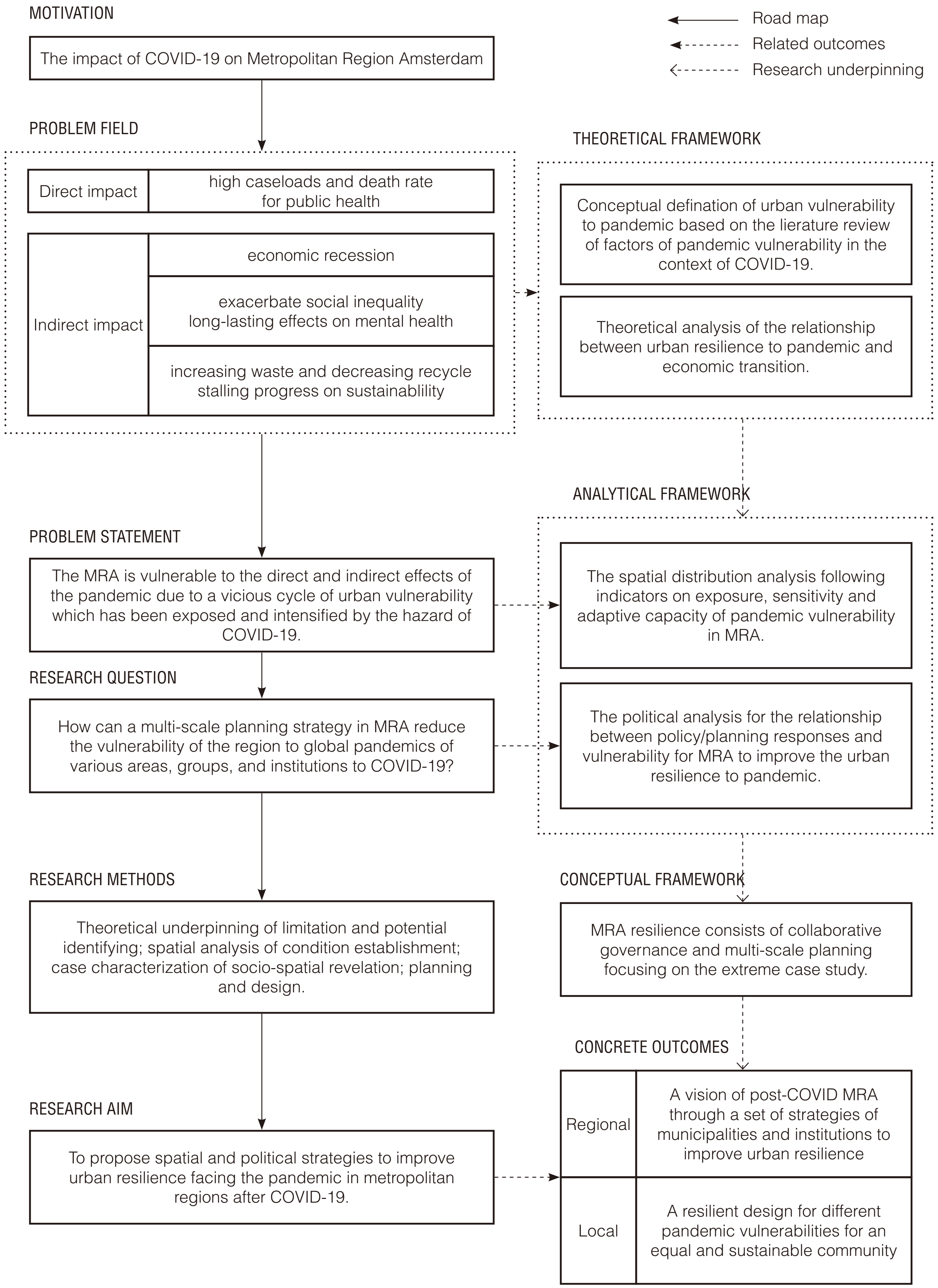

Fig. 3.1.1. Research framework. Made by author.

2. ANALYTICAL FRAMEWORK

To understand better the problematization of current conditions, the analytical concepts used in this project consist of two main sections: urban vulnerability and urban resilience. The analytical framework deconstructs those elements to evaluate urban vulnerability mapping and political assessment of MRA in different scales (Fig. 3.2.1). It is to understand and rank the vulnerability of which groups, areas, and institutions are the most vulnerable and marginalized during COVID-19. These sectors include both theoretical analysis and spatial analysis, which should be the priority to work on in this research.

Considering the structure of theoretical framework, the proposed analytical framework is made up of two parts: mapping of vulnerability, and political structure. The mapping of vulnerability is to evaluate the existing situation in MRA based on the indicators of exposure, sensitivity, and adaptive capacity explained in the theoretical paper. It reflects the present condition of the region and neighbourhood and the most vulnerable places facing the challenge of the pandemic.

The political assessment is to summarize the critical implementation of current policies in MRA in different scales and stages. Comparing the spatial-political structure with the mapping of vulnerability, the marginalized groups and areas will be highlighted, and the effectiveness of different institutions will be represented in different scales. Accordingly, the post-COVID scenarios in MRA will be proposed based on it to check whether the urban resilience can be improved for further pandemics, and who, where and what should be intensified in the vision.

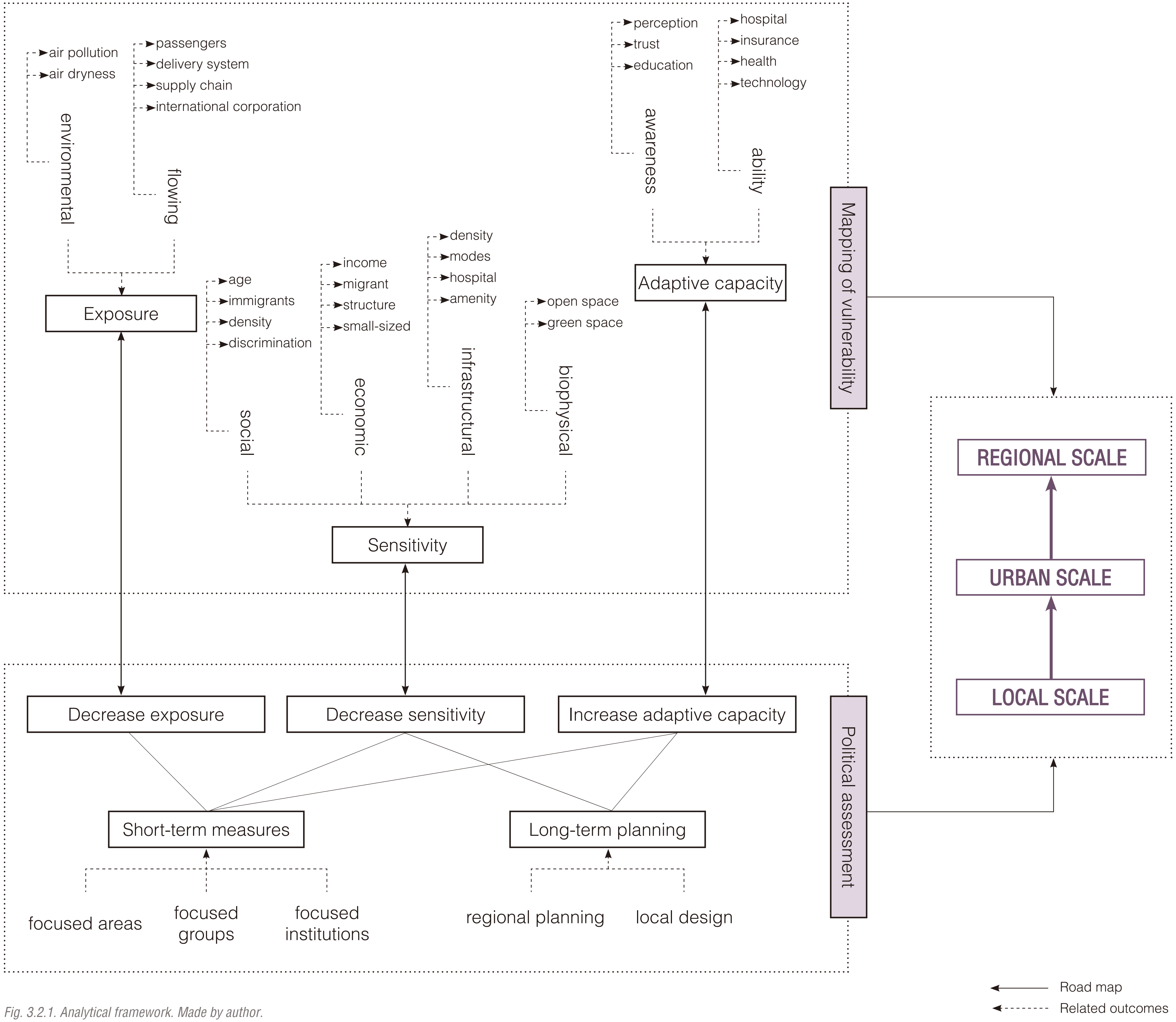

Fig. 3.2.1. Analytical framework. Made by author.

3. CONCEPTUAL FRAMEWORK

The conceptual framework explained the relationship and the process from the theoretical underpinning and analytical framework to the proposed design through the linkage of the research. As shown in Fig. 3.3.1, the vulnerability of the metropolitan region is related to its exposure, adaptive capacity, and policy responses, which indicates that the metropolitan region plays a significant role in globalization and the challenge of the global pandemic. The economic transition is the key to transfer from urban vulnerability to urban resilience. As the impact exists from vulnerable areas and groups to vulnerable governance in MRA, it is necessary to adapt these theories in different scales to propose my design approaches in different scales.

For governance, the combination of national, regional, and local governance is necessary to respond effectively to public health and indirect crises from the pandemic. "Strong coordination between all actors in charge of the response at central and regional levels is the basis of an effective response" (WHO, 2020). It includes not only frequent cross-border communication and management but community-based support for all actors.

Moreover, for multi-scale planning, the region needs to transform from a financial-dominated economic model to a sustainable and people-dominated model, which is resilient to the pandemic and developed from the Doughnut economy. The Amsterdam Institution is struggling to embrace this model for the post-pandemic economy, which is consistent with my vision and design approaches. Therefore, this project explores the development methods with the concept of Doughnut Economics and what spatial planning strategies can be proposed for a resilient MRA to the pandemic. It consists of two aspects: socio-economy and eco-economy to reach people's needs and ecological ceiling. The socio-economy is focusing on affordability, accessibility, availability, social equality, and diversity. And the eco-economy is related to emission, energy, waste, and land use.

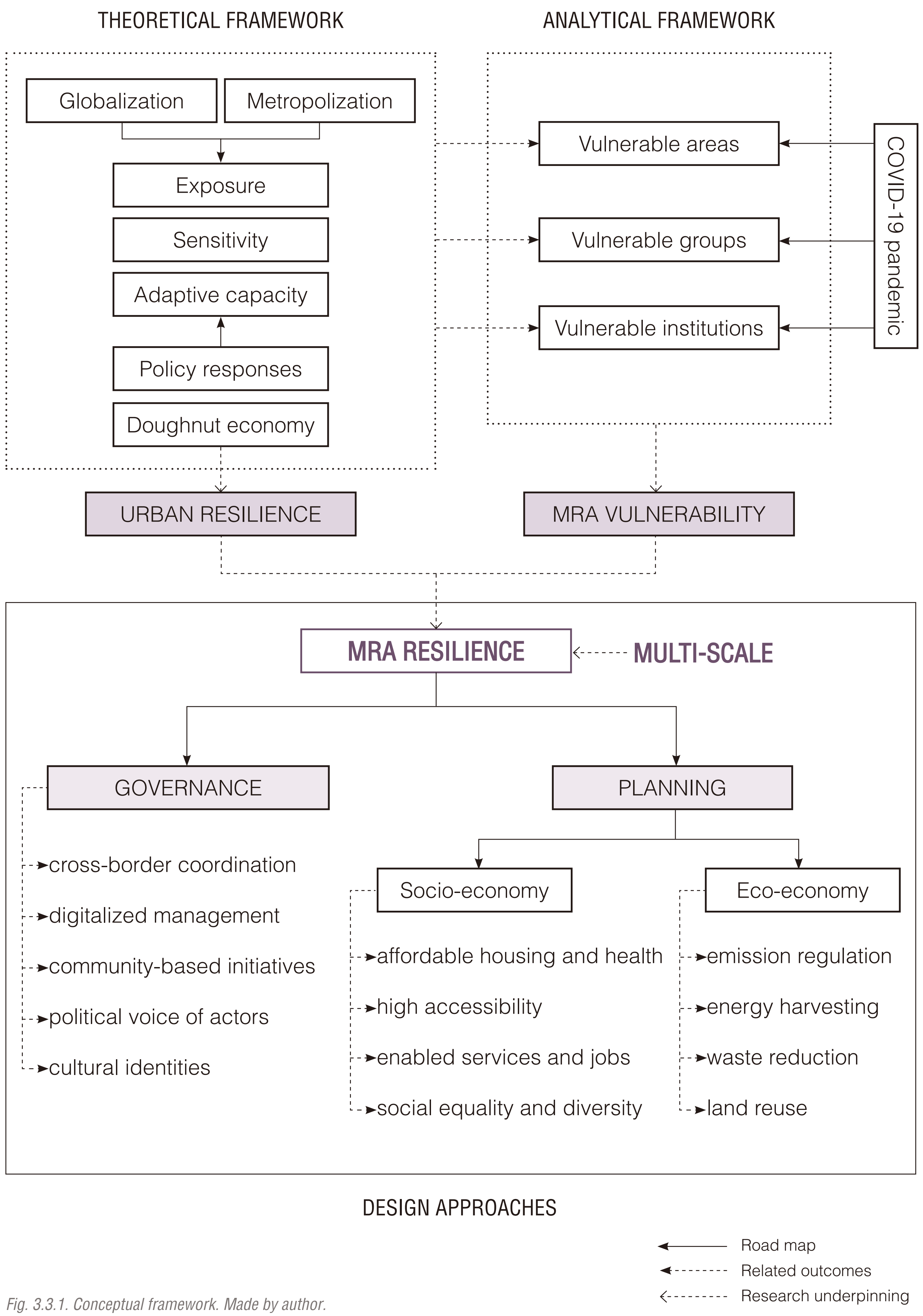

Fig. 3.3.1. Conceptual framework. Made by author.

4. EXPECTED OUTCOMES

The project proposes three main products that act intertwined: political strategies through collaborative governance, planning, and design in different scales for post-COVID MRA (Fig. 3.4.1-3.4.3).

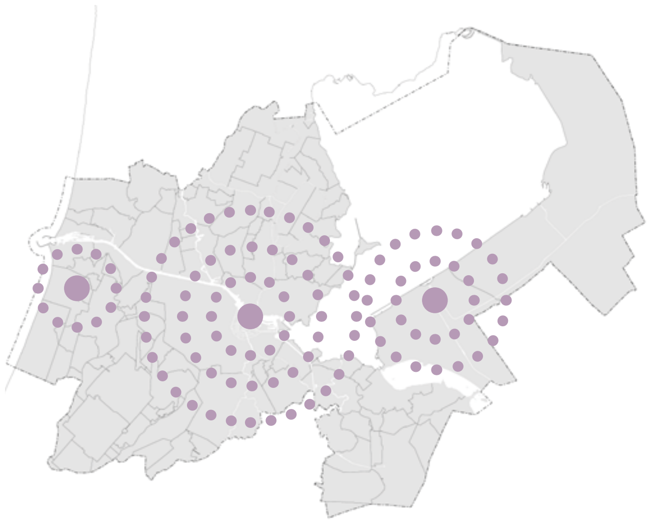

Fig. 3.4.1. Outcome of governance model. Made by author.

Fig. 3.4.2. Outcome of regional planning. Made by author.

Fig. 3.4.3. Outcome of local design. Made by author.

GOVERNANCE MODEL

01 A critical position of existing governance model base on literature review, and an evaluation of the potential location for transformation.

02 A multi-scale governance model as a rule for different institutions and stakeholders to improve the transition operability.

REGIONAL PLANNING

03 A set of indicators that assess the vulnerability in the context of pandemic in MRA representing the spatial distribution for site selection.

04 A set of planning principles that activate the daily social life and protect the ecological system.

05 A set of strategies that facilitate the economic recovery in post-COVID MRA and quantitative relationship with urban resilience.

LOCAL DESIGN

06 A typology of patterns of local impacts of COVID-19 with an understanding of its outstanding problems and local characteristics for design approaches.

07 A typological design of different local communities to be inclusive, active, and resilient neighborhoods with high living qualities.

5. RESEARCH METHODS

The research and design methods present expected methods based on the research questions and outcomes in different scales (Fig.3.5.1). The process of research is split into four parts through qualitative and quantitative analysis related to the sub-questions represented before. And the research outcomes can finally be concluded into socio-economic and eco-economic aspects that lead to the expected outcomes in regional and local scales through collaborative planning.

The MRA is not a typical nor extreme case for metropolitan areas due to its population and regional structure. However, it is one of the pioneers trans-forming its post-pandemic economic development model to a thriving and resilient region, related to the connection to globalization and sustainable local development (Boffey, 2020). Thus, it is considered as a practical case study with the potential and aspiration to evaluate and improve in several aspects. Therefore, the research methods used for different questions are positively related to the conditions of MRA, and they are grouped into four types of methods.

THEORETICAL UNDERPINNING OF
LIMITATION AND POTENTIAL IDENTIFYING

SPATIAL ANALYSIS OF CONDITION ESTABLISHMENT

CASE CHARACTERIZATION OF SOCIO-SPATIAL REVELATION

PLANNING AND DESIGN

THEORETICAL UNDERPINNING OF
LIMITATION AND POTENTIAL IDENTIFYING

1 LITERATURE REVIEW

Aim:

It is a critical review of the theoretical literature of books, reports, and news. It is to revise and define different theories, concepts, and information related to metropolization, urban vulnerability, Doughnut Economics to support the analysis of the problem and design approaches.

Outcome:

1.Problem field theories: globalization and urban vulnerability are the main theories for the influence of COVID-19 in MRA. The objective is to conclude a definition and framework for pandemic vulnerability based on the existing theories and impacts of COVID-19.

2. Metropolitan region: metropolization and polycentricity with integrated governance are studied to understand the critical aspects for efficient policy responses at a different level.

3. Urban resilience approaches: theories of economic transition are explored recently in the context of Amsterdam to improve post-pandemic urban resilience. The aim is to inform potential spatial strategies applicable to MRA at a regional and local level.

Data source:

-Google Scholar; Since Direct; Springer; Scopus.
-ETC-CCA (The European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation)
-Circle Economy; Doughnut Economics Action Lab

2 POLICY ANALYSIS

Aim:

It is research with the ongoing discourse and future planning from institutions. It is to collect and analyze the main policy instruments and available data at global, national, regional, and municipal levels for the strategies. And it can reveal the gaps and structures of governance and management to identify the limitation and potential of MRA.

Outcome:

1. Short-term governance response: measures at national, regional, and municipal levels are collected and studied with a summary in different aspects to evaluate the feasibility to mitigate short-term pandemic impacts.

2. Long-term planning strategies: the different aspects of post-COVID planning and design strategies are studied and analyzed to identify potential and limitations. Accordingly, a diagnosis of marginalization is obtained as an outcome to inform a set of alternative approaches.

Data source:

-Government of the Netherlands; RIVM (Rijksinstituut voor Volksgezondheid en Milieu/ National Institute for Health and Environment)
-City of Amsterdam; iAmsterdam; AMS Institute
-University of Amsterdam; Vrije Universiteit

SPATIAL ANALYSIS OF
CONDITION ESTABLISHMENT

3 MAPPING ANALYSIS

Aim:

It is an insight into the current situation and the initial exploration of the site. It is to visualize the conflicts and conditions of the problem as a main tool of analysis in socio-economic and eco-economic structure, network, land use, functional and morphological conditions.

Outcome:

1. A section of basic geoinformation is mapped according to the impact of COVID-19 on different scales.

2. Main aspects are identified and integrated with the outcomes of theoretical research.

4 DATA COLLECTION

Aim:

It is an exploration of quantitative official and empirical data from websites, documents, media, and publications. It is to work as evidence for problem, question, and approaches through the visualization of data as complementation of the outcomes from mapping.

Data source:

-RIVM (Rijksinstituut voor Volksgezondheid en Milieu/ National Institute for Health and Environment); CSSE (The Center for Systems Science and Engineering).
-CBS (Het Centraal Bureau voor de Statistiek/ The Central Bureau of Statistics); Rijksoverheid; Meteoblue; Allecijfers.
-Parool; AD Amsterdam.

CASE CHARACTERIZATION OF
SOCIO-SPATIAL REVELATION

5 FIELDWORK STUDY

Aim:

It means the visiting of the selected areas to document them through observation, discussion, and interview. It is to reveal the specific information on the territorial characteristics and issues that the main residents and workers have. And expert opinion and approaches about the Doughnut economy can be obtained through formal and informal interviews with people in different disciplines.

Outcome:

1. Interviews of different actors: policymakers, planners, urban experts, residents, and employers/ employees are interviewed to establish a range of opinions for risks and measures of COVID-19.

2. Field analysis: clarify and identify characteristics of vulnerable places analyzed through theories and mapping.

Locations:

-Westpoort; Amsterdam Centraal; Amstelveen; Amsterdam Nieuw-West; Amsterdam-Oost; Amsterdam-Noord.

6 STAKEHOLDER ANALYSIS

Aim:

It is an understanding of the main actors that intervened in the MRA, including regional residents and the global population. The objective of this method is to recognize the relationships between these actors and the project. It is to explore the evaluate the powerful voice and interest of different groups in collaboration planning.

Outcome:

1. Identification of key groups, institutions and organizations related to the effects and policy making of COVID-19.

2. Different aspects and mechanisms are evaluated to analyze the hierarchy and integration of the policy system that would facilitate approaches in MRA.

Data source:

-AMS Institute of Humanities Research; Social Science Research (AISSR); Global Health and Development (AIGHD); Advanced Metropolitan Solutions.
-Amsterdam Donut Coalitie/ Amsterdam Donut Coalition.

PLANNING AND DESIGN

7 SCENARIO DESIGN

Aim:

It means planning and design focused on the case of MRA and vulnerable areas. The outcome of this method is the implication of the worst scenario following the current development model and a proposed vision image after the post-pandemic transformation. It is to evaluate and test the theory and strategic approaches through different scenarios.

Outcome:

1. An existing case scenario is summarized according to the implications of current vulnerability and methods for intended outcomes in post-COVID MRA.

2. A worst-case scenario is built on understanding the urgency of urban resilience to the pandemic in MRA.

3. An utopic goal image is explored to highlight the limitations, potentials, and implications for vision management.

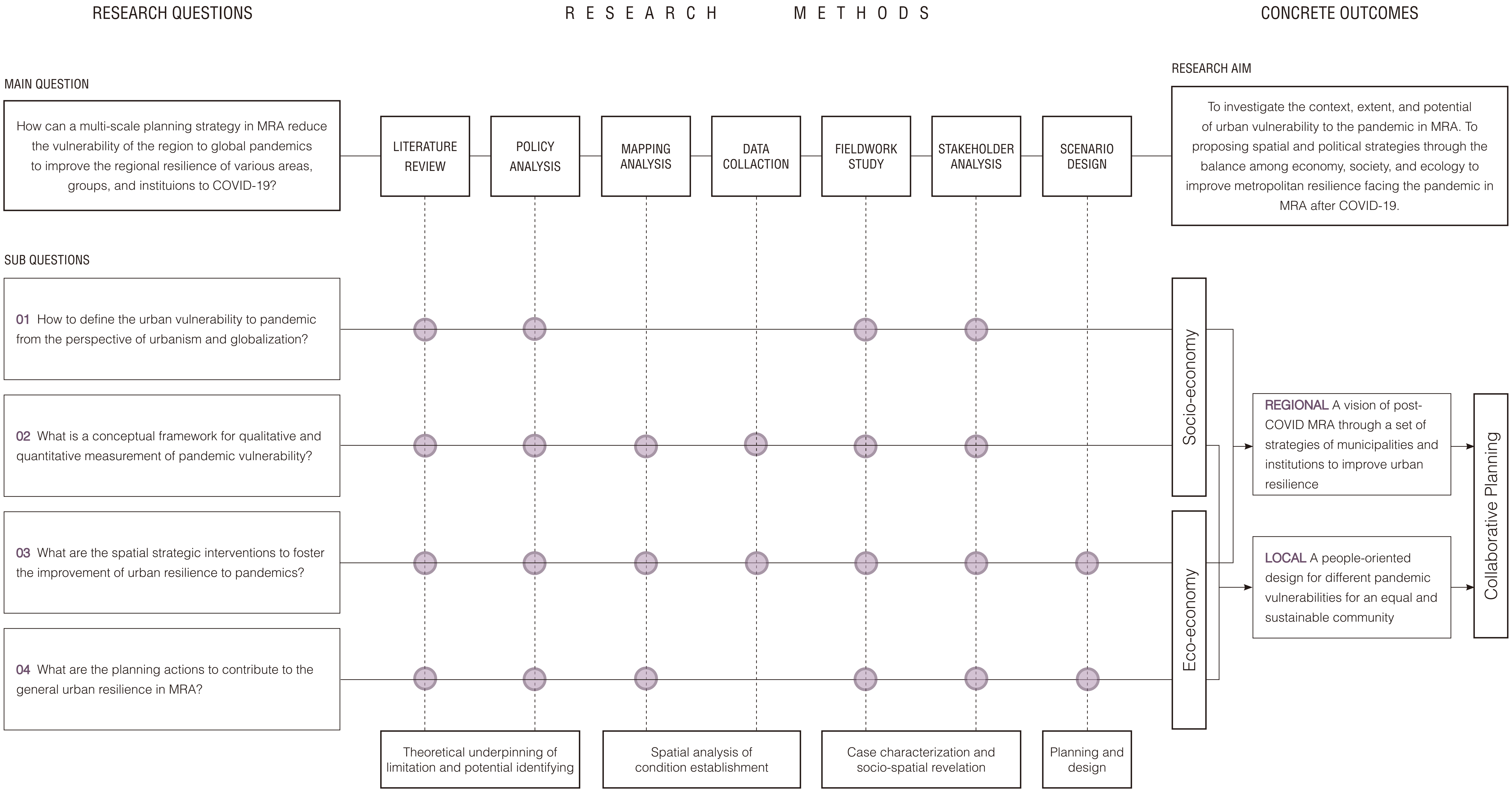

Fig. 3.5.1. Research methods. Made by author.

6. TIMELINE

The timeline in Fig.3.6.1 shows that the main activities during the graduation project. These activities are divided into five stages that the project will develop in the process to achieve different objections to the research aim.

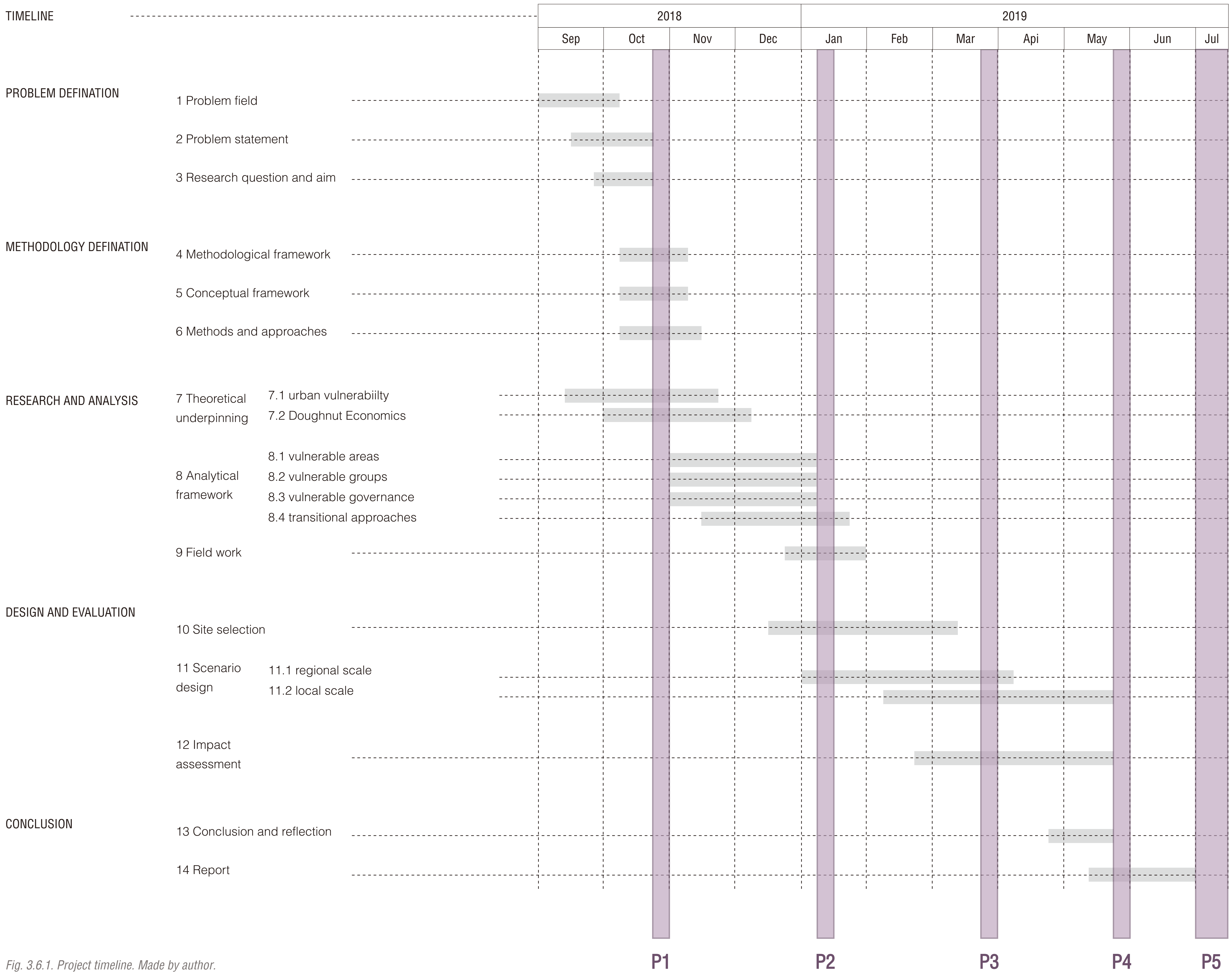

Fig. 3.6.1. Project timeline. Made by author.

Fig. 3.7.1. The City of Amsterdam in Christmas, 2020. Photographed by author.

7. CONCLUSION

This thesis is aiming at a resilient metropolitan region of globalization, facing the challenge of the pandemic after COVID-19 in MRA. This chapter is to introduce frameworks, methodology, and time planning of the project.

To select appropriate methods for this project to address problems, the methodological framework is firstly discussed in this chapter to connect identified problems, research question, research aim, and expected concrete outcomes of the project. The fundamental cause of the lasting impacts is a vicious cycle of pandemic vulnerability, so a firstly clear definition and indicators of the theory are necessary for analysis. Then, the analytical framework is developed to discover the reason for metropolitan vulnerability through related theories and spatial analysis, focusing on the site of Metropolitan Region Amsterdam. A series of spatial and political analyses are explored to highlight the extremely vulnerable areas, groups, and institutions in MRA for related planning and design. Afterward, the conceptual framework summarizes and concludes the concepts among them to introduce the process from the problem statement to the final solution in this project. And the proposed research approach is finally explained from the theoretical literature review to proposed strategies and post-pandemic vision of Metropolitan Region Amsterdam. Therefore, a timeline of this research is planned to organize my research to achieve the conclusion and goal of the project.

However, there are also some limitations to this methodology. This project thus aims to work as a priority of urban vulnerability and resilience to the pandemic, which can continue to evolve in the future with completed data and supplemented theories.

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4 URBAN VULNERABILITY

This chapter proposed a framework of indicators suited to a 'pandemic vulnerability analysis' based on current qualitative and quantitative data available in cities. It focuses on the indicators related to COVID-19 in MRA to depict the reason of vulnerable metropolis.

CONTENT

1 DEFINITION AND FRAMEWORK

1.1 COVID-19 AND OTHER PANDEMICS IN HISTORY

Several experts researching 'vulnerability' have emphasized its necessity regarding a specific situation. Brooks (2003) takes the opinion that "one can only talk meaningfully about the vulnerability of a specified system to a specified hazard or range of hazards," and need to differentiate the current and future vulnerability. Therefore, the pandemic vulnerability in this study is proposed in response to the threat of contagious diseases to short-term and long-term impacts like public health, social, and economic crisis in urban areas, focusing on COVID-19. Comparing with the last three pandemics before in world history, SARS in 2003, H1N1 in 2009, ZIKV in 2015, the latest pandemics similarly begun and attacked mostly in urban areas (Table 4.1.1). Moreover, these pandemics have led to both direct health issues and indirect adverse effects. It has shed light on existing urbanization problems, showing a heightened sensitivity of these areas in the global network to the pandemic.

Cities are the fastest-growing type of human settlement with the largest population, while they have become the fertile ground for pandemics as they are serving as intermediaries between international networks, municipalities, and people. When a cluster of corona cases appeared in 2019 from Wuhan, China, it has mutated into a pandemic that has ravaged many countries and cities through the vast worldwide network in a short time. The direct person-to-person transmission of COVID-19 is the main route of spread related to the population concentration in cities (WHO, 2020). During the spread, urban areas have become the epicenter of the pandemic, where 90% of reported cases are located (UN,2020). For example, the initial focus of the new coronavirus, Wuhan, is a metropolis of about 11 million, where more than 4,000 people have died.

Furthermore, most corona cases also spread and concentrated in highly urbanized cities in Europe (Fig. 4.1.1). Milan and the region of Lombardy, as the capital and one of Italy's richest areas, were the first epicenter of COVID-19 in Europe. London was the UK's first concentration of corona cases. The COVID-19 spread rapidly in the vulnerable Greater London due to its international links, public transport network, and worst air quality (Rode, 2020). And the Netherlands, one of the current pandemic hotspots, has reached more than 457,000, a large number of whom are people living or working in the capital city Amsterdam (CSSE, 2020). And beyond people's physical-health direct impact, it has a set of associated impacts on social functioning and the urban economy. COVID-19 is having an impact on metropolises, which has focused the attention on the role and vulnerability of interconnected cities in the current increasingly globalized world.

PANDEMIC	YEAR	EPICENTERS	DIRECT IMPACT	INDIRECT IMPACT	
			PUBLIC HEALTH	ECONOMY	SOCIETY
SARS (Keogn-Brown & Smith, 2008)	2003	Hong Kong, Singapore, Toronto	It has killed at least 774 people worldwide from 29 countries and territories.	Tourism and agriculture impacts were estimated to be substantial at US$ 1.3 in Hong Kong.	Distress among frontline healthcare workers and public members, many of whom were anxious, fearful, and depressed.
H1N1 (McKibbin, 2009)	2009	Mexico, Hong Kong, Osaka	It was estimated to have about 284,00 deaths.	It cost the global economy decrease about $360 billion within a year.	It lowered the return on education and increased family burden on healthcare.
ZIKV (Ulansky, 2016)	2015	Recife, Miami, Orlando, New York	It reached more than 1.5 million people infected in Brazil.	The short-term economic impact in the Latin American and the Caribbean region is a total of US$3.5 billion or 0.06% of GDP.	The effect is disproportionately higher in low socio-economic groups.
COVID-19 (CBS, 2020)	2019	Wuhan, London, Milan, Amsterdam	There have been 37,640,243 confirmed cases in 188 countries, resulting in more than 1 million deaths.	GDP in Amsterdam declined more than half in Q2 2020 with fewer investments and trade.	A soaring unemployment rate of 53% in March in Amsterdam, which is far above the national average.

Table 4.1.1 The comparison of SARS, H1N1, Zika virus, and COVID-19 on territory and impacts (Source: Keogn-Brown & Smith, 2008, McKibbin, 2009, Ulansky, 2016, CBS, 2020)

1.2 INTERPRETATION OF THE DEFINITION

What makes urban areas vulnerable? On the one hand, a straightforward answer exists about poverty and underdevelopment (Allen, 2003). On the other hand, it is positively related to the crisis interplay between inter-territory and inner-territory processes where the coping ability of marginalized groups has diminished (Moser, 1998). And for developed countries and wealthy cities, it is necessary to grapple with the nature and linkage of the main determinants involved in urban vulnerability. The research on urban vulnerability is increasingly abundant throughout recent years with broad definitions and scopes in different disciplines. However, there has been little research explicitly exploring the definition and concept of urban pandemic vulnerability. It is urgent for innovative responses because cities are epicenters of pandemics besides the risk of climate and poverty. A systematic review of the existing definition of urban vulnerability is thus needed to conceptualize this field.

There are many different definitions of urban vulnerability. In summary, urban vulnerability relates to its adaptability to be attacked by the threat (Adger et al., 2004). The majority of current definitions on urban vulnerability focus on two aspects: social vulnerability, including poverty, powerlessness, resource depletion, and environmental vulnerability like heat, floods, and forest fires. For urban vulnerability of social crises, it represents people's ability to deal with hazards in socio-economic aspects (Allen, 2003). It means 'the insecurity or wellbeing of individuals or communities in the face of changing environments in the form of sudden shocks, long term trends or seasonal cycles' (Moser, 1998). Numerous studies focused on the issue of social vulnerability, and all of them highlight that cities are the most vulnerable areas with the worst impact due to the concentration of population, economy, specialization, and innovation (Piñeira Mantiñán and Trillo-Santamaría, 2011). In their research, the consequences of social vulnerability include unemployment, poverty, social inequality, and decreasing purchasing power. Whereafter social segregation exists with a limited ability to protect residents from certain risks and their negative consequences. Based on this definition, the framework consists of three determining factors: economic vulnerability, social vulnerability, and residential vulnerability (Fig. 4.1.2).

For urban climate vulnerability, it is an urban property referring to the possibility of climate events and the likelihood that the system can be negatively affected by hazards or disasters (Nicholls et al.,1999). Even though there are different definitions with many ways of qualifying (Füssel, 2007; O'Brien et al., 2007), the climate vulnerability is mostly represented as an interaction of both internal properties and external drivers including overall three key elements: exposure, sensitivity, and adaptive capacity (Fig. 4.1.3). The exposure represents the exacerbated climate conditions of a system through economic and social activities such as transportation and materials storage. Sensitivity means the extent to which a system is affected by impacts. And the adaptive capacity means the potential and the degree of a system that can absorb or mitigate impacts from the hazard (Romero-Lankao & Qin, 2011).

Based on these references, a logical outline of the understanding of urban pandemic vulnerability has been defined. The pandemic impacts are mainly represented in three consequences: urban spaces, social groups, and institutions. Therefore, the pandemic vulnerability is the combination of these two aspects, and the proposed definition adopts from the former in the context of pandemic and its impact on the urban scale (Fig. 4.1.4):

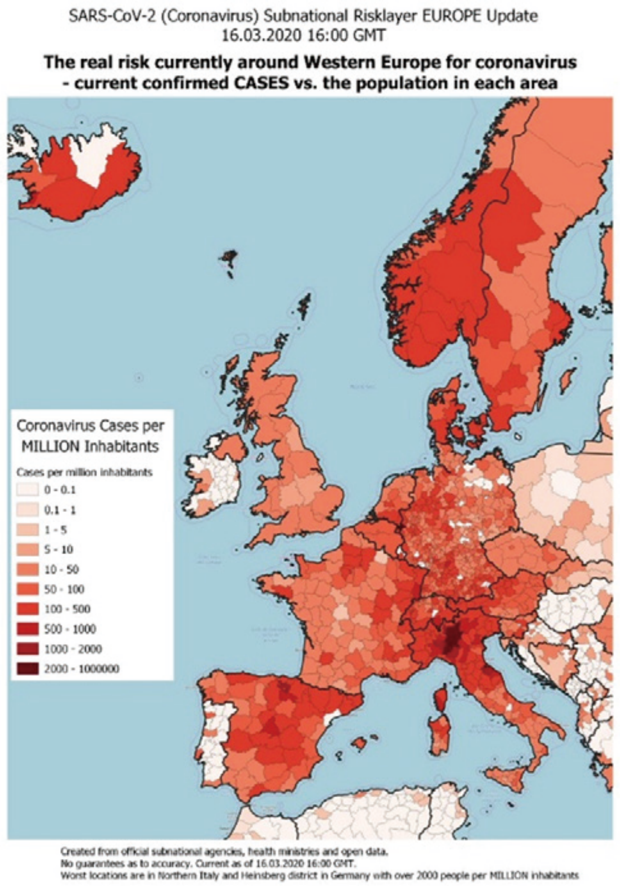


Fig.4.1.1. The coronavirus cases per million inhabitants in Europe updated 16.03.2020 16:00 GMT (Source: https://twitter.com/risklayer/status/)

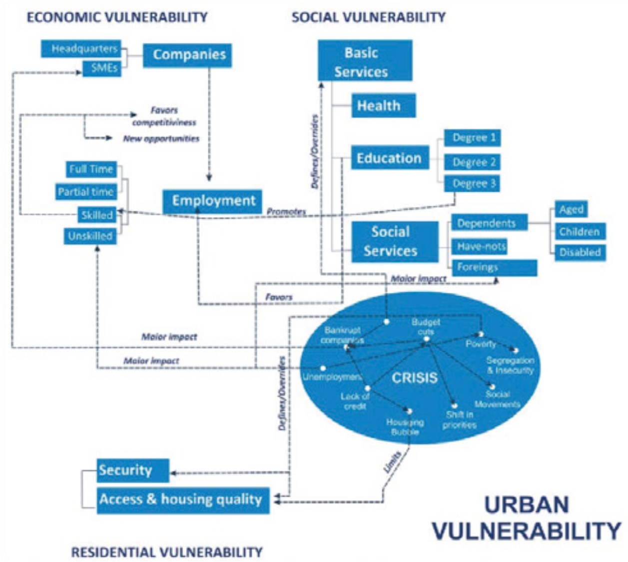


Fig. 4.1.2. A conceptual framework of urban vulnerability to poverty and social segregation (Source: Piñeira Mantiñán and Trillo-Santamaría, 2011).

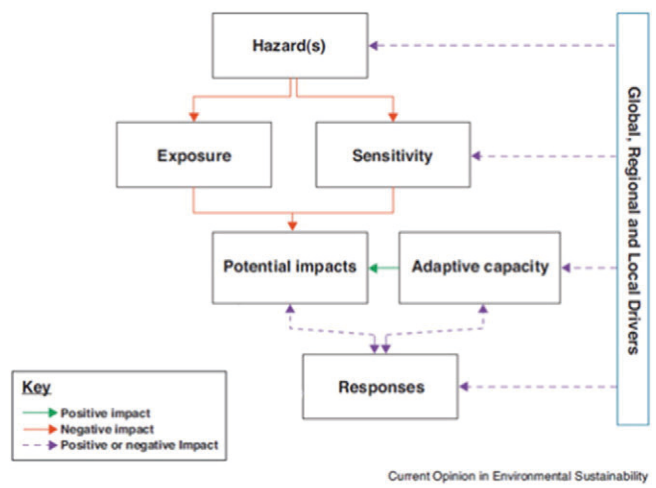


Fig. 4.1.3. A conceptual framework of urban vulnerability to global climate change (Source: Romero-Lankao & Qin, 2011).

The pandemic vulnerability of a city means the severity to which a system is susceptible to suffer from the pandemic, when the urban spaces, social groups, and institutions are negatively affected in the challenge of human health and its following crises.

Similar to the framework of generalized vulnerability, this study defines pandemic vulnerability through three components: exposure, sensitivity, and adaptive capacity. These components also parallel to the definition of regional economic resilience to pandemic by Gong et al. (2020): local aggregation of infected people, urban current factors (e.g. population density, trade dependency), and governmental effectiveness. Accordingly, exposure means the pandemic context the system is subject to, which can be influenced by external drivers, such as environment, globalization, and population. Sensitivity is the extent to which the city is influenced by risks that the population cannot absorb, both directly and indirectly. And adaptive capacity is the potential and ability of a system that can adjust to a pandemic crisis and cope with its consequences. Therefore, the policy response for urban vulnerability can be divided into three ways: decreasing exposure, decreasing sensitivity, and increasing adaptive capacity, and the actionability of these three approaches is increasing due to their various indicators.

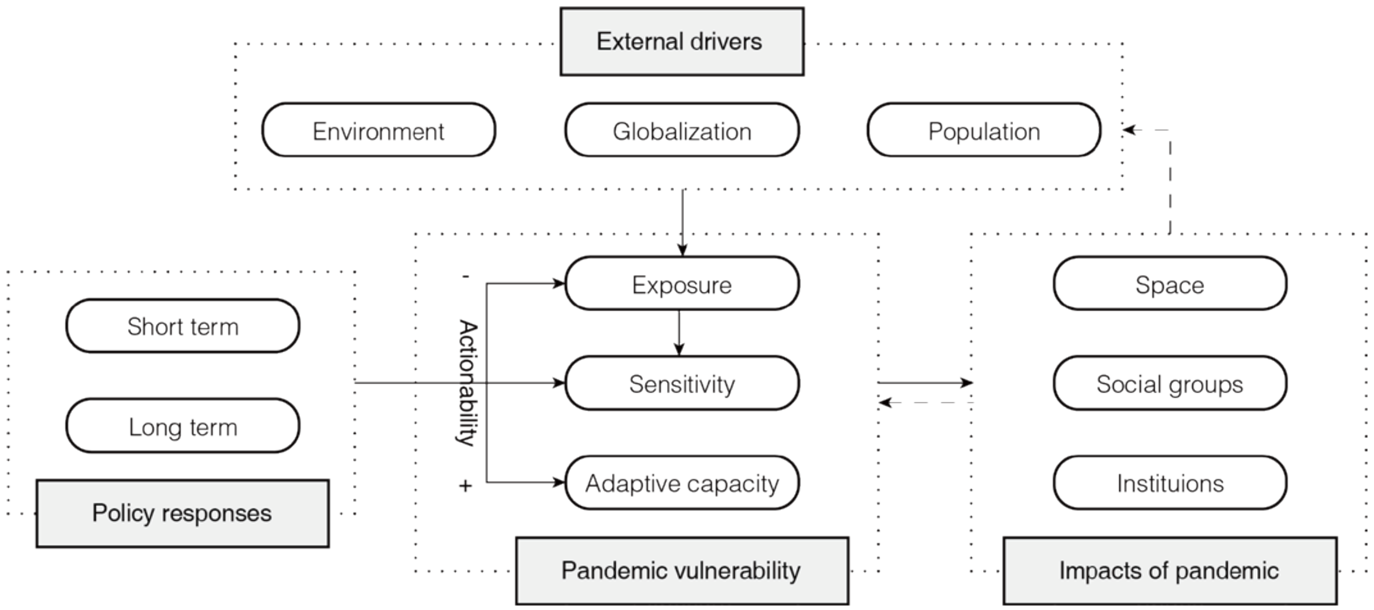


Fig. 4.1.4 The conceptual framework of urban vulnerability to pandemic.

2 INDICATORS OF PANDEMIC VULNERABILITY

According to the framework, each of the three components should consist of different indicators to assess pandemic vulnerability. They will be meaningful to identify the vulnerable areas, groups, and institutions at local levels. There are several possible applications of indicators, including identification of mitigation targets, vulnerable people, regions, and sectors, raising awareness, policy guidance, and scientific research (Hinkel, 2011). Besides, the analysis of vulnerability is more useful when their spatial characteristics are taken into account. Füssel (2007) argues that identifying a vulnerable situation often relates to spatial reference and specific attributes to a specific hazard. Therefore, indicators of pandemic vulnerability in this study are a set of place-specific analytical elements from a spatial perspective in the context of COVID-19.

This study follows the structure of European Environment Agency (EEA) indicators based on the definitions from Intergovernmental Panel on Climate Change (IPCC) about urban ecological vulnerability with relevant climate-related risks, types of determining factors and responses (Swart, 2012). I firstly review relevant literature published recently in response to threats of COVID-19. Papers were searched for scholarly literature in SCOPUS and the Web of Science using the keywords of "covid*/coronavirus," "urban/city/cities," and "planning/design." Following the initial search, many articles are not related to the influencing factors of urban vulnerability as indicators. Besides those from the pathological and psychosocial lens, there is a large portion of papers about the urban impact of COVID-19, like improving air quality and decreasing transportation. Therefore, after filtering and rechecking their abstracts, the categorization is refined following the three components according to its framework. Table 4.2.1 provides an overview of the proposed factors in three aspects, which are divided into short and long term related to different political stages of the COVID-19.

Aspect	Exposure		Sensitivity				Adaptive capacity	
	Environment	Flow	Social	Economic	Infrastructural	Biophysical	Awareness	Ability
Space	air pollution	import/ export nodes	residential density		traffic density	open space		hospital beds
	air dryness	delivery system			hospital accessibility	green space		
					amenity accessibility			
Social groups		daily passengers	age distribution	household income	motorized dependency		risk perception	insurance
			immigrants	migrant workers			education level	healthy
			discriminated foreigners					ability to use technology
Institutions				tourism/ mining/ manufacture			government trust	government integration
		international corporations		small-sized businesses				government efficiency

Table 4.2.1 System of pandemic vulnerability factors in different stages; indication in stages. Short term Long term

2.1 EXPOSURE

The exposure indicators cover two main factors: environmental factors focusing on air quality and flowing factors about population and economic flow. Firstly, it is evident that the health problems of COVID-19 are related to air quality. According to the study in Italy, there is a strong relationship between deaths and air pollution. There is a higher spread rate in northern Italy, where higher air pollution levels are located (Cartenì et al., 2020). Besides, some studies have found out that drier air facilitates the transmission of the coronavirus. From the perspective of virus propagation, it is more likely to drop down in a humid air environment (Zoran et al., 2020). As coronavirus is an airborne virus, other environmental parameters such as soil and water pollution are limited. Secondly, connectivity is another variable for exposure indicators. Lin et al. (2020) identified the population exchange, especially in Wuhan, China, as a majority influencing factor of the spread. It indicates that the government needs to implement more protection responses in areas with frequent passenger flow like commercial centers, airports, and railway stations. And during the long-term impact of economic shutdowns, the supply chains have been broadly discussed. For instance, the transport restriction induced by border closure in COVID-19 has affected the food supply chains in cities (Pulighe and Lupia, 2020). Napierala et al. (2020) pointed out that the recovery of more internationalized companies in Poland is more complicated, positively related to global conditions. It shows that the more international clients they host, the more impacts they suffer in the outbreak. Overall, the combination of existing low air quality and national/international connectivity nodes contributes to the different degrees of exposure to pandemic vulnerability. These indicators are represented by either quantitative environmental data or relative distribution in grided and point formats.

2.2 SENSITIVITY

Sensitivity indicators cover four categories: social sensitivity, economic sensitivity, infrastructural sensitivity, and biophysical sensitivity. While some indicators are relevant in both short-term and long-term impacts (e.g., people with low household income have limited medical opportunities in the short term and are more sensitive to financial troubles in the long term), most indicators are specific to a certain period.

Social sensitivity is represented by some old social problems exposed in a new light, discussed in developing and developed countries. The focus is mainly on the long-standing issues of social inequalities. There is a growing recognition of the older people as a high-risk population to COVID-19 because of the hypo-immunity, disability of emergency, limited financial resources, and social isolation. As they are the group who is reliant on others for health care and daily living, the 'homestay' measures present a significant challenge to ensure their basic needs. It is also influenced by ethnicity and culture, particularly immigrants, who suffer more from the exposure to the pandemic, limited accessibility to health care, and risk of unemployment. For instance, the death rate of the Black and Latino in New York is double of the White (Wade, 2020). Besides, the poor living in slums with over-high density, lower incomes, and precarious livelihoods are always difficult to contain impacts. In many cities in Global South, the living conditions for the poorest dwellers are even worse than prisoners, making it difficult to mitigate the spread through social distancing (Biswas, 2020). And the poor living conditions further exacerbate the long-term impact of the lack of access to essential services. Last but not least, due to the origin and cross-border spread of the virus, there is increasing discrimination and stigmatization of foreigners, and it increased the sensitivity of the society in social stability and integration (Wade, 2020).

Economic sensitivity indicators are the most salient determinants to the long-term impact, particularly to the threat of economic recession. Migrant workers are the initial vulnerable group affected by a predicted period of recession. Creţan and Light (2020) figured out that in European countries with rising unemployment rates, international employment opportunities decrease accordingly in Western Europe. This recession increases the unemployment of migrant workers. And for different economic structures, it can be expected that the specialized economy is vulnerable. The pattern in Poland shows that cities that rely on tourism, mining, and manufacture are mostly affected by the outbreak (Krzysztofik et al., 2020). Accordingly, they predict that the recovery of these industries is much more challenging. Furthermore, small- and medium-sized businesses are more sensitive to absorb the consequences of pro-longed restrictions and probably end up in bankruptcy.

The transport infrastructure and service accessibility have been considered as critical factors of the spread of the virus. It is proved by the relationship between the population mobility and the pandemic spread in Italy that the density of trips is strongly related to the infectious cases 21 days later (Cartenì et al., 2020). Similar findings are confirmed from another perspective that there is a significant decrease in the reported corona cases following the travel restrictions. Furthermore, many papers focuse on the resilience of various transport modes. There is a substantial relationship between flights and railway services from Wuhan and infected cases in the destination (Zhang et al., 2020). For other transport modes, Teixeira and Lopes (2020) found that the cycling and walking network showed a relatively lower decrease than the subway system, with an increasing shift from subway users to bike-sharers. Therefore, the motorized transportation modes are more vulnerable to the pandemic. The accessibility to health and daily services is a critical issue that requires ethical equity while the pandemic is occurring. The areas with low accessibility are always living places for the poor and marginalized groups, explained in social sensitivity.

There is a lack of quantitative evaluation on the green and open spaces for the spread of COVID-19, but some arguments exist that cities need to increase public spaces for physical distancing and mental health. Providing ample open space can accommodate residents' recreation demands to meet outdoors (Honey-Rosés et al., 2020). And the reconfiguration of green space can also increase the urban greenery that may contribute to urban resilience through an improved environment against other viruses.

2.3 ADAPTIVE CAPACITY

There are many ways to structure the indicators of adaptive capacity (Swart et al., 2020). However, the relationship between some indicators and the available information in a metropolitan and urban scale is weak (e.g., investments made only for specific groups or governance can only play a limited role in the interconnected urban system) or unstable (e.g., testing rates in different municipalities are changing continuously). Therefore, this framework is developed for generic capacity indicators, which are necessary and valid for most populations, areas, and institutions for a long time. Risk awareness is predominantly related to the development of society, regarding the ability to understand, access, and communicate information of the pandemic. For instance, people with low-risk perception and low level of trust in government have been identified by Thoi (2020) as a high-risk population, which makes it challenging to achieve the objectives. Another vulnerable group is people with low educational levels who suffer disproportionately from the disease and the financial troubles related to COVID-19 (Qian and Fan, 2020). Moreover, the response-ability to the pandemic is the other factor of adaptive capacity. Several literature pieces indicate that adequate investment in primary healthcare systems benefits the effective response to the pandemic, including hospital beds, insurance, and social health conditions (Thoi, 2020). Besides, using smart technology is evidenced as a new ability to adapt to major social and economic issues through teleworking, online commerce and education, and telemedicine (Kunzmann, 2020). In contrast, they have also raised another concern about their accessibility and affordability, which requires more attention to the digital divide. Finally, for urban governance, the conflicts between different actors and different levels of governance have been exposed by COVID-19. Fragmented governance and inefficient use of limited resources are blamed for the poor management of the spread in some states in the US (Connolly et al., 2020).

2.4 INDICATORS FOR MEASUREMENT

Periodic outbreaks characterize infectious pandemics, and urban areas are regularly exposed to crises. Therefore, prediction of pandemic vulnerability is necessary to highlight the spatial distribution of major vulnerable sectors and propose strategies for improvement accordingly. This paper provides an introduction to the suggested indicators for qualitative and quantitative evaluation. According to the above literature review of influencing factors, Table 4.2.2 explains indicators to measure pandemic vulnerability in a particular context.

Since the indicators affect different aspects, their data collection and measurement methods should be adjusted accordingly. Indicators in space are factors related to the spatial characteristics and traffic accessibility, whose measurement method of vulnerability is determined according to the distance. Indicators in social groups represent the vulnerable people, so their spatial distribution in urban areas should be focused through the density of concentration. Indicators in institutions are based on various administrative regions instead of specific sites, which should be calculated in municipalities to discuss the vulnerability in different levels. Besides, as adaptive capacity is the only one components with positive impact on pandemic vulnerability, more vulnerable means more exposure, more sensitivity, and less adaptive capacity.

ASPECT	FACTOR/INDICATOR	MORE VULNERABLE	LESS VULNERABLE
		MORE EXPOSURE	LESS EXPOSURE
SPACE	air pollution (NO2/PM2.5)	high concentration of air pollutants	low concentration of air pollutants
	air dryness	low air humidity	high air humidity
	import/ export nodes	close to port, airport, etc.	far from port, airport, etc.
SOCIAL GROUP	daily passengers	more frequent commutes	less frequent commutes
INSTITUTIONS	delivery system	congested and dense	streamlined and organized
	international corporations	many global firms depending on trade	few global firms
		MORE SENSITIVITY	LESS SENSITIVITY
SPACE	residential density	high residential density	low residential density
	traffic density	high traffic density	low traffic density
	hospital accessibility	close to hospital, clinic, etc.	far from hospital, clinic, etc.
	amenity accessibility	close to market, activity center, etc.	far from market, activity center, etc.
	open space	close to park, playground, etc.	far from park, playground, etc.
	green space	close to garden, nature, etc.	far from garden, nature, etc.
SOCIAL GROUP	age distribution	older than 60/65	younger than 60/65
	immigrants	unstable short-term migration	stable long-term migration
	discriminated foreigners	Asian, non-EU people, etc.	EU people, Dutch, etc.
	household income	low average household income	high average household income
	migrant workers	daily national/international commuting	close to working place
	motorized dependency	car drivers, public traffic travelers, etc.	bicycle users, walkers, etc.
INSTITUTIONS	tourism/mining/ manufacture	congested and dense	streamlined and organized
	small-sized businesses	many global firms depending on trade	few global firms
		LESS ADAPTIVE CAPACITY	MORE ADAPTIVE CAPACITY
SPACE	hospital beds	residential areas with fewer beds	residential areas with more beds
SOCIAL GROUP	risk perception	low pandemic perception	high pandemic perception
	education	low education level	high education level
	insurance	uncovered by insurance	covered by insurance
	healthy	bad health condition	good health condition
	ability to use technology	new to using technology	skilled use of technology
INSTITUTIONS	government trust	low trusted, conflict tradition	high trusted, consensus tradition
	government integration	fragmented political structure	integrated political structure
	government efficiency	low working/reacting efficiency	high working/reacting efficiency

Table 4.2.2 Measurement of pandemic vulnerability indicators.

3 EXTERNAL DRIVERS

The first external reason for pandemic vulnerability in MRA is its high globalization. It is a region hyper-connected with the world. The Amsterdam Schiphol Airport and Amsterdam Port are gateways for not only the region but the Netherlands through constant shifting information and capital streams (Jong, 2006). Compared with airports in other metropolitan regions, Schiphol Airport is the main node, whose aircraft movements, commercial passengers, and commercial cargo are increasing in the lead (Fig. 4.3.1). As a result, MRA is more tightly linked to other countries and regions in Europe than any other metropolitan area in the Netherlands, leaving it more exposed to virus transmission (Fig. 4.3.2). Frequent population, economic, material links and flows not only enable the virus to spread more rapidly across borders, but also make the economy and society of MRA relevant to the global environment.

Fig. 4.3.1 Flights in the three biggest Dutch airports from 2010 to 2019. Illustrated by author based on CBS.

10,000 local flights

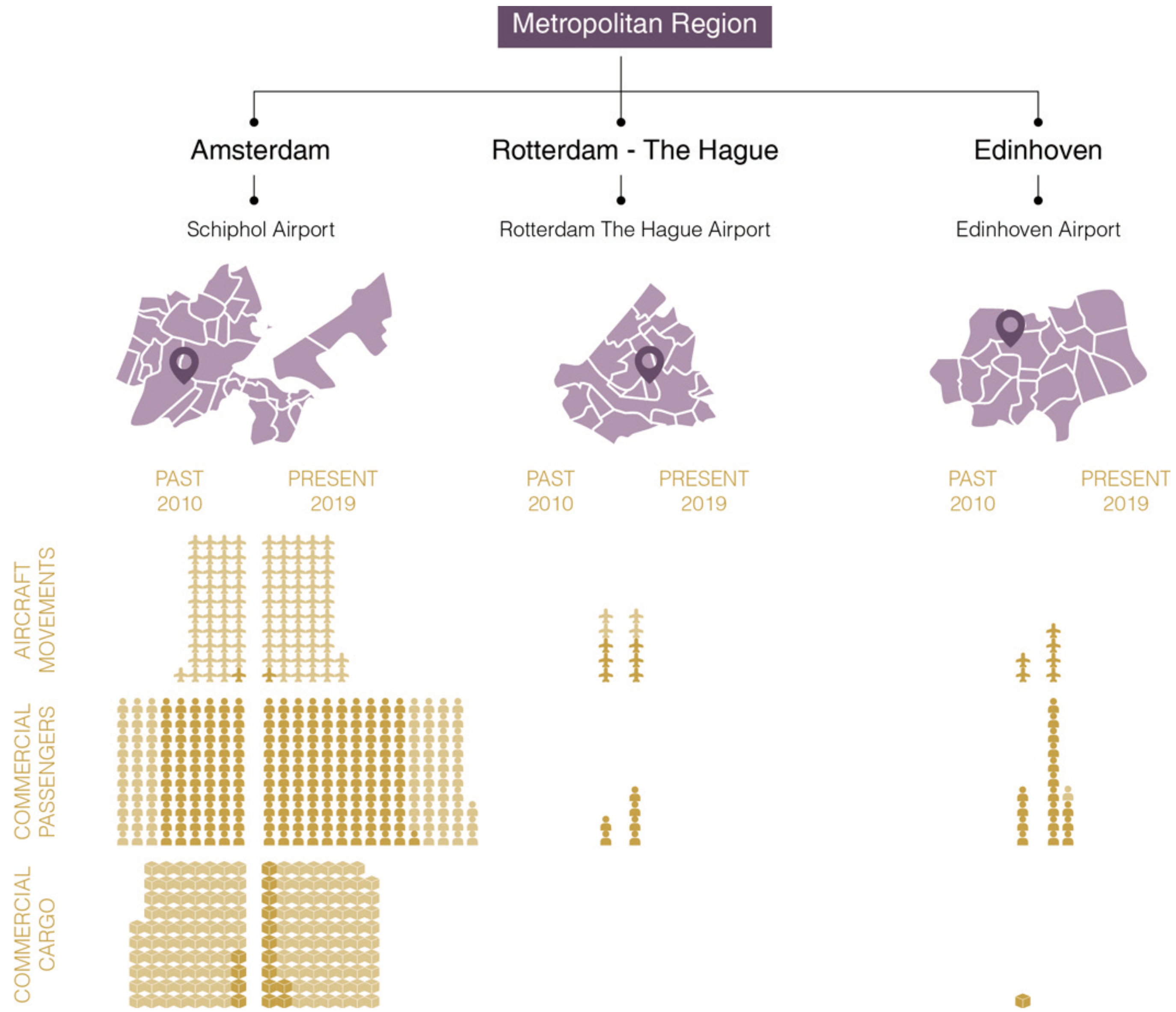
10,000 cross-country flights

500,000 European passengers

500,000 intercontinental passengers

20,000-ton European cargo

20,000-ton intercontinental cargo



3.1 GLOBALIZATION

Fig. 4.3.2 Direct flights from Amsterdam (Schiphol Airport) to other European countries. Illustrated by author based on FightConnections.

>50 direct destinations

<50 dirence destinations

0 500 km

N

3.2 POPULATION

The population in MRA has grown by an average of 11,000 a year over the past five years, of which half have been immigrants (CBS, 2017). According to the figures from Statistics Netherlands, the domestic immigrant population in the last two years has been negative, which means that half of the population growth has come from other countries. Fig. 4.3.3 shows that the immigrants are unevenly distributed in different cities. Relatively, most of the immigrant population live in cities in MRA, like the city of Amsterdam, Diemen, Almere, and Leystad. Nearly one-third of people in Amsterdam come from non-western foreign countries until 2019 (Fig. 4.3.4).

However, both the experience from previous crises and the impact of the current pandemic suggest that COVID-19 has a major impact on both migrants and people with migrant backgrounds. For example, due to certain factors of instability, frequent travel of migrants to different countries and cities greatly increases the possibility of disease, and they are also the most vulnerable to the impact of prevention measures such as lockdown (OECD, 2020). Studies in several countries have found that cities with more migrants tend to have higher coping risks than smaller, closed ones to the pandemic (OECD, 2020).

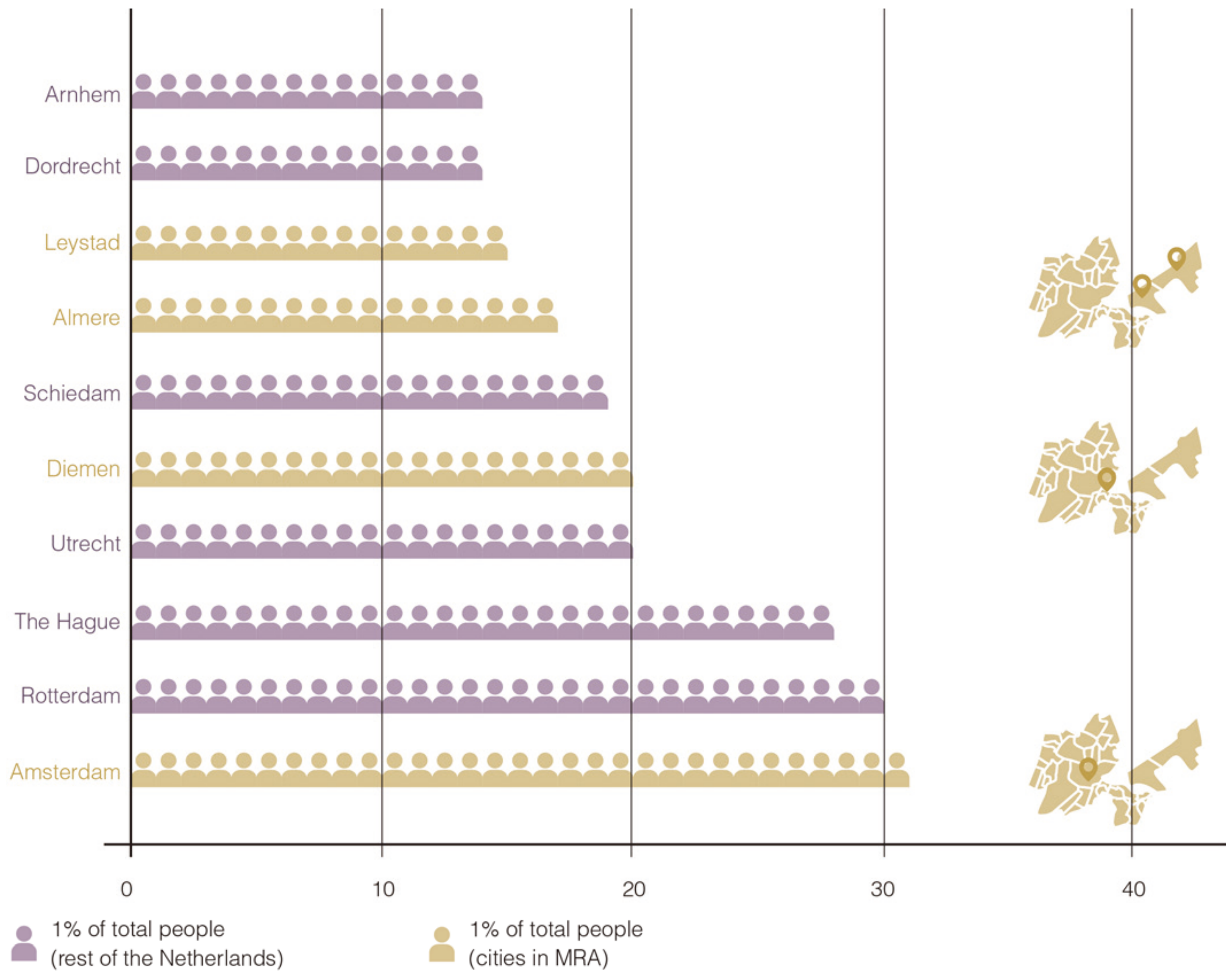


Fig. 4.3.3 Top ten municipalities with the largest proportion of non-western immigrants, 2012. Illustrated by author based on CBS.

Fig. 4.3.4 Migration per municipalities, 2019. Illustrated by author based on data source: CBS.

4. REGIONAL MEASUREMENT

4.1 EXPOSURE

According to the theoretical framework, pandemic vulnerability is affected by three components: exposure, sensitivity, and adaptive capacity, whose indicators are measuring tools to cumulate impact of different aspects. Therefore, available data from the government has been used in the MRA to create a risk index of urban vulnerability to pandemic. It can be regarded as a tool for various actors, like policymakers in MRA to highlight neighborhoods with different types of vulnerability as focus areas to improve through different strategies.

Exposure consists of environment and flow, where as many indicators should be included as possible. For the scope of MRA, 5 parameters are finally chosen: air pollution, air dryness, import/export nodes, daily passengers, and international corporations (Fig.4.4.1). And for better quantification, each indicator is concretized into a kind of representative data, which then is transformed into mapping from Fig 4.4.2 to Fig. 4.4.6.

MRA is one of the biggest metropolitan areas in the Netherlands, and maps of exposure shows how the region, especially Amsterdam city is highly developed and exposed to pandemic risks. Most of the air pollutant, daily passengers, international corporations are located in the city center. It is also relatively close to the Amsterdam Port and Schiphol Airport. The city of Amsterdam has a more direct connection with the global network. Therefore, it should be in a higher risk of exposure, although the air humidity is better in the city center due to a dense water network.

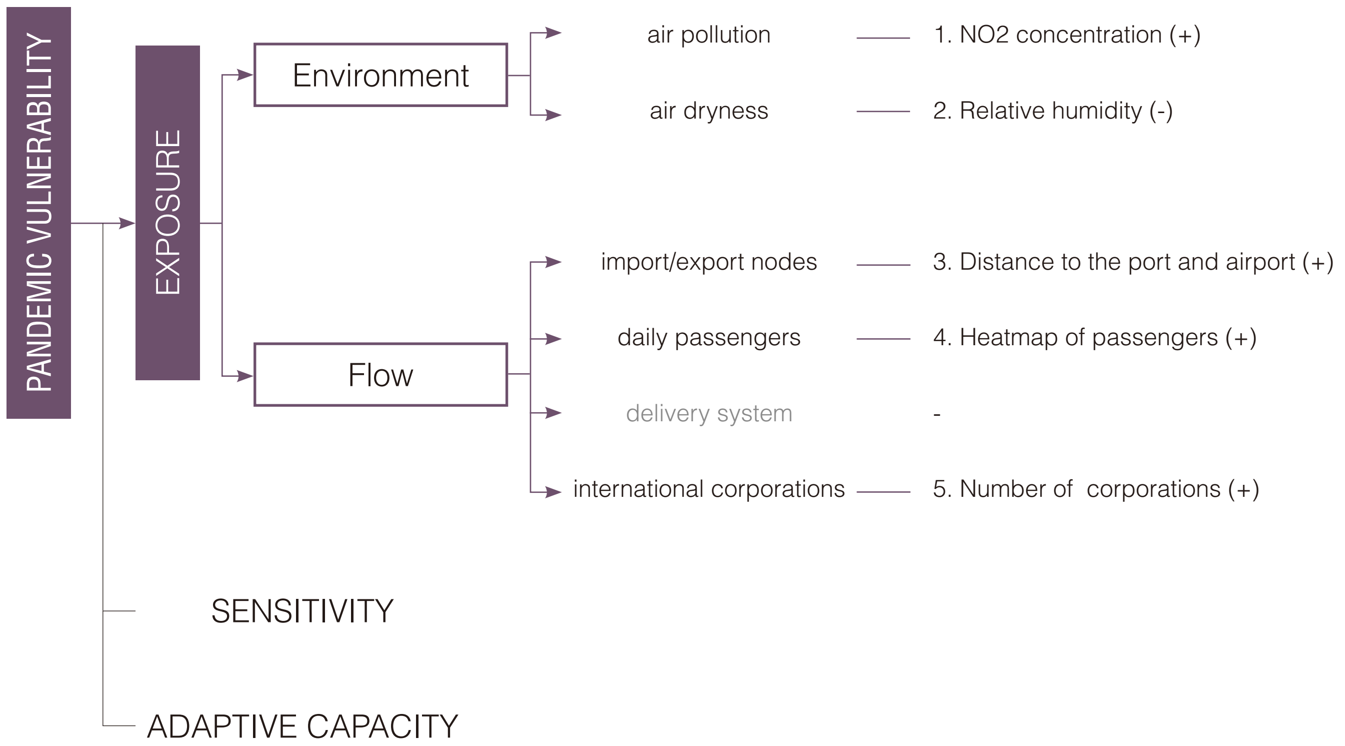


Fig. 4.4.1 Available indicators of exposure in pandemic vulnerability ("+" negative impact; "-" positive impact). Made by author.

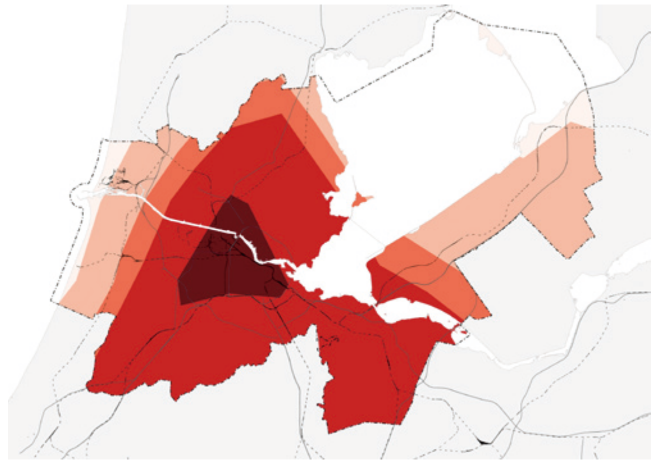


Fig. 4.4.2 Air pollution: NO2 concentration (ug/m3), 17:00 27.11.2020. Illustrated by author based on Meteobule.

20 30 40 50 60

Fig. 4.4.5 Daily passengers: Heatmap of railway stations weight by passengers. Illustrated by author data based on CBS.

5 4 3 2 1

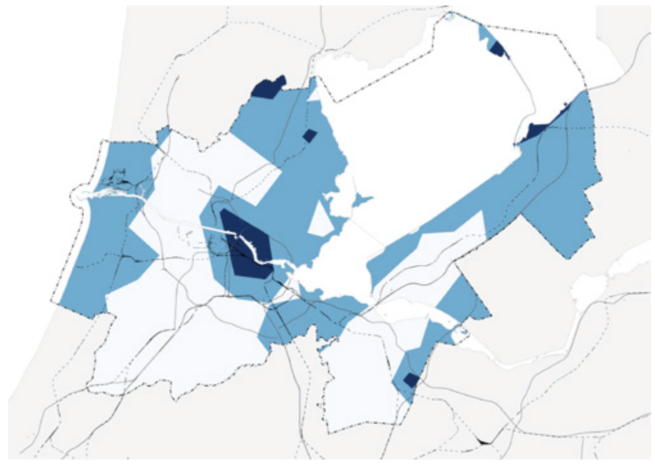


Fig. 4.4.3 Air dryness: Relative humidity (%), 17:00 27.11.2020. Illustrated by author based on Meteobule.

75 80 85

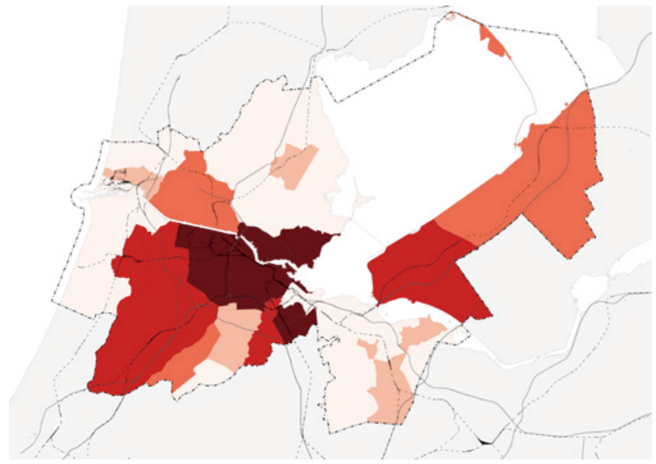


Fig. 4.4.6 International connection: Number of international corporations, 2015. Illustrated by author based on OSM.

0-2 2-7 7-15 15-50 50+

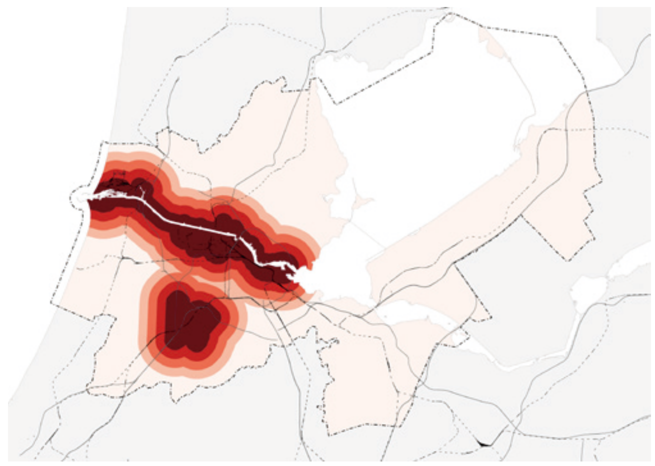


Fig. 4.4.4 Import/export: Distance to port and airport(m). Illustrated by author based on OSM.

8000+ 6000-8000 4000-6000 2000-4000 0-2000

The resulting map of exposure is calculated through a raster analysis. Firstly, each layer should be acquired and clipped or expanded into the extent of MRA in raster layers. Then, the values for each indicator had to be normalized to ensure meaningful comparisons and calculations among them. Calculations with each layer could be done to make them count equally. In this project, since there are no more references, all parameters have the same weight in the calculation of MRA. Finally, the following average formula was used in the raster calculator through QGIS to create the risk index map for exposure:

Exposure Index= (air pollution- air dryness+ import/export nodes+ daily passengers+ international corporations)/ 5

By adding some geographical context, like the built areas, water, green land, Fig. 4.4.7 shows the final map of exposure more comprehensible. As previously speculated, Amsterdam is the city with the highest risk index, among which Amsterdam Centraal, Westpoort, and Schiphol Airport are more exposed to the pandemic. It is similar to the political focus from institutions that railway stations, the port, and the airport are the main entrance of the virus. It can be seen as a support for measures decreasing exposure, such as increase detection and lockdown concentrated in these areas. Comparing with Amsterdam, some remote areas like Lelystad are low exposed to COVID-19. It is the reason why these cities tend to be affected later in both physical problems and the economic crisis.

Fig. 4.4.7 Risk index of exposure in MRA. Made by author.

Risk hierarchy

1 - border
2 - highway
3 - railway
4 - rural area
5 - water

0 10 km
N

4.2 SENSITIVITY

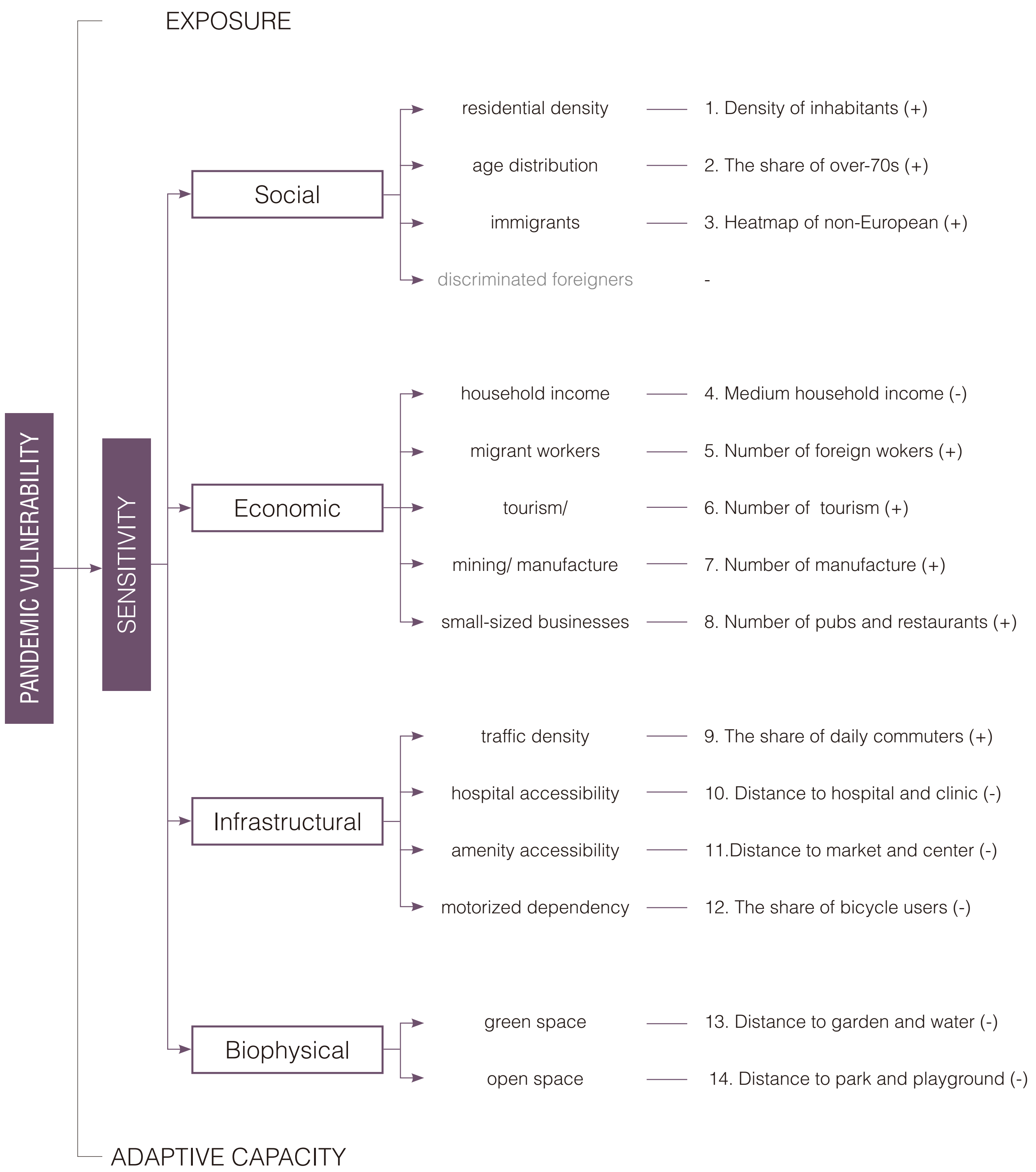
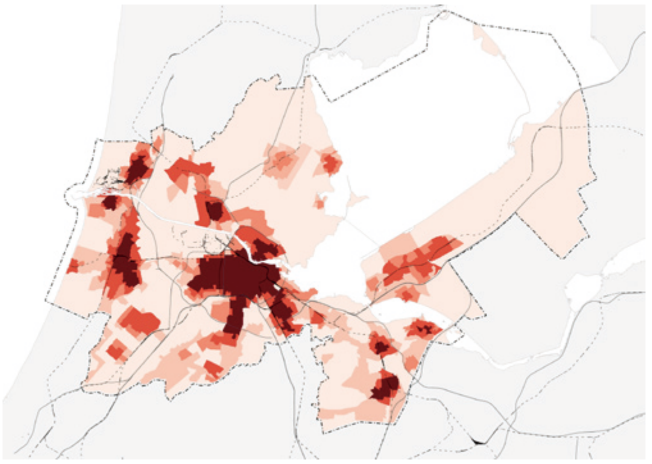


Fig. 4.4.8 Available indicators of sensitivity in pandemic vulnerability ("+" negative impact; "-" positive impact). Made by author.

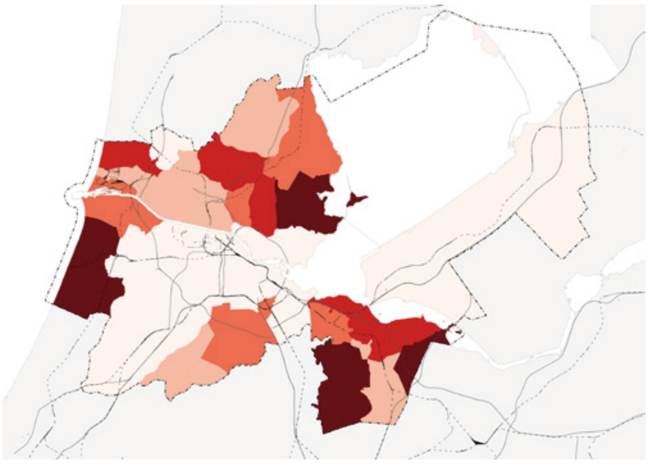
Similar to the analysis of exposure, sensitivity has four aspects: social sensitivity, economic sensitivity, infrastructural sensitivity, and biophysical sensitivity (Fig. 4.4.8). These four influence categories have the same weight, whose respective index number differs greatly. For example, recent studies on COVID-19 have focused on the economic impact of the vulnerability, while biophysical factors have been less studied, so there are fewer measurable indicators for the latter two. To narrow the bias caused by limitation, different from the calculation of exposure, the analysis of sensitivity is divided into four parts related to different aspects of firstly. Then, the final resulting map could be the average of these four to a more meaningful conclusion.

The 14 indicators have been transformed into available data except for discriminated foreigners, which can be seen as the same result of non-European immigrants in the context of COVID-19 in the Netherlands. There are 7 negative indicators (residential density, age distribution, immigrants, migrant workers, tourism, mining/ manufacture, small-sized business, traffic density) and 7 positive indicators (household income, hospital accessibility, amenity accessibility, motorized dependency, green space, open space). It means that for negative indicators, there was a positive correlation between regional sensitivity and index and vice versa. Therefore, they need to be added or subtracted in exactly the opposite way for the final resulting map to be calculated. To make the final result positive to observe easily, the project added the factors with a negative impact on the site and subtracted those with a positive impact, so the higher the final score, the higher the sensitivity.



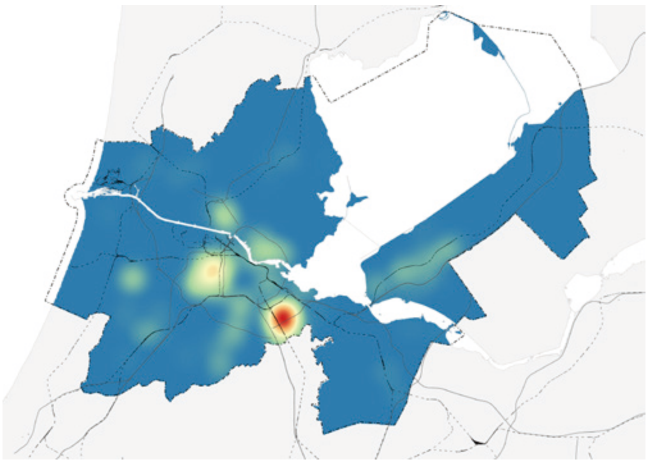
0-500 | 500-1000 | 1000-1500 | 1500-2500 | 2500+

Fig. 4.4.9 Residential density: Inhabitants per 10,000 m2, 2018. Illustrated by author based on Pdok.



6-12 | 12-14 | 14-16 | 16-18 | 18-24

Fig. 4.4.10 Age distribution: The share of over-70s in the total population (%), 2019. Illustrated by author based on CBS.



80+ | 60-80 | 40-60 | 20-40 | 0-20

Fig. 4.4.11 Immigrants: Heatmap of people of non-EU foreign origin (%), 2014. Illustrated by author based on Sleutjes, et al..

4.2.1 Social sensitivity

For social sensitivity, 3 indicators are included: residential density, the age distribution of over-70s people, and immigrants with a non-EU background (Fig. 4.4.9-4.4.11). Comparing the three maps, there is an interesting phenomenon: the city center has large areas of high-density living, but residents there tend to be younger and more localized. Older people and immigrants are more likely to live in areas around Amsterdam with lower housing prices, such as Amsterdam Zuidoost and Amstelveen.

Similar to the calculation of exposure, the result of social sensitivity is calculated through normalized raster analysis by the following average formula (Fig. 4.4.12):

Social Sensitivity Index= (residential density+ age distribution+ immigrants)/3

The risk index of social sensitivity represents the same conclusion: except Westpoort without residential areas, the periphery of Amsterdam city has higher social sensitivity than the city center, like Amsterdam Nieuw-West, Amsterdam Zuidoost, and Amstelveen. In addition, some surrounding cities have also begun to show social sensitivities due to continuous construction. Unlike Amsterdam city, they tend to be more sensitive in the center than in the periphery because of the higher density concentration and the increasing number of young people moving to the suburbs. Some newly built areas like Almere and Lelystad are more socially resilient than others with lower density, more young people, and domestic residents.

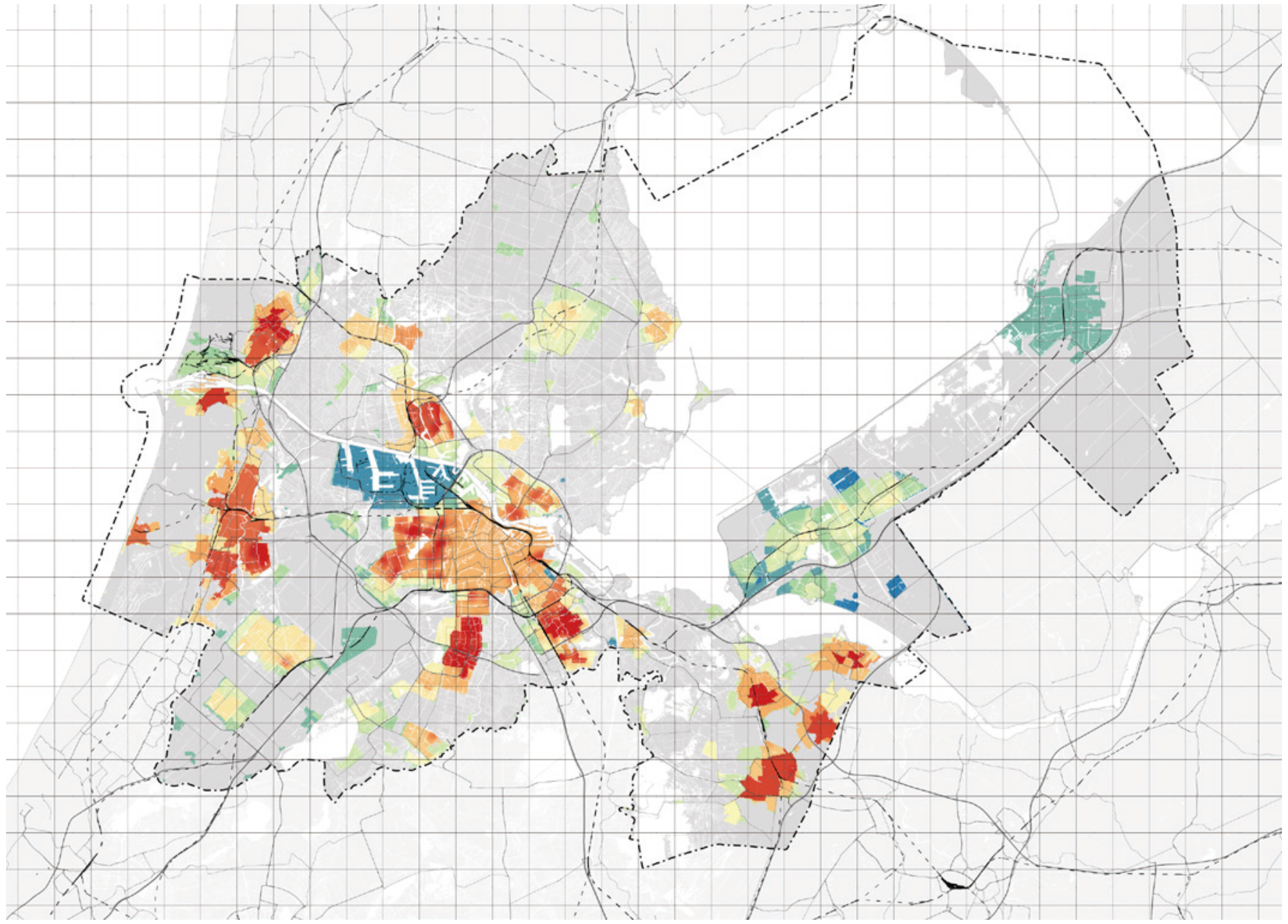


Fig. 4.4.12 Risk index of social sensitivity in MRA. Made by author.

Risk hierarchy

1 | 2 | 3 | 4 | 5

border | railway | water | highway | rural area

0 10 km

N

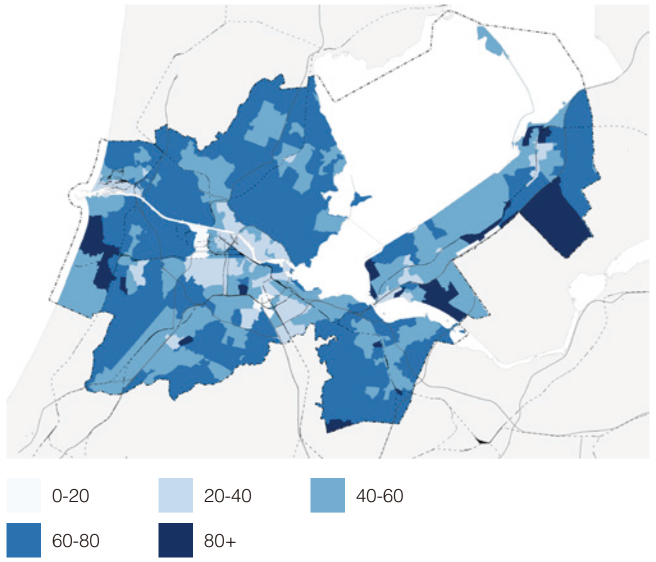


Fig. 4.4.13 Household income: Median household income per day. Illustrated by author based on Pdok.

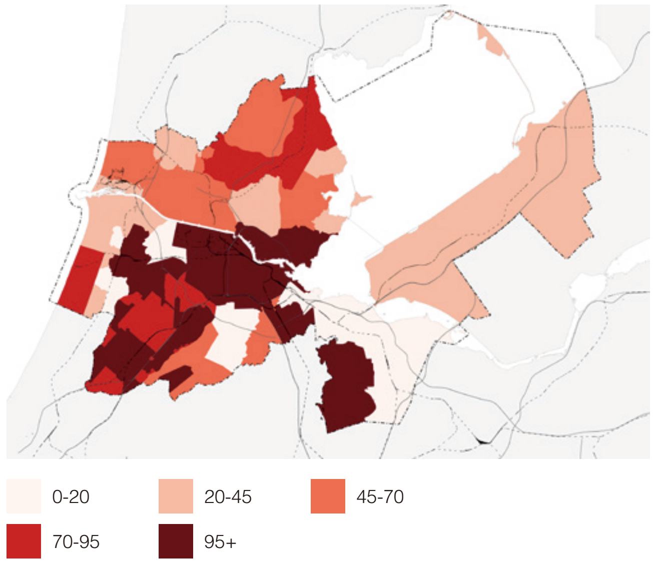


Fig. 4.4.14 Tourism industry: Tourism related companies per municipalities, 2018. Illustrated by author based on OPM.

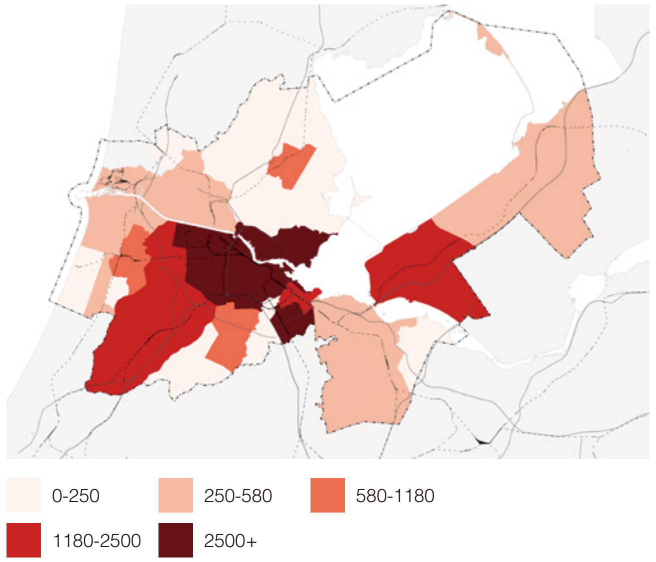


Fig. 4.4.15 Migrant workers: The number of foreign workers per municipalities, 2018. Illustrated by author based on CBS.

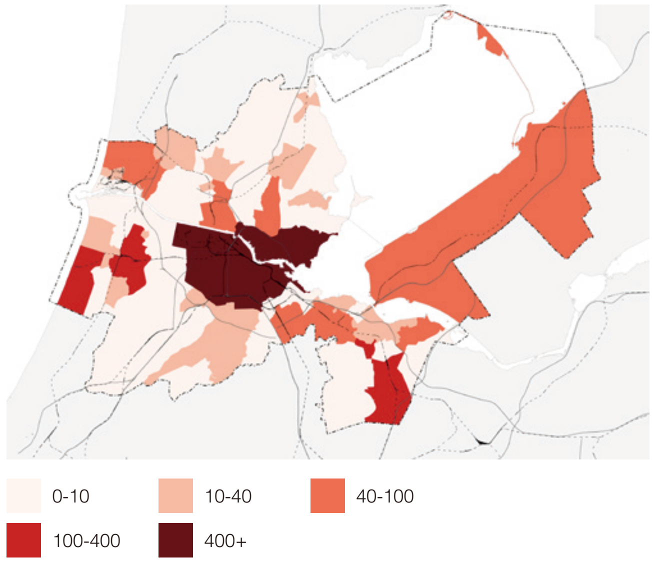


Fig. 4.4.16 Manufacture industry: Manufacture related companies per municipalities, 2018. Illustrated by author based on OPM.

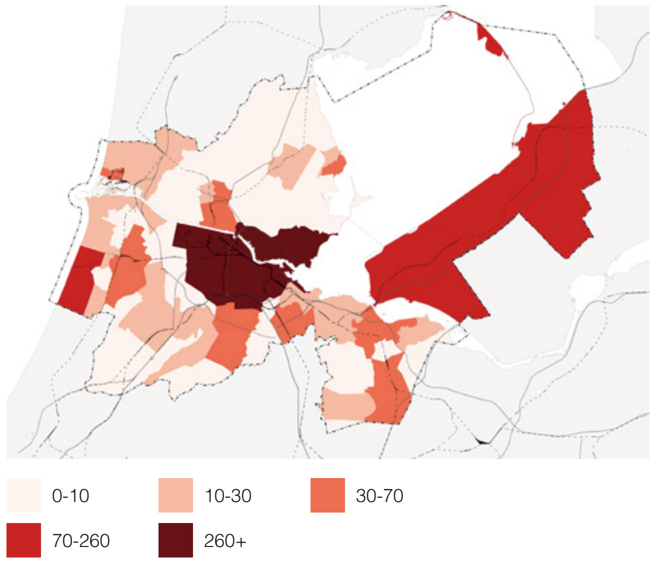


Fig. 4.4.17 Small-sized companies: Small-sized companies per municipalities, 2018. Illustrated by author based on OPM.

4.1.2 Economic sensitivity

For economic sensitivity, there are 5 indicators: household income, the tourism industry, migrant workers from foreign countries, the manufacturing industry, and small-sized companies (Fig. 4.4.13-4.4.17). Maps of various economic industries show that Amsterdam city is the most developed area with mixed and abundant companies for different economic activities. However, on the one hand, the highly related economy on tourism, manufacture, migrant workers, and small-sized companies has linked the city closely with the international economy; on the other hand, it makes the economy of Amsterdam vulnerable to the impact of the global situation. Meanwhile, Fig 4.4.13 shows that the majority of residents in Amsterdam city are low-income workers, which means they are more sensitive to the economic recession. Therefore, the result of economic sensitivity is the raster average of normalized indicators by the following formula (Fig. 4.4.18):

Economic Sensitivity Index= (-household income+ migrant workers+ tourism+ manufacture+ small-sized businesses)/5

The resulting map represents the same that Amsterdam is more sensitive in the economy. Amsterdam Zuidoost, Zaandam, Haarlem, and Almere are also sensitive while better than Amsterdam. Amsterdam Zuidoost and Haarlem are municipalities that are dominated by tourism, and there are more residents with low income living in Amsterdam Zuidoost. Zaandam and Almere have more manufacturing industries and small-sized businesses. In each of these cities, there are small groups of poor people living in neighborhoods that have become more sensitive areas.

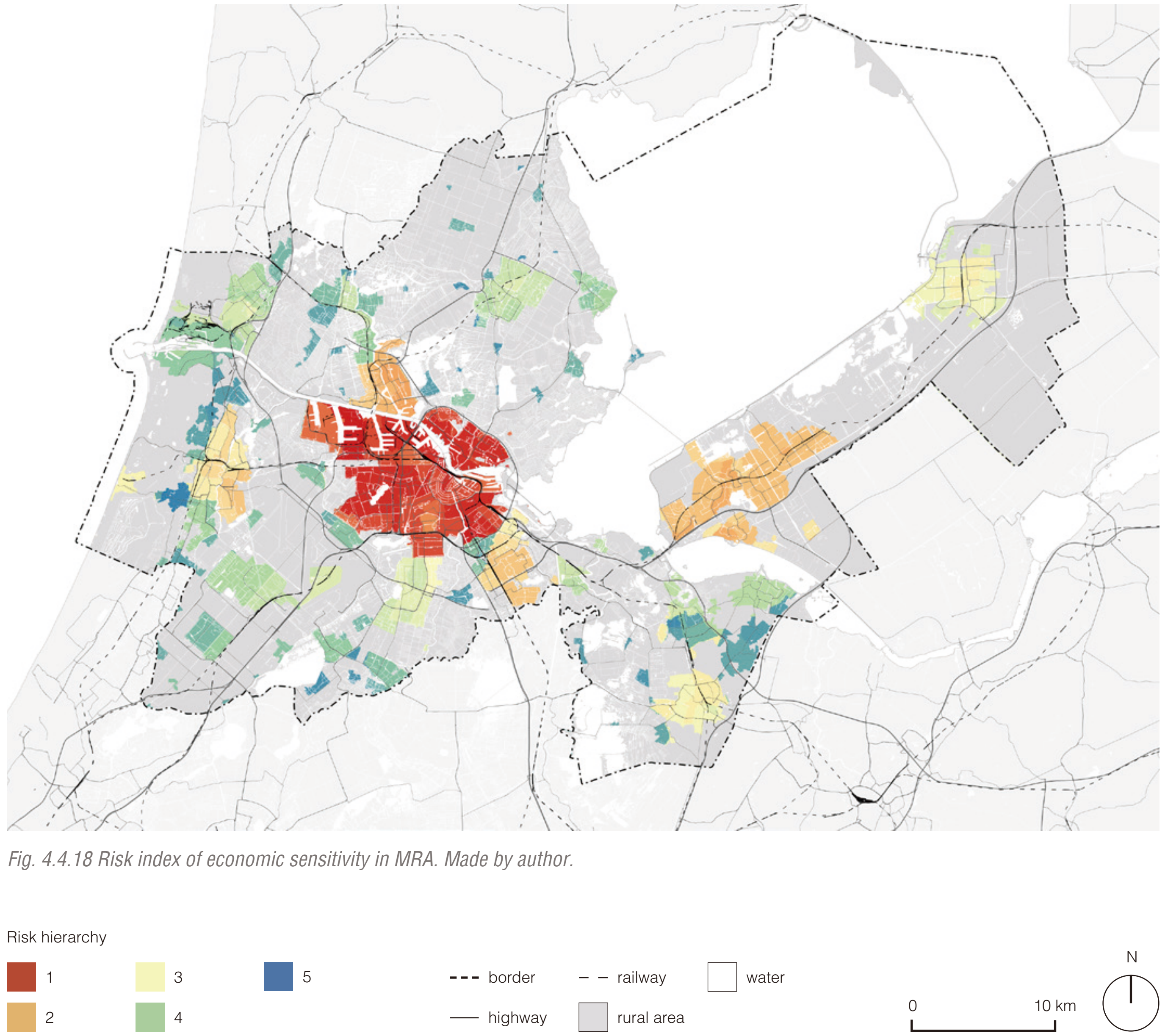


Fig. 4.4.18 Risk index of economic sensitivity in MRA. Made by author.

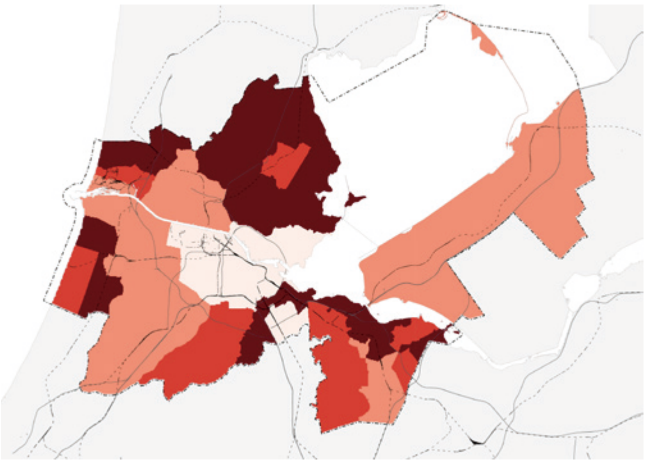


Fig. 4.4.19 Traffic density: The share of daily commuters per municipalities (%), 2019. Illustrated by author based on CBS.

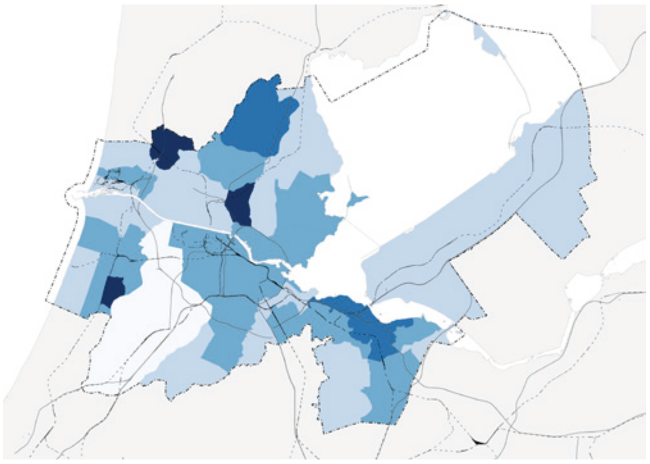


Fig. 4.4.20 Motorized dependency: the share of bicycle users in the total population (%), 2015. Illustrated by author based on CBS.

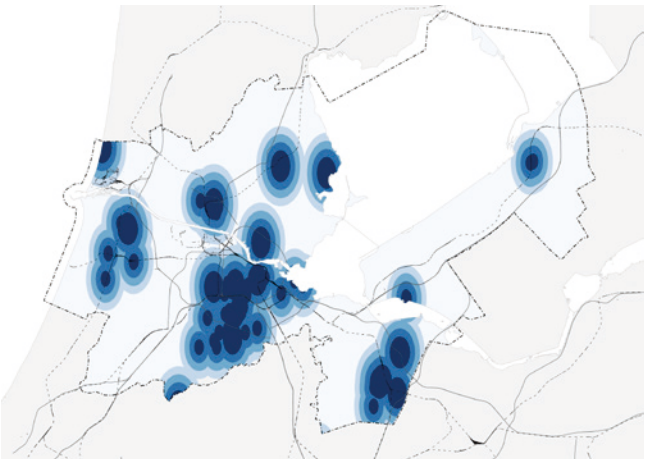


Fig. 4.4.21 Hospital accessibility: Distance to hospital and clinic by weight (m). Illustrated by author based on OPM.

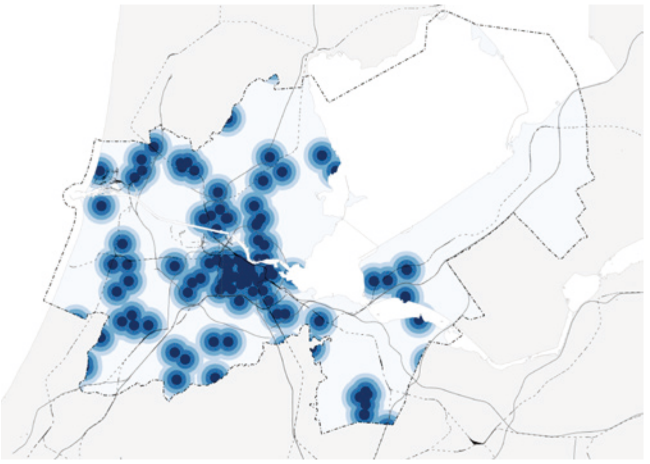


Fig. 4.4.22 Amenity accessibility: Distance to market and community center (m). Illustrated by author based on OPM.

4.1.3 Infrastructural sensitivity

For infrastructural sensitivity, this study includes 4 indicators: traffic density represented by the share of daily commuters, motorized dependency represented by the share of bicycle users, hospital accessibility, and amenity accessibility (Fig. 4.4.19-4.4.22). The majority of infrastructural factors are positive to sensitivity, which is concentrated in big cities, where most residents prefer to use bicycles for their daily life. Besides, as seen from the map, most of the people who commute across municipalities live in cities other than Amsterdam.

Then, the result of infrastructural sensitivity is the raster analysis of normalized indicators by the following average formula (Fig. 4.4.23):

Infrastructural Sensitivity Index= (traffic density- hospital accessibility- amenity accessibility- bicycle dependency)/4

Therefore, contrary to the former analysis, the bigger cities are mostly less sensitive in infrastructure. Compared with the overlayed infrastructure transportation network, it can be found that the denser the highway and railway transportation network is, the more resilient the infrastructure is generally. Amsterdam city and Zaandam have better infrastructure conditions in MRA, while some suburban areas like Bussum in the southeast are in a higher risk hierarchy of infrastructural sensitivity.

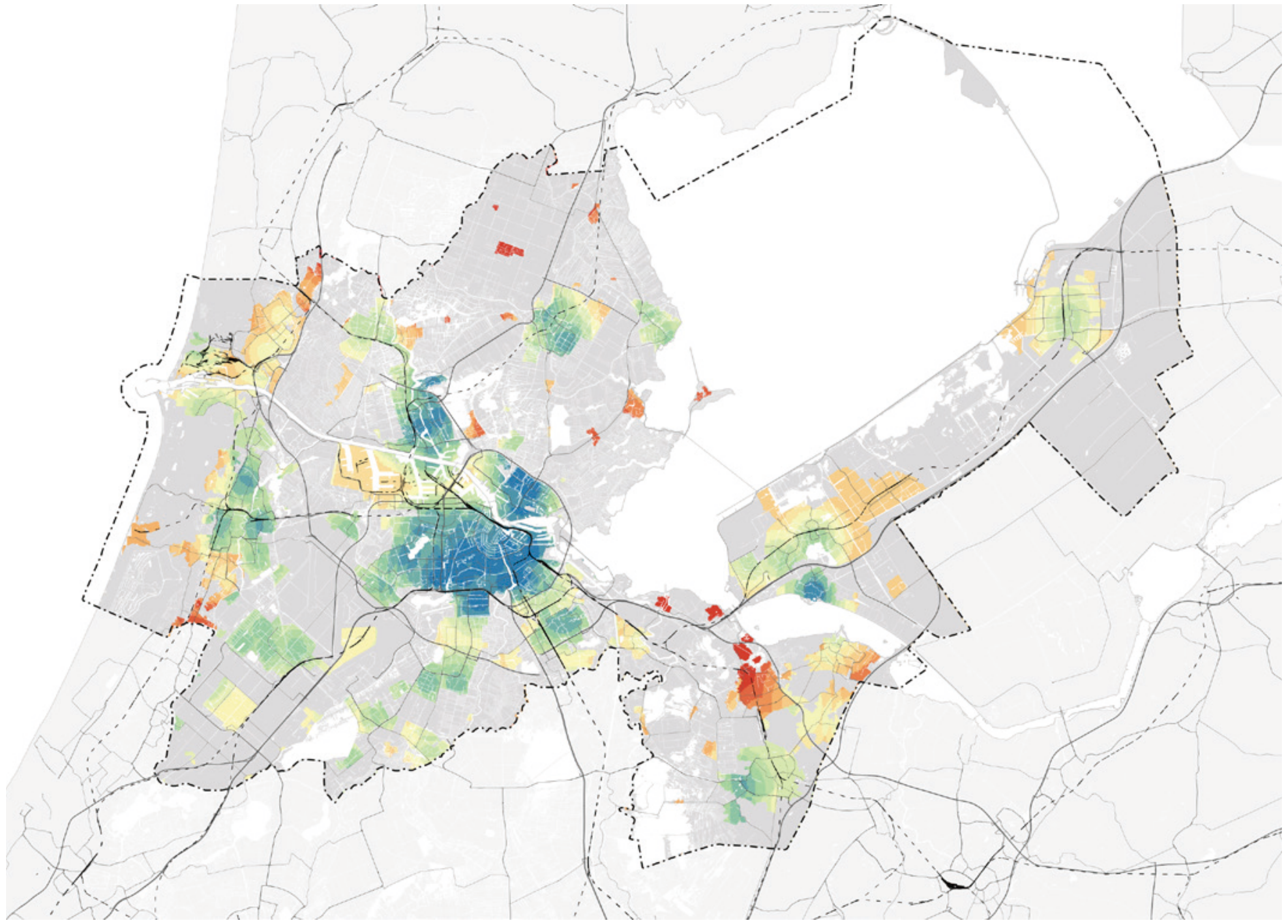


Fig. 4.4.23 Risk index of infrastructural sensitivity in MRA. Made by author.

4.1.4 Biophysical sensitivity

For biophysical sensitivity, there are only 2 indicators included: green and blue space accessibility, playground, and plaza accessibility (Fig. 4.4.24-4.4.25). These two indicators are also positive factors for sensitivity. Maps show that the biophysical condition in most cities are well developed that residents in MRA can reach green and open space within 4000 meters.

Therefore, the result of biophysical sensitivity is the raster analysis of normalized indicators by the following average formula (Fig. 4.4.26):

Biophysical Sensitivity Index= (-green space accessibility-open space accessibility)/2

The resulting map highlighted the most sensitive areas in biophysics, such as Westpoort and Schiphol Airport, which are not residential areas for living. It means that the biological environment of MRA is better, which can reduce their sensitivity to a certain extent. Especially the city of Amsterdam, the concentrated green space and open space in the city can provide more opportunities for inhabitants to keep healthy both physical and mental. Thus, they can better protect themselves from Coronavirus during the pandemic and maintain a positive life attitude at the same time.

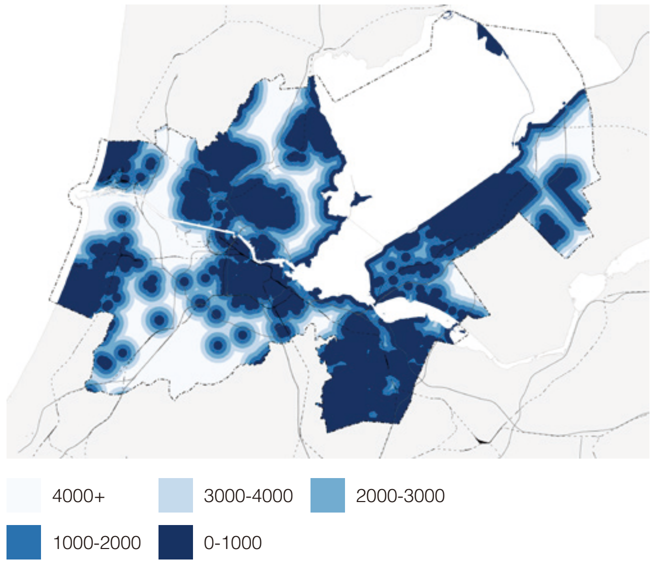


Fig. 4.4.24. Green space accessibility: Distance to green and blue (m). Illustrated by author based on OPM.

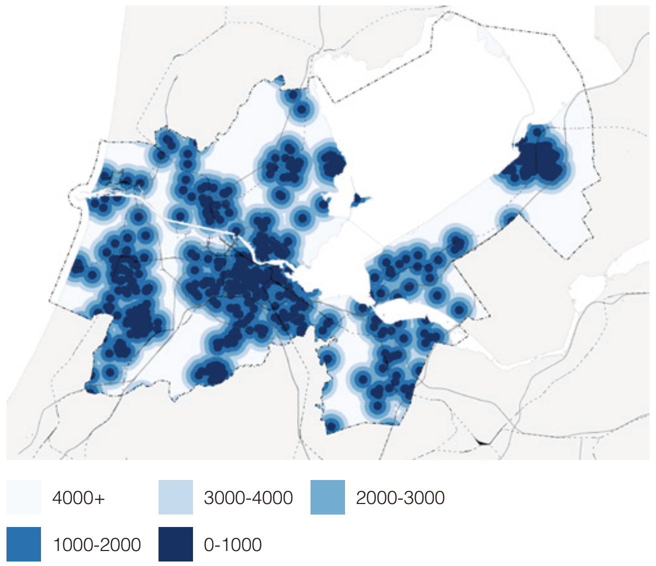


Fig. 4.4.25. Open space accessibility: Distance to playground and plaza (m). Illustrated by author based on OPM.

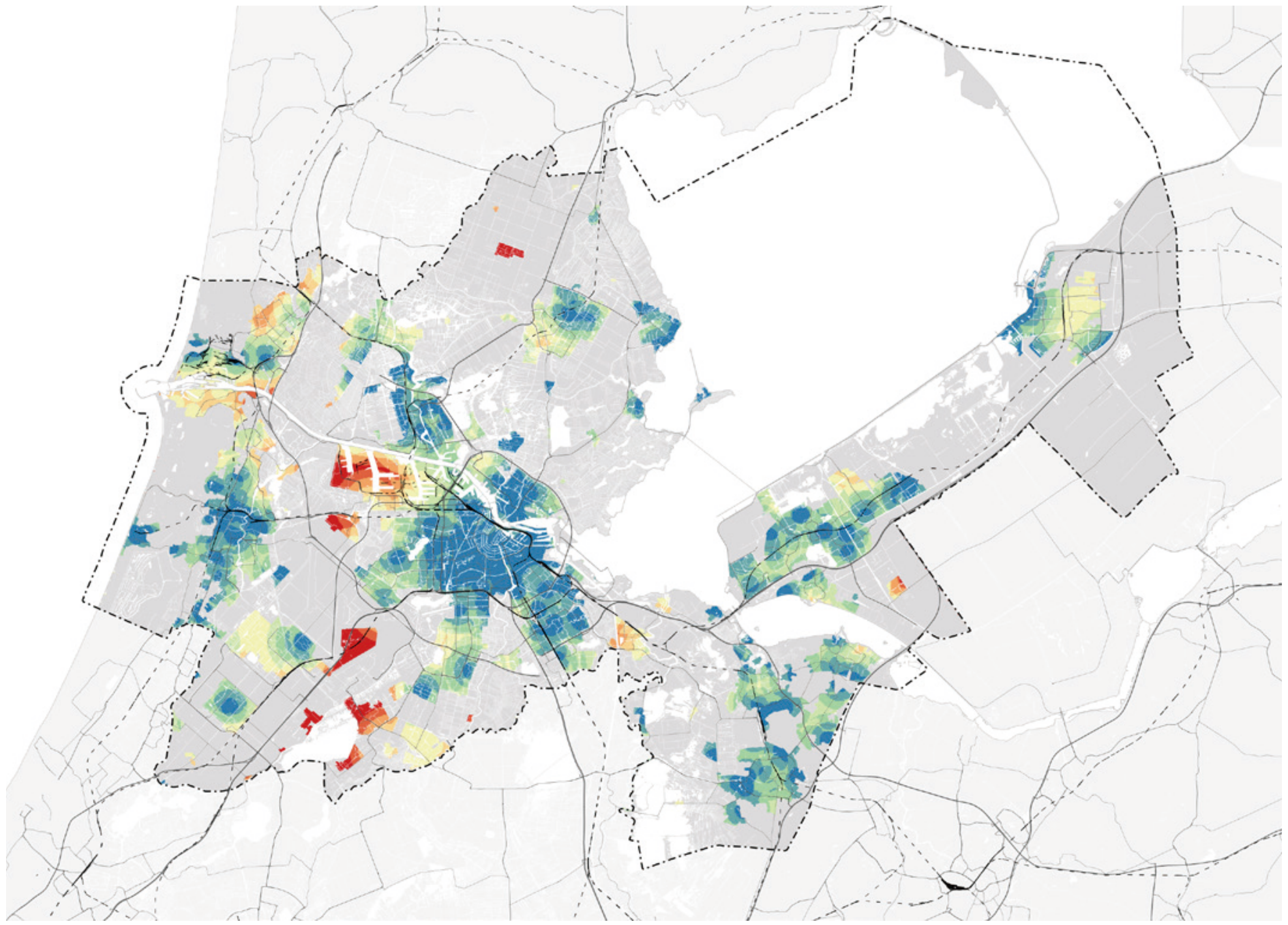
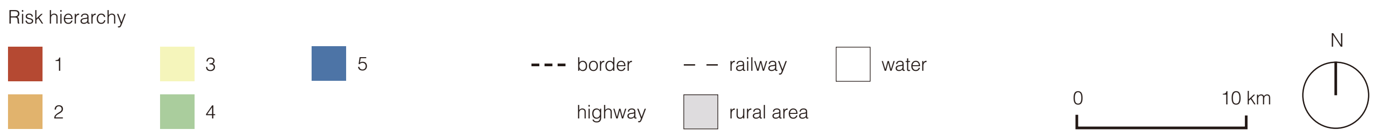


Fig. 4.4.26. Risk index of biophysical sensitivity in MRA. Made by author.



The final map of sensitivity is calculated as the average of the former 4 maps: social sensitivity, economic sensitivity, infrastructural sensitivity, and biophysical sensitivity. These raster layers have been adjusted to a proper extent with normalized values for calculation. Therefore, the raster calculation can be done with the same weight through the following average formula in QGIS to create the final risk index map for sensitivity:

Sensitivity Index= (social sensitivity+ economic sensitivity+ infrastructural sensitivity+ biophysical sensitivity)/4

Fig. 4.4.24 finally shows the map of sensitivity with water, infrastructure network, urban areas, etc. The map shows that the most sensitive area is Westpoort, the Amsterdam port, which is a center of factories, manufacture with low public facilities accessibility. Several neighborhoods in the periphery of Amsterdam are also sensitive. For example, Geuzenveld in Amsterdam Nieuw-West is home to sensitive groups of immigrants, who has low income and high dependency on public transportation for commuting. The residential areas with the richer people represent lower sensitivity to the pandemic. Badhoevedorp, Volendam, and Nieuw-Loosdrecht are all elite communities. Wealthy people move from urban centers to suburbs like these, and often their second homes here can be a good way to escape the virus for remote working. They live in a better environment with more open space and green space, which also helps to improve their resistance.

Fig. 4.4.27 Risk index of sensitivity in MRA. Made by author.

Risk hierarchy

- 1
- 2
- 3
- 4
- 5

- border
- highway
- railway
- rural area
- water

0 10 km

N

4.3 ADAPTIVE CAPACITY

The analytical framework of adaptive capacity consists of two aspects: awareness and ability (Fig. 4.4.28). Since most of the data is obtained on the urban or regional scale, it is difficult to scale down to the local scale with limited comparability. Therefore, the six factors in the final framework are included: the share of tertiary education, government trust in House of Representatives, hospital beds, the share of mortality represented health, the density of WIFI represented the ability to use technology, and government economic activities for efficiency.

Similar to the infrastructural and biophysical sensitivity, the indicators of adaptive capacity are mostly positive to pandemic vulnerability. To separate them for different calculations, the positive maps were shown in blue, while the negative ones were shown in red (Fig. 4.4.29- 4.4.34). The maps suggest that the Amsterdam city should be more adaptable. It is because residents there are better educated, healthy, and able to use technology, and the Amsterdam government is more reliable and efficient. However, the average level of hospital beds is significantly lower in Amsterdam, possibly due to the overpopulation, which may also reduce its ability to withstand the pandemic to some extent.

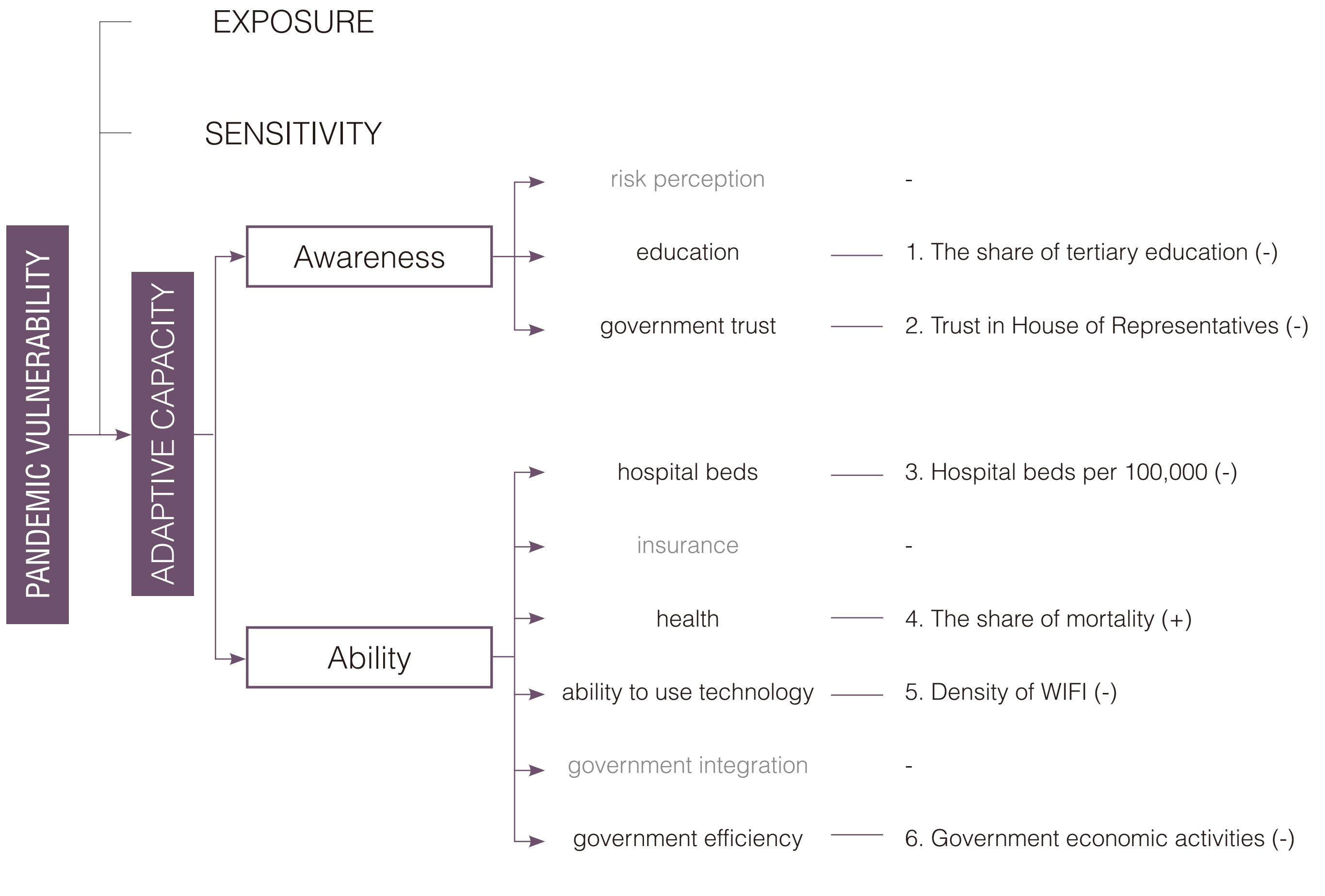


Fig. 4.4.28 Available indicators of adaptive capacity in pandemic vulnerability ("+" negative impact; "-" positive impact). Made by author.

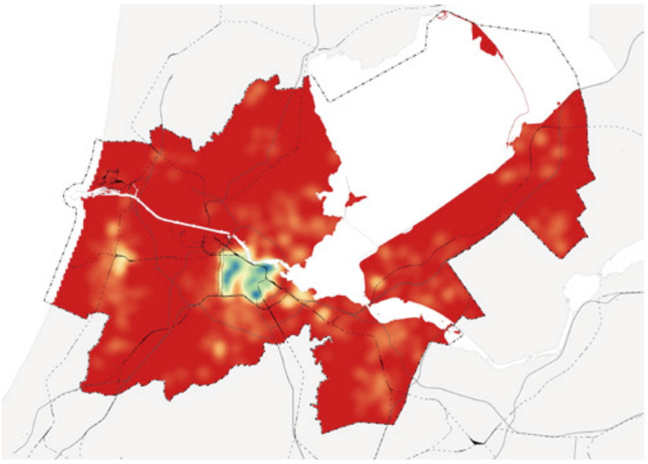


Fig. 4.4.29 Education: The share of people with tertiary education (%), 2016. Illustrated by author based on Sleutjes, et al..

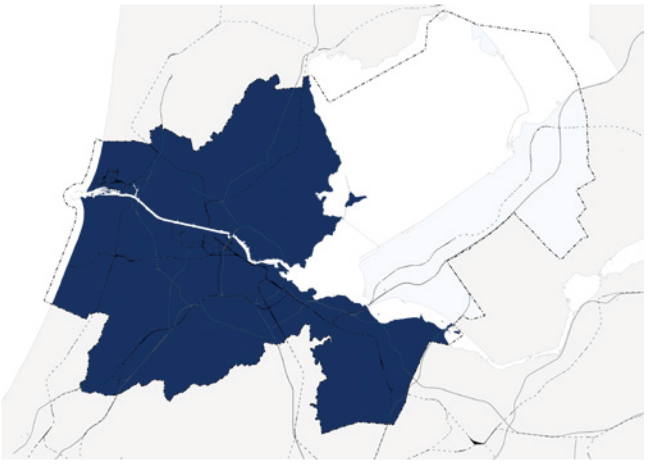


Fig. 4.4.30 Government trust: Trust in the House of Representatives (%), 2017/2018. Illustrated by author based on StatLine.

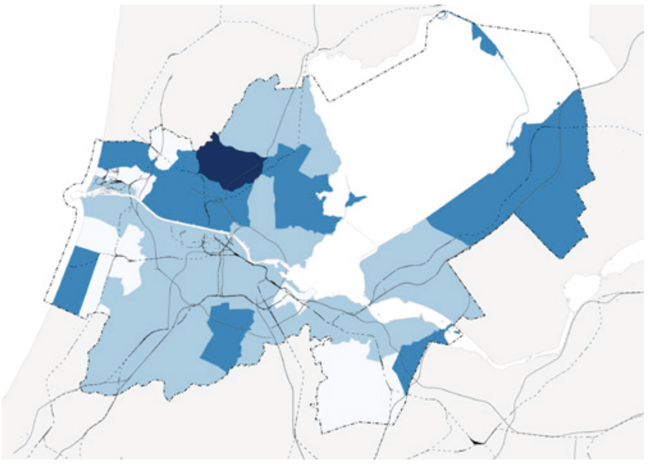


Fig. 4.4.31 Hospital beds: Number of hospital beds per 100,000 inhabitants, 2020. Illustrated by author based on RIVM.

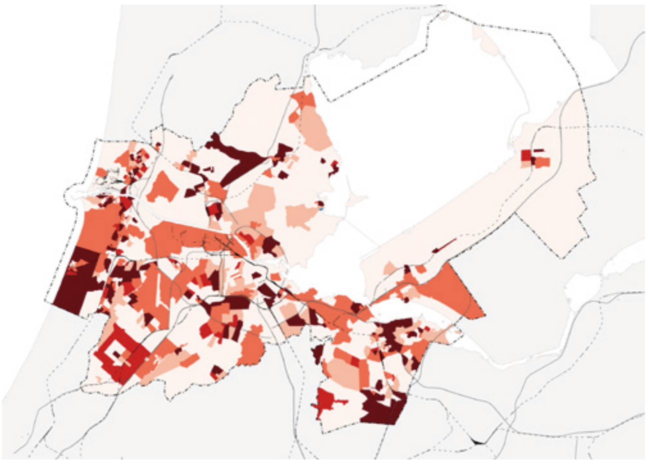


Fig. 4.4.32 Health: The share of mortality in the total population (%), 2012. Illustrated by author based on Pdok.

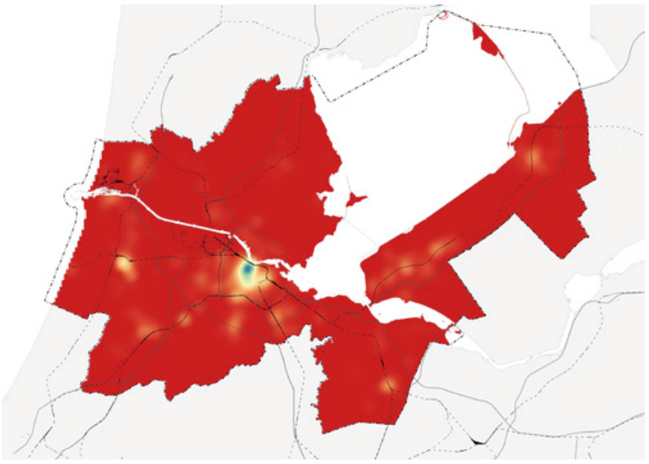


Fig. 4.4.33 Ability to use technology: Average density of WIFI from 2015 to 2019. Illustrated by author data based on WIGLE.

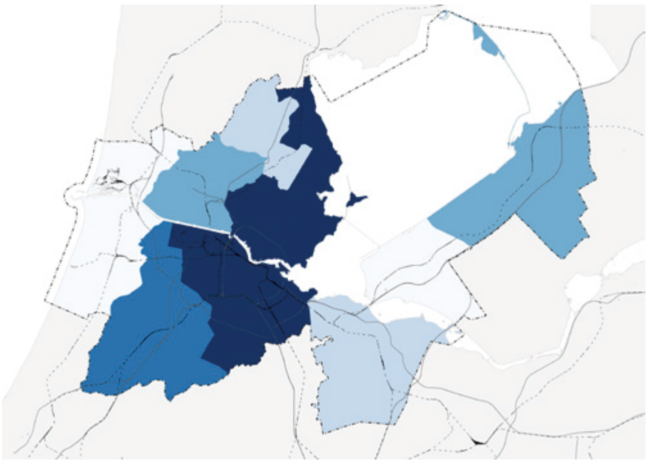


Fig. 4.4.34 The growth rate of government economic activities (%), 2018. Illustrated by author based on CBS.

The calculation method is the same as that of exposure because the factor number is relatively average, it does not need the classified calculation like sensitivity. Firstly, after importing all the maps, they were rasterized within the scope of the MRA. The value of each indicator is then normalized to make the following calculations meaningful. Finally, these parameters were analyzed in QGIS with the same weight through the following average formula for the risk index map:

Adaptive Capacity Index= (-education- government trust- hospital beds+ mortality- ability to use technology- government efficiency)/6

Therefore, Fig. 4.4.35 represents the hierarchy of adaptive capacity in urban areas. Different from the maps of exposure and sensitivity, the city of Amsterdam has more adaptive capacity. It is because of the high integration of institutions during the pandemic, but high education and health level of residents in the city. They have a clearer understanding and attention to the pandemic and crisis, so they will make adequate preparations, such as complying with policies and maintaining social distance. Other municipalities like Almere shows less adaptability to the pandemic. The main reason is the low government trust and efficiency of government work. Slower government response can seriously affect the timeliness of the outbreak, and the loss of trust among citizens makes it harder to implement measures in these cities.

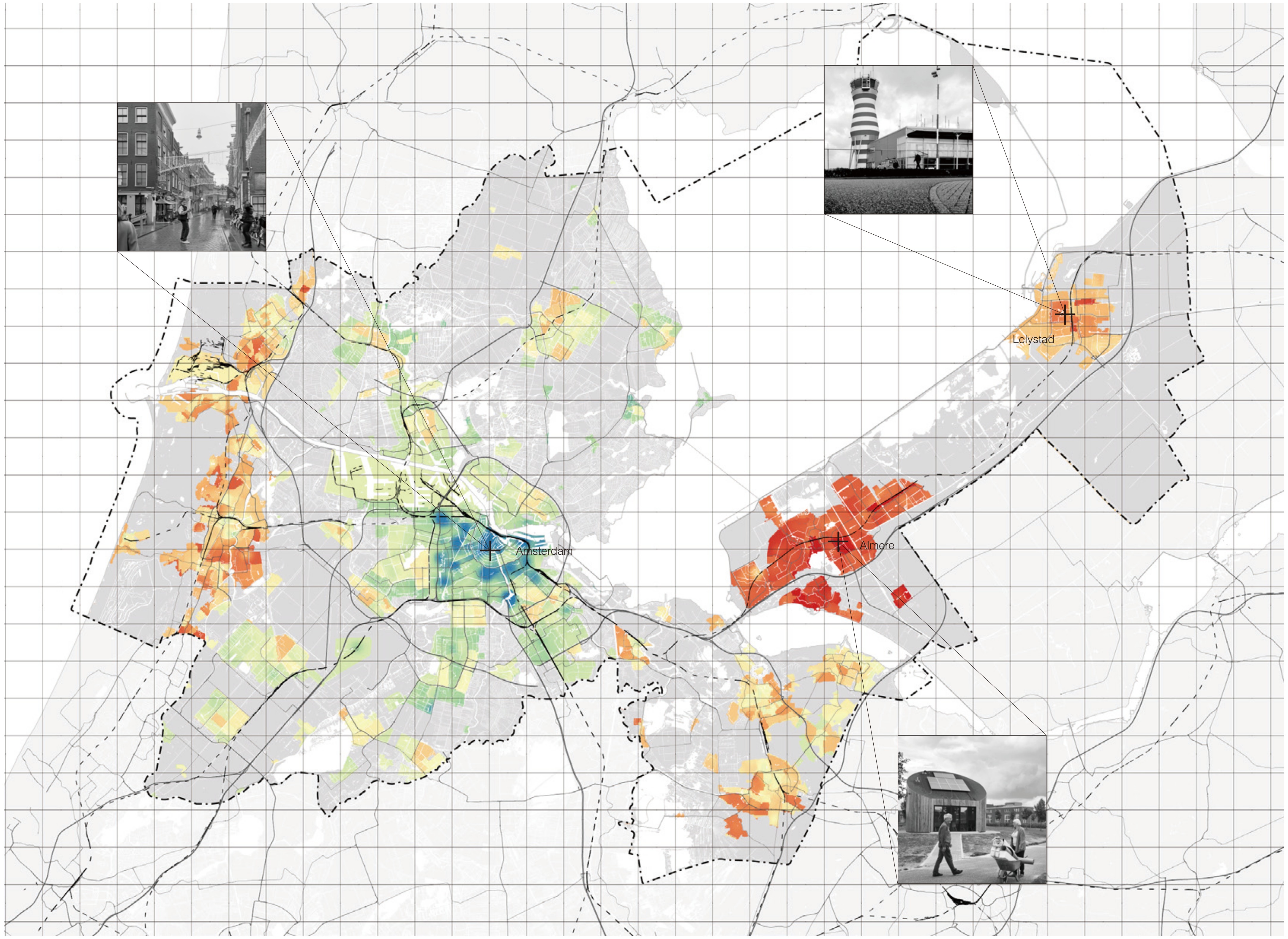


Fig. 4.4.35 Risk index of adaptive capacity in MRA. Made by author.

Risk hierarchy

- 1
- 2
- 3
- 4
- 5

- border
- highway
- railway
- rural area
- water

0 10 km

N

5. VULNERABILITY TYPOLOGY

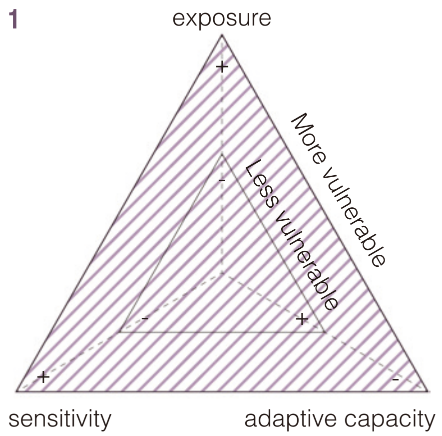
5.1 TYPES OF PANDEMIC VULNERABILITY

Through the former series of analyses, this study concluded that different areas of MRA are facing different issues on pandemic vulnerability. It is insignificant to simply add the three components together and average out an overall "vulnerability index" since it will not guide further improvement strategies. For example, an area that is fully exposed to the virus can be less vulnerable because of its high adaptive capacity. Therefore, instead of calculating a vulnerability ranking, the project presents eight vulnerability types as the conclusion based on different highlights of exposure, sensitivity, and adaptive capacity (Fig. 4.5.1-4.5.8).

The eight types take the shape of a triangle, with three vertexes: exposure, sensitivity, and adaptive capacity. Since the previous raster maps with scores ranging from 0 to 1, this project defines high vulnerability as a score higher than 0.5. For example, if a risk index of exposure in one place is 0.7 higher than 0.5, it means it has high exposure. These typological triangles put the high index outside and the low index inside, except adaptive capacity, which is positive for vulnerability. Therefore, the larger the triangle area of a place, the closer it is to the outer edge, the greater its vulnerability to pandemics. The most vulnerable type is the first one with high exposure, high sensitivity, and low adaptive capacity; while the eighth type is the least vulnerable with low exposure, high sensitivity, and high adaptive capacity.

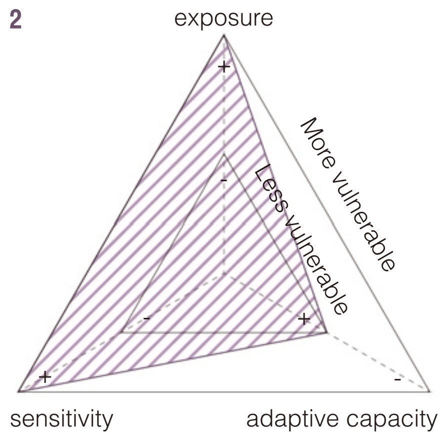
This project aims to improve the urban resilience to the pandemic. A typological study of urban vulnerability can accurately reflect the major challenge of a place. and is of great significance for the subsequent improvement strategies. According to the theory of pandemic vulnerability, the policy response for it can be divided into three ways: decreasing exposure, decreasing sensitivity, and increasing adaptive capacity. Therefore, design and policy with different emphases can be put forward according to different types and local conditions, and the aim of this project can be finally achieved, that is, less vulnerability and improved urban resilience.

1



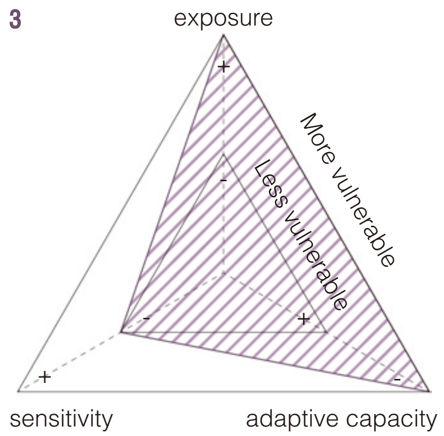
Exposure	Sensitivity	Adaptive capacity
+	+	-

2



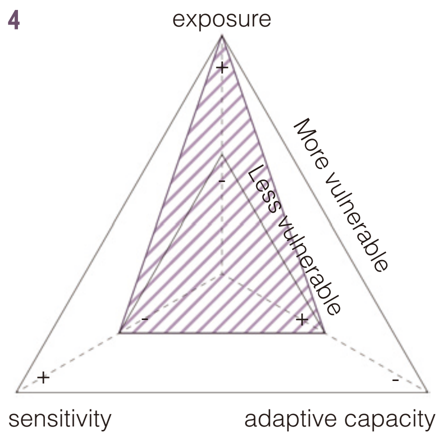
Exposure	Sensitivity	Adaptive capacity
+	+	+

3



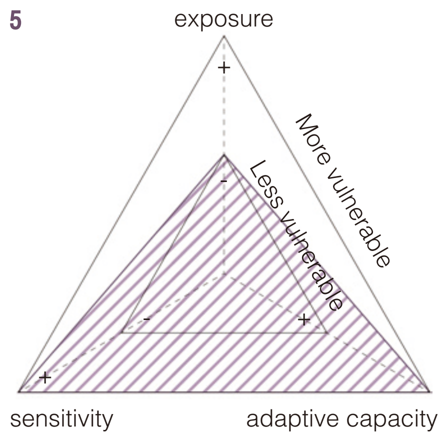
Exposure	Sensitivity	Adaptive capacity
+	-	-

4



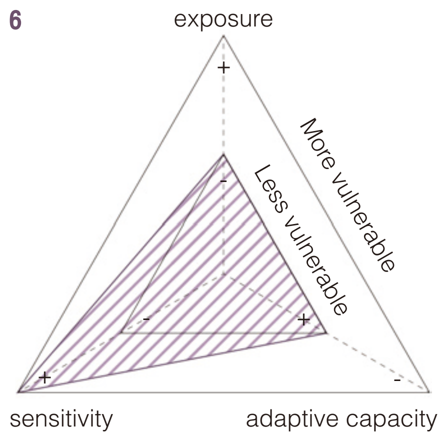
Exposure	Sensitivity	Adaptive capacity
+	-	+

5



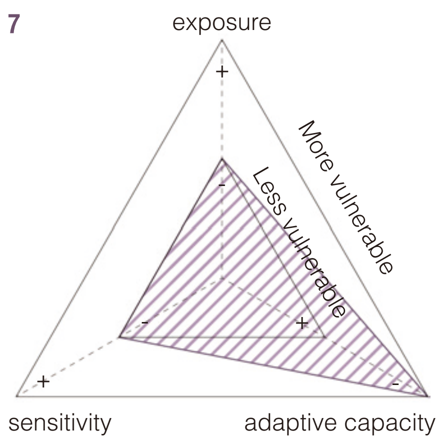
Exposure	Sensitivity	Adaptive capacity
-	+	-

6



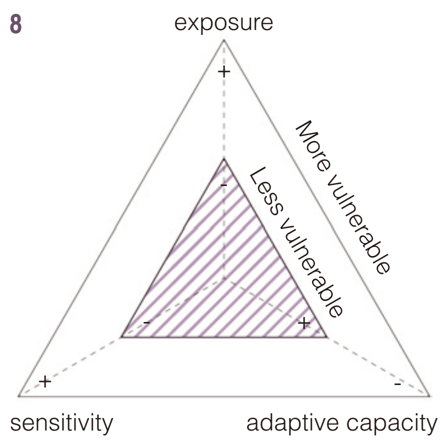
Exposure	Sensitivity	Adaptive capacity
-	+	+

7



Exposure	Sensitivity	Adaptive capacity
-	-	-

8



Exposure	Sensitivity	Adaptive capacity
-	-	+

Fig. 4.5.1-4.5.8 Typology by different exposure, sensitivity, and adaptive capacity. Made by author.

5.2 TYPOLOGICAL MAPPING

The typological map of pandemic vulnerability is calculated based on the results of exposure, sensitivity, and adaptive capacity. Firstly, all of these raster layers should be imported into a GIS file. Then, values of exposure and sensitivity had to be transformed into two categories: high value (greater than 0.5) and low value (less than 0.5), represented by 1 and 0 separately. And in order to simplify comparison, for adaptive capacity "1" means low value (less than 0.5), while "0" means high value (greater than 0.5). Finally, the typological mapping can be calculated through the following formula:

*Typology= types of exposure*100+ types of sensitivity*10+ types of adaptive capacity*

Therefore, the eight types can be distinguished by the value of raster. For example, "111" means high exposure, high sensitivity, and low adaptive capacity, equal to the first type. By adding the geographical context, Fig. 4.5.9 shows the typological mapping of pandemic vulnerability in MRA. The types in MRA show obvious zoning characteristics. Firstly, high exposure types are concentrated in Amsterdam city. It means that Amsterdam, as the capital of the Netherlands and the most internationally connected global city, is the first to be attacked by the pandemic and the following series of crises. Secondly, highly sensitive areas are more scattered around the periphery of cities, such as Westpoort and Nieuw-West in Amsterdam, Almere Buiten, and Heemskerk. It reflects that peri-urban areas are often hotspots of sensitive populations, where an unstable economy and inadequate infrastructure can enhance their vulnerability to the pandemic. Thirdly, cities except for Amsterdam mostly have the low adaptive capacity. Institutions in the surrounding cities are far less reliable, efficient, or valued by residents than in the capital. As a result, people in these areas may have higher incomes and enjoy better living conditions, but it is difficult to resist the effects of the pandemic for a long time. It is the reason why they can escape at the beginning of the outbreak, but got seriously affected in the second wave.

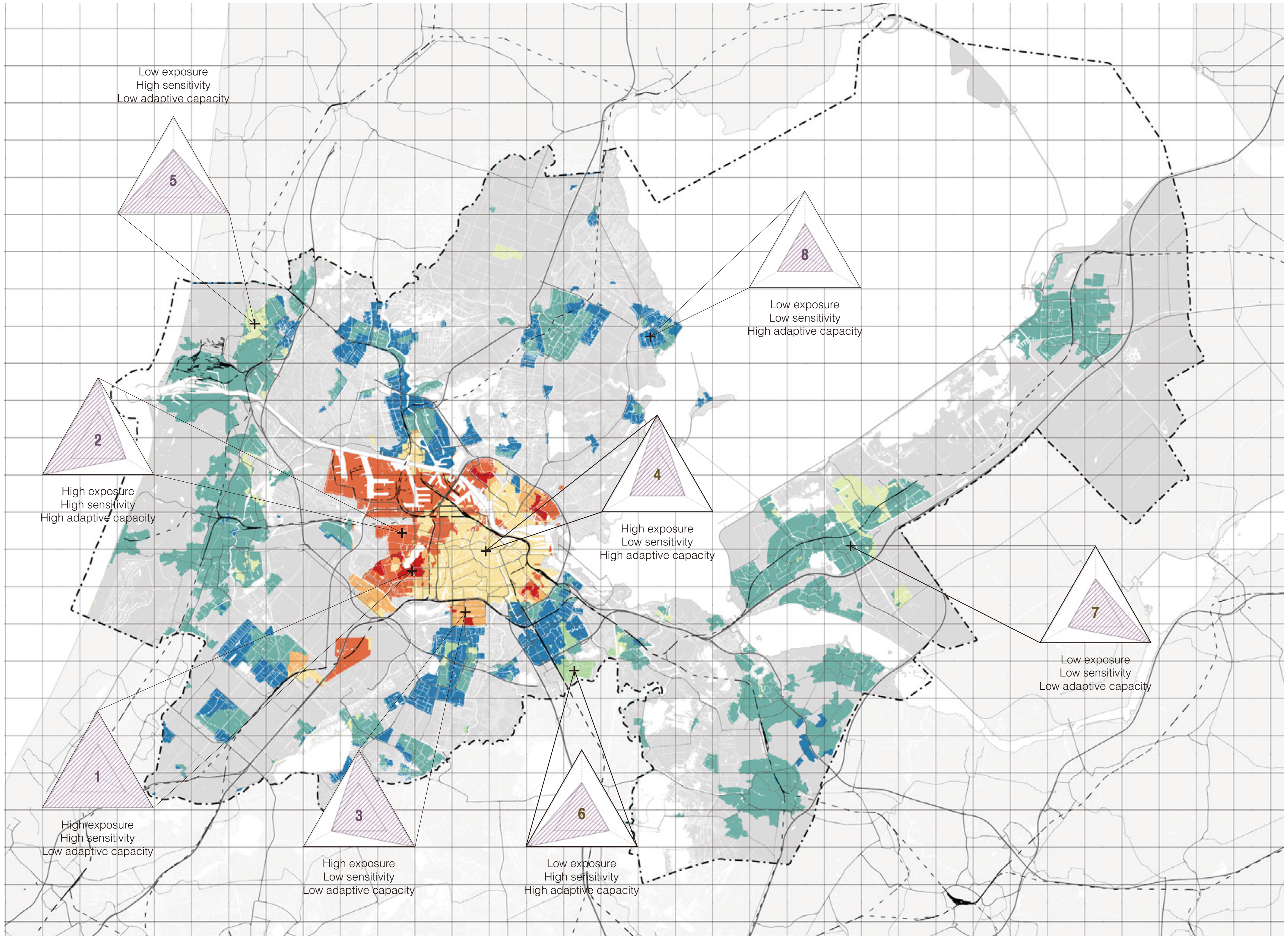


Fig. 4.5.9 Typological mapping of pandemic vulnerability in MRA. Made by author.

Typology

1, 2, 3, 4, 5, 6, 7, 8

border
highway
railway
rural area
water

0 10 km

N

Fig. 4.6.1. The desolate public open space in the neighborhood, Geuzenveld-Slotermeer, Amsterdam, 2020. Photographed by author.

6. CONCLUSION

While the academic community is currently dealing with the urban impact of COVID-19, there is a deficit of focus on its underlying dynamics. Research on the definition and framework of urban vulnerability to a pandemic is very much needed since infectious diseases have become a considerable threat in the strengthened interconnected global system. Therefore, this chapter firstly prioritizes the assessment of risks and pandemic vulnerability based on the available literature. It attempts to understand the pandemic vulnerability associated with the definition and framework of both climate and social vulnerability. It consists of three components: exposure affected by external drivers, sensitivity, and adaptive capacity. Identify critical factors that are then considered as indicators for evaluation and preparation for future pandemics. This study explores a comprehensive set of indicators, which could qualitatively and quantitatively analyze the urban vulnerability.

Through external and internal analysis, this chapter then applies the theoretical framework in the context of MRA. Global connectivity and migration analysis demonstrate that the pandemic vulnerability in MRA is partly driven by external factors. Through indicators of the framework and quantitative analysis by raster calculation in QGIS, there are three resulting maps with risk index for hierarchy. These maps show the level of exposure, sensitivity, and adaptive capacity in different places. Therefore, based on these conclusions, the eight types of pandemic vulnerability were summarized, which were represented on the map of MRA finally.

The purpose of this chapter is to conclude a definition and framework for pandemic, and apply it at the spatial level and to test and evaluate its accuracy. It also aims to identify the sites in MRA that need to be focused on planning.

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5 URBAN RESILIENCE

This chapter focuses on the theoretical exploration about urban resilience and innovative approaches through case study. It finally developed the planning methodology to the pandemic from the theory of adaptive planning.

CONTENT

1. DEFINITION OF RESILIENCE

Over the past decades, the concept of "resilience" explodes increasingly. There are related studies in policy and practice from many disciplines, like economics (Béné et al., 2014), environmental change (Almedom, 2008), community planning (Bahadur et al., 2013) and social disasters (McEvoy, Fünfgeld, & Bosomworth, 2013). However, the concept is 'in danger of becoming a vacuous buzzword' in terms of its 'overuse and ambiguity' of diverse spatial conditions and temporal dimensions (Rose, 2007). Therefore, it is significant to firstly understand the exact meaning of the term 'urban resilience'.

Based on a wide range of literature reviews on resilience, there are three distinguishable concepts that researchers have been debated: engineering resilience, ecological resilience, and social-ecological resilience. They respectively correspond to single-state equilibrium, multiple-state equilibrium, and dynamic non-equilibrium (Davoudi et al., 2012, see Fig. 5.1.1). Engineering resilience refers to the capacity of a system to return to the single-state equilibrium, which emphasizes the minimal effects of the disturbance (Holling, 1973, p. 17). It is mostly embraced by disaster studies, psychology, and economics (Pendall et al., 2010). Ecological resilience posits that there are multiple stable states in contrast with a single stability domain (Gunderson, 2000, p.426). Systems can be transformed from one equilibrium to another, facing the disturbance. It thus emphasizes not only the efficiency to bounce back but also the persistence and even changed characteristics to maintain existence (Holling, 1996, p.33). The socio-ecological resilience is propagated recently by notions of dynamic non-equilibrium, which mainly challenged stability (Pickett, Cadenasso, & Grove, 2004). It suggests that systems subjected to dynamic disasters can change, adapt and transform themselves to a qualitatively different form. The interdependent people and natural systems can therefore shift thresholds in various ways (Folke et al., 2010, p. 21).

This view of socio-ecological resilience is similar to the evolutionary perspective. Therefore, this approach is also called by Davoudi (2012) evolutionary resilience in the context of economic geography. Evolutionary resilience broadens the definition of equilibrium conceptualizations as the ability to maintain functions and processes by resisting, recovering, or adapting to change (Holling, 1973, see Fig. 5.1.2). Preparedness is the learning capacity of a system to enhance its ability of resistance, recovery, and transformation. And persistence refers to the ability to persist in disturbances (Davoudi, Brooks, & Mehmood, 2013). Adaptability and transformability are two major dimensions in the framework of Socio-Ecological Systems (SESs) (Folke et al., 2010). Adaptability refers to the ability to absorb impacts without crossing a threshold and then recover from them. Transformability refers to the ability to change the function of the system and moving to new desirable stability of trajectory. Resilient thinking requires firstly to assess potential under current stable conditions, and secondly to foster the resilience of the new trajectory (Folke et al., 2010). This framework of preparedness, persistence, adaptability, and transformability is a dynamic interaction in-between various scales and actors in SESs.

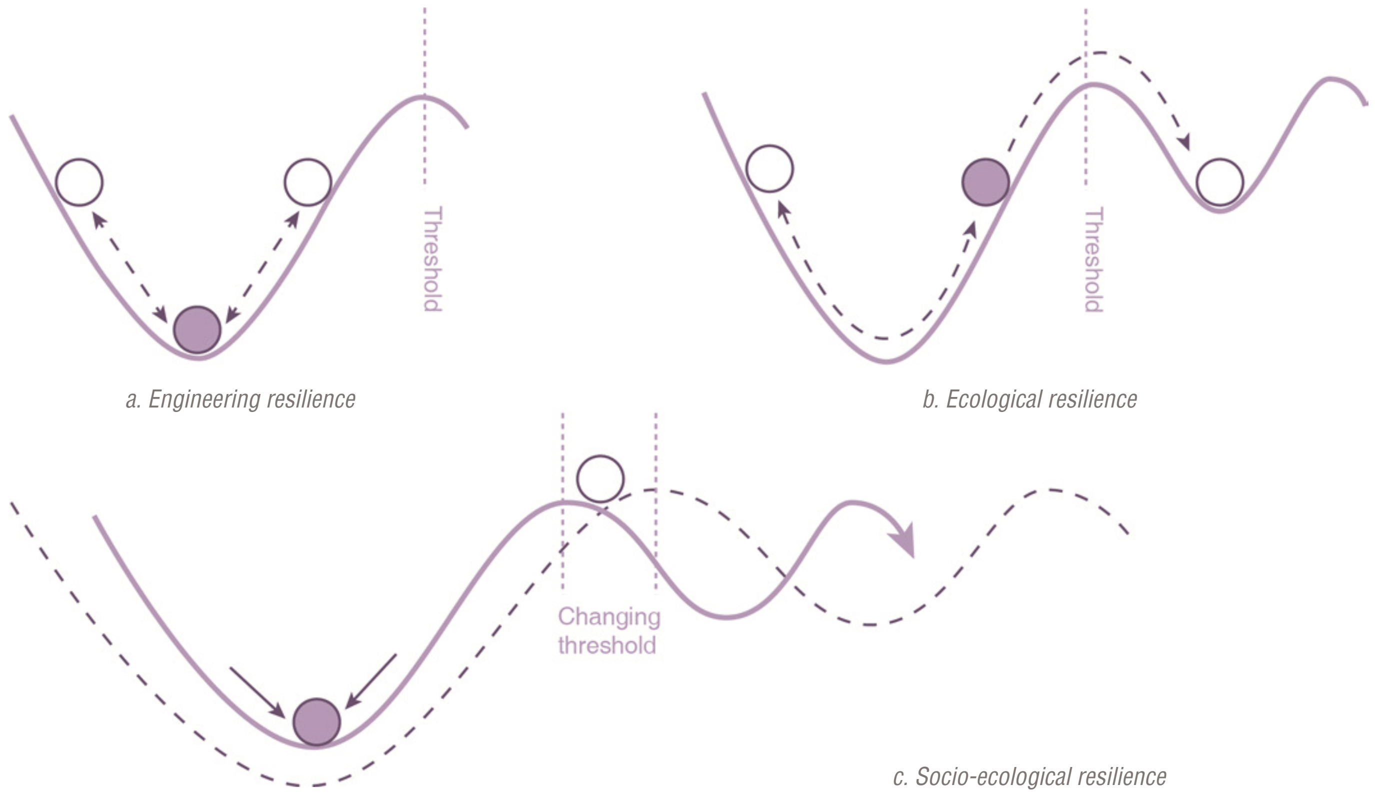

Fig. 5.1.1."Cup and ball"schematic diagrams illustrating the common concept. Source: Young et al, 2018.

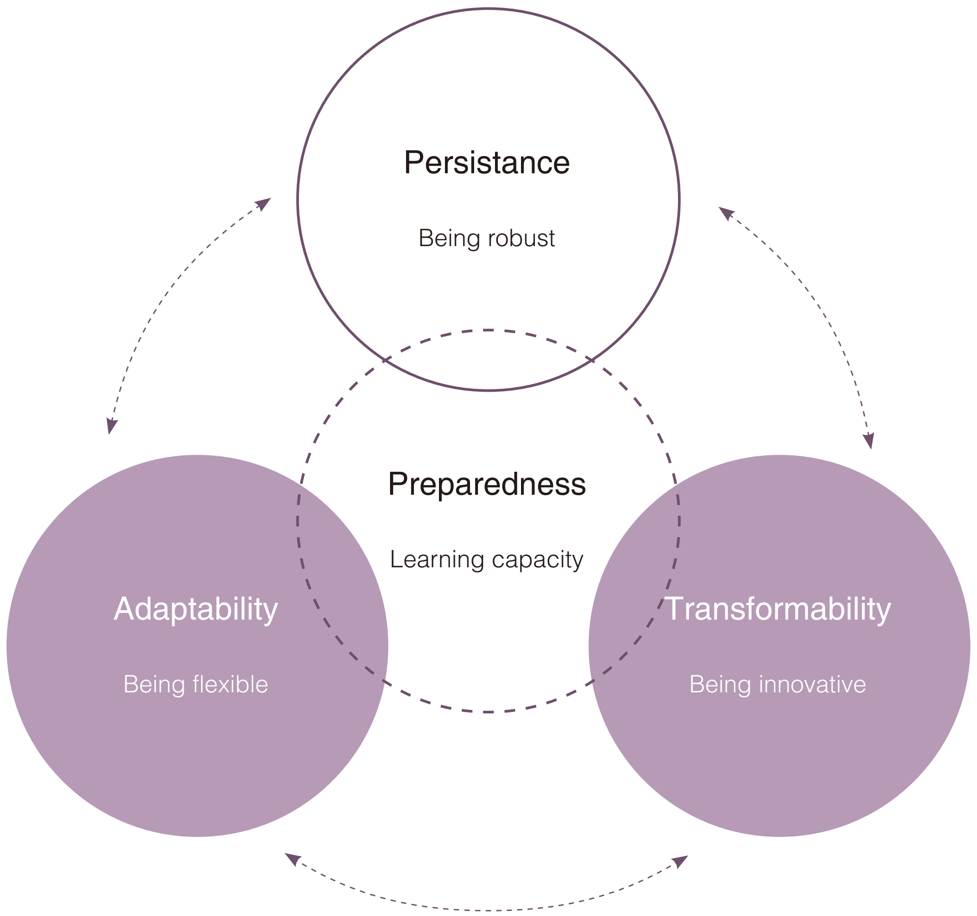

Fig. 5.1.2 Dimensional framework for evolutionary resilience. Made by author, adapted from "Evolutionary Resilience and Strategies for Climate Adaptation" by Davoudi, 2013.

2. ADAPTIVE CYCLE

Most resilient planning methodology proposed are for an ecosystem to address the uncertain future based on an integrated view called 'adaptive cycle' (Holling, 1986, see Fig. 5.2.1). The infinity curve represents four distinct phases of change for systems, including growth (r), conservation (K), creative destruction (Ω), and reorganization (α) (Gunderson & Holling, 2002). This adaptive cycle offers a framework of resilience as continually changing from an evolutionary understanding. There are two major transitions in the adaptive cycle: the foreloop from r to K, and the backloop from Ω to α (Gunderson & Holling, 2002). The foreloop is a slow phase for growing with incremental steps. In this period, capital of resources is accumulated through increasing connectivity. The backloop is a rapid but short phase to reorganize. This phase can take the opportunity of released structures to redesign, reorganize, and redistribute the resources in the system (Kauffman, 1995). SESs exist at multi-scales of space, time, and social system, where adaptive cycles interact hierarchically called "panarchy" (Gunderson & Holling, 2002, see Fig. 5.2.2). Panarchy is used to rationalize that the smaller and faster levels are experiments of the larger and slower levels, while the larger ones set the conditions for the smaller ones. This model was derived from the study of ecosystems. It is used as a tool for resilient thinking focusing on the process of destruction and reorganization. It will be more complete if urban planning can combine these processes with the view of system dynamics (Gunderson & Holling, 2002).

Therefore, a planning approach has been explored called 'adaptive planning' or 'adaptive governance' (Folke et al. 2005, see Fig. 5.2.3). Cities no longer has to reach the predefined goals for urban ecosystem services. This conceptual framework is proposed based on the need for procedural resilient strategies in urban areas. It represents a new way of thinking about climate adaptation to contribute to resilience. The key of this method is the dynamic evaluation, which means an information-based approach, controlling and adjusting adaptation strategies through monitoring indicators. In addition, in the context of climate change, the shared information will play a major role in the framework (Camacho, 2009). Finally, cities can be empowered by themselves through "learning by doing" to be more resilient.

However, pandemic resilience for society differs from ecological resilience. 'Socio-ecological resilience' explains that systems can become more resilient with a higher capacity to be prepared, persistent, recover, and transformative. It challenges the traditional urban thinking and environmental management strategies (Nunes, 2019). Social theorists have also argued with the reasonability to apply ecological models to social structures despite social issues, like scale, power, and equity (Weichselgartner & Kelman, 2015). Firstly, there is a general lack of clarification of resilience. In other words, "resilience of what". There is a big difference between the resilience of society to specific pandemics and the resilience of systems to general development. Secondly, there is a lack of spatial and temporal trade-offs. Pandemic resilience has to consider the system in wider scales and interconnected networks, instead of taking cities as a "self-organizing" unit (Beilin & Wilkinson, 2015). Given the rapid mobility of the economy and urban populations, pandemics can spread more easily in between different cities to affect larger population groups on different scales. Thirdly, there is an inherent conservatism to keep the unjust situation for ecology(Joseph, 2013). Adaptive cycles of the ecosystem "accept change somewhat passively", neglecting the consideration to address the essential causes of crises (Evans, 2011, p.224). For pandemic resilience, however, it should focus on not only mitigating infectious virus but necessary systemic transformation for social justice. Therefore, it is necessary to propose a new planning method for pandemic resilience in SESs.

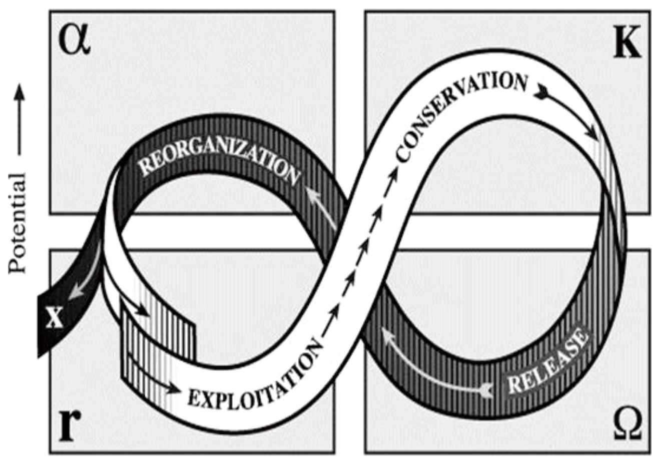

Fig. 5.2.1 Adaptive cycle for ecosystem. Source: Folke et al., 2010.

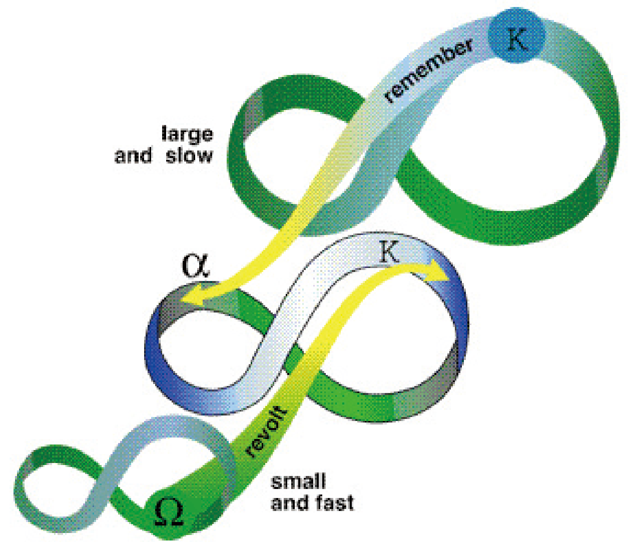

Fig. 5.2.2 Panarchy of adaptive cycle. Source: Gunderson & Holling, 2002.

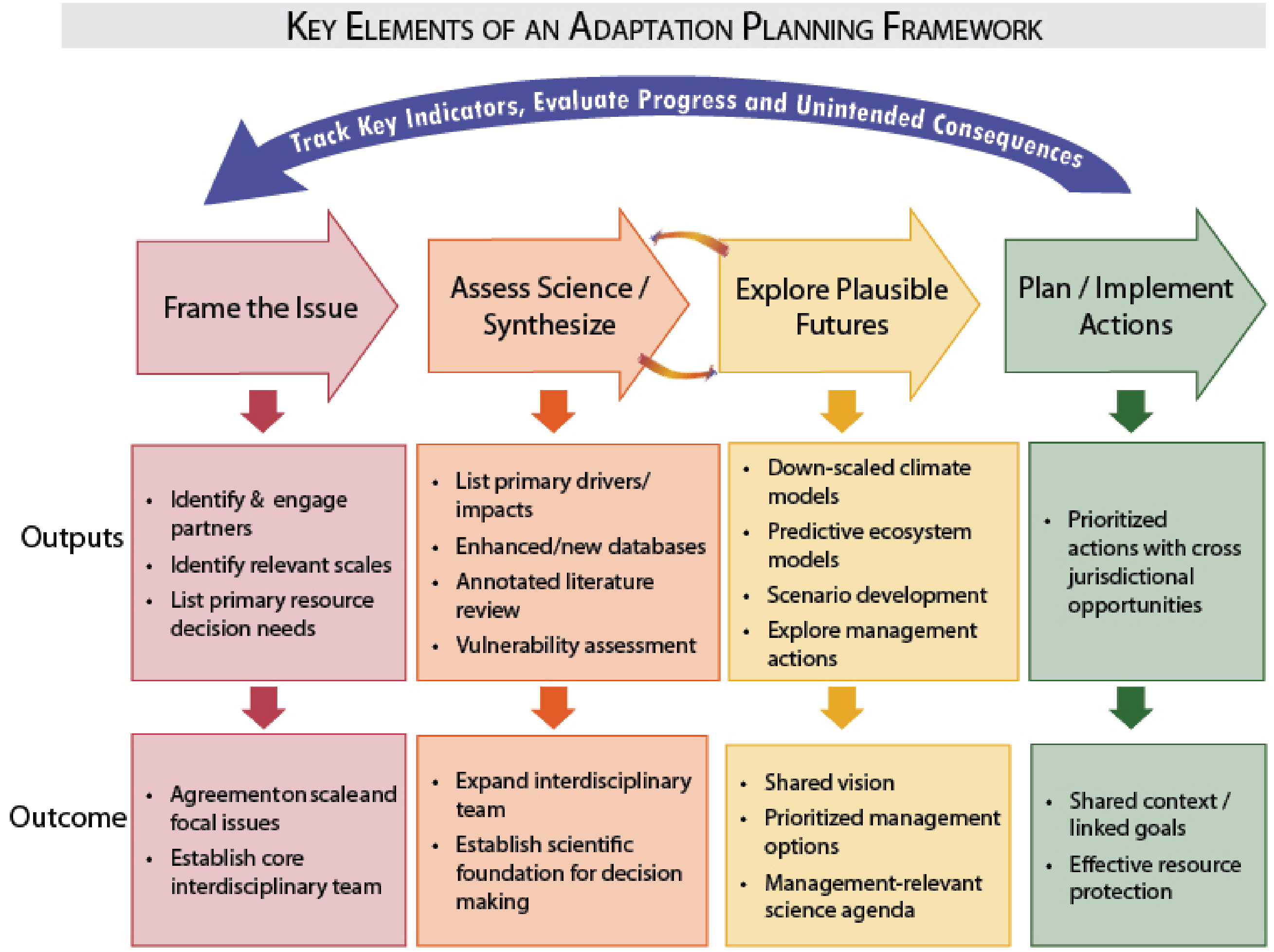

Fig. 5.2.3 Adaptive planning framework for climate change. Source: https://www.nps.gov/subjects/climatechange/toolkit-adaptation.htm

3. CASE STUDY

3.1 SUPERBLOCKS IN BARCELONA

Cities are facing congestion and pollution, which have become major problems for urban resilience. Therefore, Enter Barcelona, the capital of Catalonia, Spain, firstly introduced a simple idea based on blocks, named Superblocks in 2016 (Ajuntament de Barcelona, 2016). Strategies aim to make 'Barcelona a city for living in'. It is a part of a ten-year plan to carving out car-free blocks to reduce the air and noise pollution on urban streets (Ajuntament de Barcelona, 2016). Superblocks are mainly presented through neighborhoods of 400m×400m blocks, where motorized traffic is restricted to the outskirts. Therefore, the city can be given back to the residents by opening up the streets inside to pedestrians and cyclists (Fig. 5.3.1). The entire space of streets is designed for not only walking and cycling but more open space to communicate and test new public uses for socio-economic activities.

However, these thorough revamps of the city require a huge amount of capital investment. These new strategies have been implemented in several neighborhoods in the Gràcia district. After that, they are going to spread to other cities like Vitoria, La Coruña, Ferrol, Viladecans, and El Prat (UNDP, 2016). The current accomplished six Superblocks has already cost € 38 million with work beginning in 2022, and the European Investment Bank (EIB) will provide € 95 for 40 more projects (UNDP, 2016). Nonetheless, the number of Superblocks falls far behind the planning from the municipality, which intends to eventually innovate over 500 in Barcelona (Ajuntament de Barcelona, 2016).

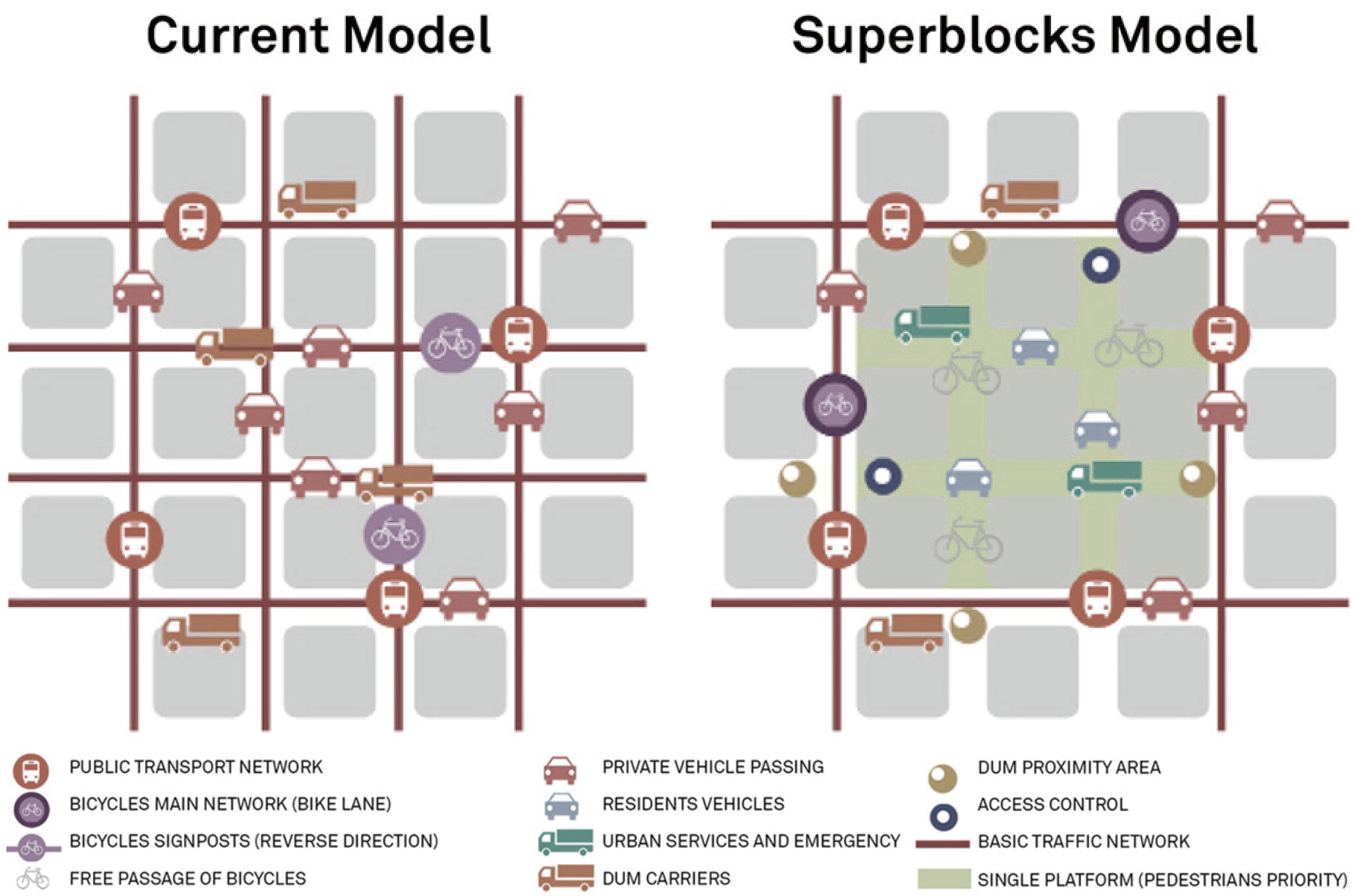

Fig. 5.3.1 Superblocks model. Source: https://barcelonarchitecturewalks.com/superblocks/, by Ajuntament de Barcelona.

3.2 GATED COMMUNITIES IN CHINA

In urban areas in China, the dominant and most common response is a compulsory lockdown, which includes not only municipal institutions and public buildings but also communities (Li & Lu, 2020). At the beginning of the outbreak, all communities had to close their gates to restrict the movement of residents. Although there is a debate about whether China should have taken such strict measures, gated communities are one of the most direct and effective ways for China to fight the COVID-19 (Hamama, 2020). In most cities during peak times, a family is allowed to send only one person out every two or three days for necessities by presenting a temporary pass card. These emergency responses can be implemented overnight by simply closing a few gates.

The lockdown in China is undoubtedly supported by gated communities. Their flexibility and manageability have also proved their contribution during SARS (Hamama, 2020). However, the expansion of gated communities has long been a problem for cities in China. These neighborhoods were originally designed to facilitate unified development by real estate developers, but they have now become "cities within cities" (Wang, 2020). The almost privatized public facilities, closed by fences and gates, have had serious impacts on the natural landscape and social ecology of cities. Besides, oversized gated communities not only prevent residents from communicating with nearby streets but also reduce their functioning for a living (Liu, 2001). These physical and psychological barriers prevent residents from using city streets. Overall, gated communities create a vicious circle: the fewer people there are on the sidewalks, the less social activity there is, and the more people the streets appear unattractive (Boddy, 1992).




Fig. 5.3.2-5.3.5 Gated communities in China during COVID-19. Source: https://www.sixthtone.com/news.

3.3 AMSTERDAM CIRCULAR ECONOMY

Based on the Doughnut Economy, the planning for Amsterdam is to ensure social justice within the ecological boundaries. Therefore, a circular city is going to be constructed to save raw materials, consuming and producing while offering more jobs for citizens (Gemeente Amsterdam, 2020). In a circular economy, the city is developing considering the Earth. Raw and other materials can be reused by renewable energy. Meanwhile, the progress of sharing, reusing, and repairing will be sped up, which can reduce environmental pollution and increase social solidarity from economic behaviors in Amsterdam (Gemeente Amsterdam, 2020). These strategies aim to halve the use of new materials by 2030 and to become circular by 2050 (City of Amsterdam, 2020).

However, according to the Amsterdam Circular Strategy (2020), the city cannot be 100% circular until 2050 (Fig. 5.3.6). Amsterdam has entered the fourth stage of the circular economy since April 2020. Afterwards, there are 200 new circular projects for 2021, which were built on 116 implemented projects in 2020 (Carey & Andrews, 2020). Although 80% of wastes in Amsterdam has been recycled in various forms, it only accounts for 8% of the raw materials used for new products (Dutch News, 2020). The goal of a circular Amsterdam is difficult to be achieved in a short term. This time-consuming planning is likely to improve the urban resilience for the city in the future of 30 years, but cannot respond to emergency pandemics.

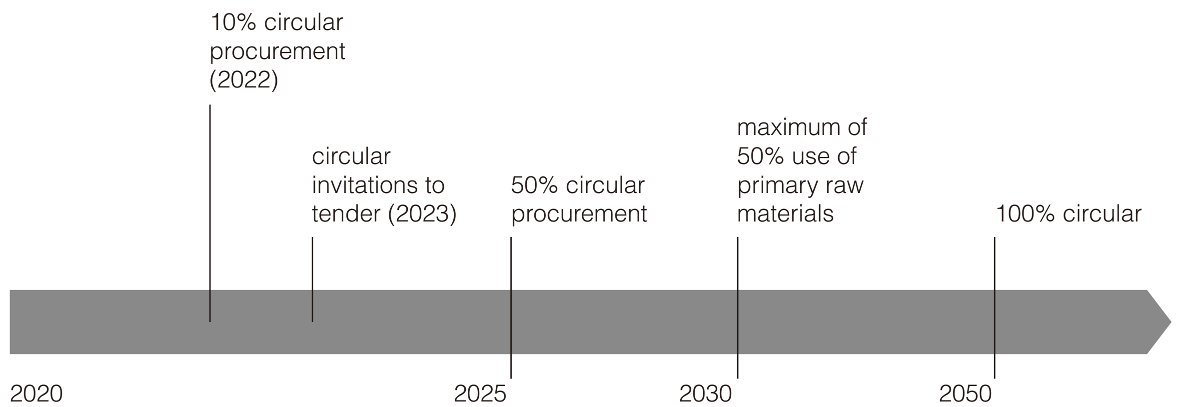

Fig. 5.3.6 Amsterdam circluar economy till 2050. Source: https://www.amsterdam.nl/en/policy/sustainability/circular-economy/

3.4 CONCLUSION

These strategies are recognized through elaborating the "five Ws" from Meerow and Newell (2016) related to urban resilience for whom? What? When? Where? And why? Table 5.3.1 reflects that these planning approaches are characterized in different beneficiaries, spatial and temporal outcomes in different areas. For example, Superblocks in Barcelona focuses on the neighborhoods affected by air and noise pollution from traffic infrastructure. Furthermore, only individuals in gated communities can benefit from the policy during the specific pandemic in China. And circular strategy in Amsterdam is a long-term vision, whose system boundary is extended from the city to the global environment.

Therefore, this brief comparison highlights the challenges for socio-ecological resilience to the pandemic. Planning strategies in Barcelona, China, and Amsterdam for COVID-19 can mitigate the pandemic to some extent but have a series of shortcomings for urban resilience. Superblocks in Barcelona can solve the problem of air pollution with more public open spaces for residents, but the high cost of investment has prevented the project from promoting to other cities. Gated communities in China have played a key role in limiting the spread of the virus, but such urban forms have a long-term negative impact on the daily lives of citizens. The circular economy proposed by Amsterdam institutions is a future-oriented vision for ecological and social sustainability, which cannot respond to outbreaks until the aim in 2050.

Pandemic is an unpredictable and uncertain socio-ecological issue, which is making it more challenging to respond quickly and consider varying stakeholders. Resilient planning for the ecosystem is inefficient and tendentious to deal with the dynamic change that pandemic characterizes. These formal planning instruments have gradually proven not to deal with the constantly changing conditions of social systems (Lutzoni, 2016). The conflicts between the traditionally resilient planning method and pandemic issues in the case study reflect an urgent need to change. We need to critically reconsider the notions of urban planning from a dynamic perspective and to determine winners and losers for measurement. Therefore, a more flexible and dynamic approach for urban planning is required in the context of SESs and frequent threats from an epidemic in metropolitan areas.

		Superblocks	Gated communities	Circular strategies
Who?	TRADEOFFS	Beneficiaries are city residents with most serious impacts from traffic	Beneficiaries are city residents exposed to pandemic risk	Beneficiaries are general population in Amsterdam and the world
What?		Generic community resilience	Specifically focused on pandemic mitigation	Generic global resilience
When?		Both short-term and long-term resilience	Focused on current residents and based on current estimates of risk	Long-term resilience
Where?		Neighborhoods with the most pollution from the traffic within the municipal boundaries	Neighborhoods with the most pandemic cases within the municipal boundaries	All of the neighborhoods
Why?		Goal is an outcome: carving out car-free blocks to reduce the air and noise pollution	Goal is a process: restricting population movements to reduce transmission	Goal is an outcome: increased social justice and ecological friendly

Table. 5.3.1 Illustrative applications of the "five Ws of urban resilience" to pandemic adaptation planning. Made by author.

4. “DYNAMIC PLANNING”

4.1 DYNAMIC TIME

In terms of the time dimension, traditional planning often follows a linear time sequence (Fig. 5.4.1). Planners firstly need to propose a final vision, and urban planning can be regarded as a solution-oriented approach to achieve the desirable outcome (Osualt et al., 2013). Problems and related strategies are pursuing as planned, which are most permanent and non-reversing, without considering that “the planning processes have been increasingly unsuited to the pace of change” (Bishop & Williams, 2012). Therefore, long-term planning cannot respond or change quickly, especially to emergencies, like a pandemic. Besides, the permanent and usually top-down strategies mean high investment and high risk during the implementation, as it is difficult to guarantee a successful outcome the same as predicted.

Therefore, following the panarchy framework of adaptive cycles, the dynamic planning in this project emphasizes a reversing approach: a process-oriented method questioning how a system can develop to change in-between adaptive cycles in different levels without defining a fixed state (Fig. 5.4.2). Planning is a dynamic process in different speeds of action. The planning of both fast and slow levels develops following adaptive cycles. From r to K, as the foreloop as mentioned, the development emphasizes the preparedness of urban resilience. ‘A forest cannot prevent fire or stop climate change. Humans can’ (Swanstrom, 2008, p. 18). Similarly, the foresight and prevention of epidemic by developed technologies is an important way to reduce uncertainty. The backloop from Ω to α emphasizes the persistence of resilience. It is a part of managing pandemic risks with adequate resources and utilities for both physical and mental health.

This project focuses on the resilience of adaptability and transformability. They are also the most distinctive aspects of socio-ecological resilience. The invention and experiment in the short-term levels can transform into the slower strategies for stabilization. Meanwhile, the accumulated memory in the long-term levels can moderate the pandemic to mitigate the local impact and recover quickly. It is at the heart of dynamic resilience, increasing the adaptability and transformability of SESs. It focuses on not only the ability for specific pandemics but the general resilience for the future generation. Therefore, it requires both flexibility, pathways to the resilient networks, and resourcefulness, efficient and diverse strategies in a quick response.

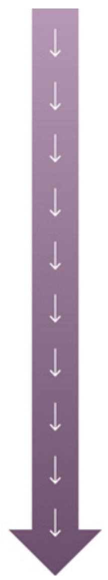

Fig. 5.4.1 Traditional linear planning. Made by author.

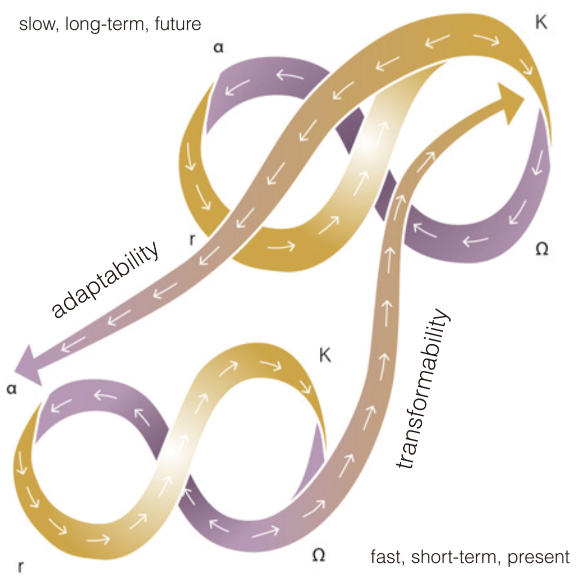

Fig. 5.4.2 Dynamic temporal planning. Made by author, adapted from Holling and Gunderson (2002, pp. 34–41).

4.2 DYNAMIC SPACE

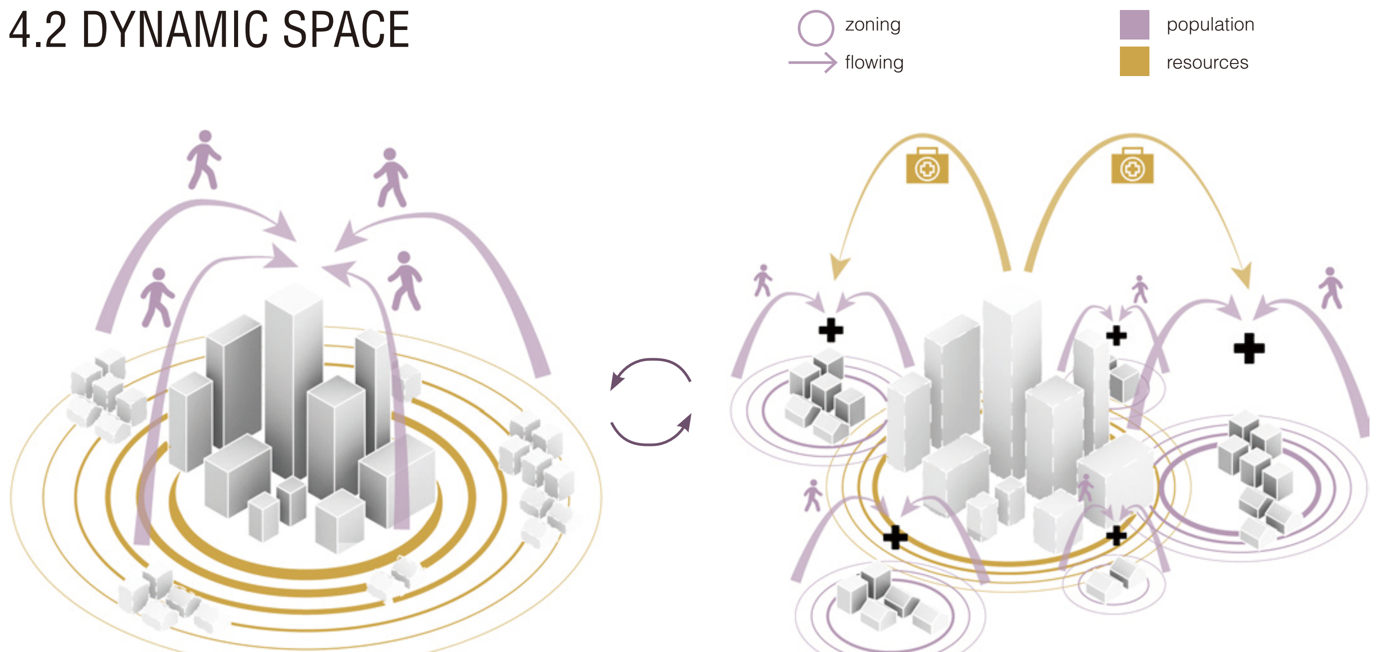

Fig. 5.4.3 Process of metropolitan region. Made by author.

Fig. 5.4.4 Process of small cities. Made by author.

Adaptability: in-between the metropolitan region and small cities

In dynamic planning for adaptability, a region can be changed between two spatial forms: metropolitan region and small cities. During the period of urban development without pandemics, the region exists as a metropolitan area, similar to the current spatial form of MRA. Resources are fixed, stable, and concentrated, while the population is mobile. Therefore, most of the limited resources are aggregated in one or several capital centers, while the population from other communities will form a centripetal flow to obtain resources.

The dynamic regional space can be split into several self-dependent small cities during an outbreak. The urban resources once concentrated in a few capital centers will be divided into other areas. Moreover, the population mobility of residents can be spontaneously reduced due to the just allocation of resources and implementing temporary legislation and governance methods. A reduction in the flow of population movement can efficiently mitigate the impact of the pandemic and reduce the spread of the virus.

Fig. 5.4.5 Outcome of dynamic network. Made by author.

Transformability: dynamic network

With the implementation of the Amsterdam Doughnut Economy and the technological underpinning of sustainable development, the spatial outcome for transformability is a dynamic network, where the material flow will replace the part of population flow. Local resources can be fully and efficiently used in the region through rational allocation and flexible spatial design. It is not limited to tangible resources such as materials, food, and goods, but also intangible resources such as energy and knowledge. At the same time, population flow will be organized in a safer and healthier mode, preserving the benefit of social interaction in the metropolitan area.

Fig. 5.4.1. The canal in Slotermeer, Amsterdam, 2020. Photographed by author.

5. CONCLUSION

A pandemic is an event difficult to anticipate or predict how the new challenge is emerging. Urban resilience is a way of responding. Among various concepts of resilience, socio-ecological resilience emphasizing not only bouncing back and forth but the flexibility and resourcefulness of systems to adapt. Evolutionary resilience and adaptive cycle promote new resilient thinking of dynamic adaptability for improving preparedness, persistence, recovery, and transformation. The concept of adaptive planning has been increasingly discussed for the ecosystem resilience. However, the disadvantages of traditional planning in Barcelona, China, and Amsterdam have presented the difference among responses for socio-ecological resilience. They highlighted an urgent demand for a new planning approach. Then, this chapter identified challenges of pandemic resilience, and gaps between resilient planning for pandemic and resilient planning for the ecosystem. According to the rapid infectious of virus in different scales, in pandemic adaptation, strategies have to be dynamic in both time and spatial dimensions. Therefore, this project proposes a 'dynamic planning' concept, based on the concept of adaptive planning to adapt processes transforming to a resilient metropolitan region. This concept's two main dimensions are:

Dynamic time: following the adaptive cycle in the panarchy model with dynamic responses in slow, long-term, and future levels and fast, short-term, and present levels of planning to respond to the pandemic.

Dynamic space: resilient through adaptability in-between two dynamic forms of the region from the metropolitan area to small cities, and through transformability to the circular network in the future.

Therefore, the combination of these two dimensions enables the region and government institutions to respond quickly to the pandemic with different focuses on different phases.

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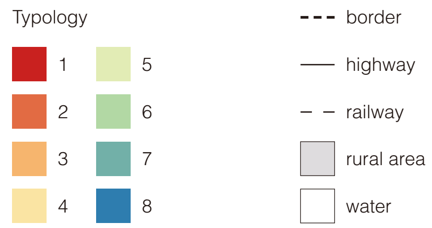
6 | IMPLEMENTATION

This chapter presents detailed design strategies through 'dynamic planning'. The planning starts from Geuzenveld-Slotermeer, based on the quatitative indicators from the framework of vulnerability, and sclaes up to the MRA.

CONTENT

1. VULNERABLE AREA



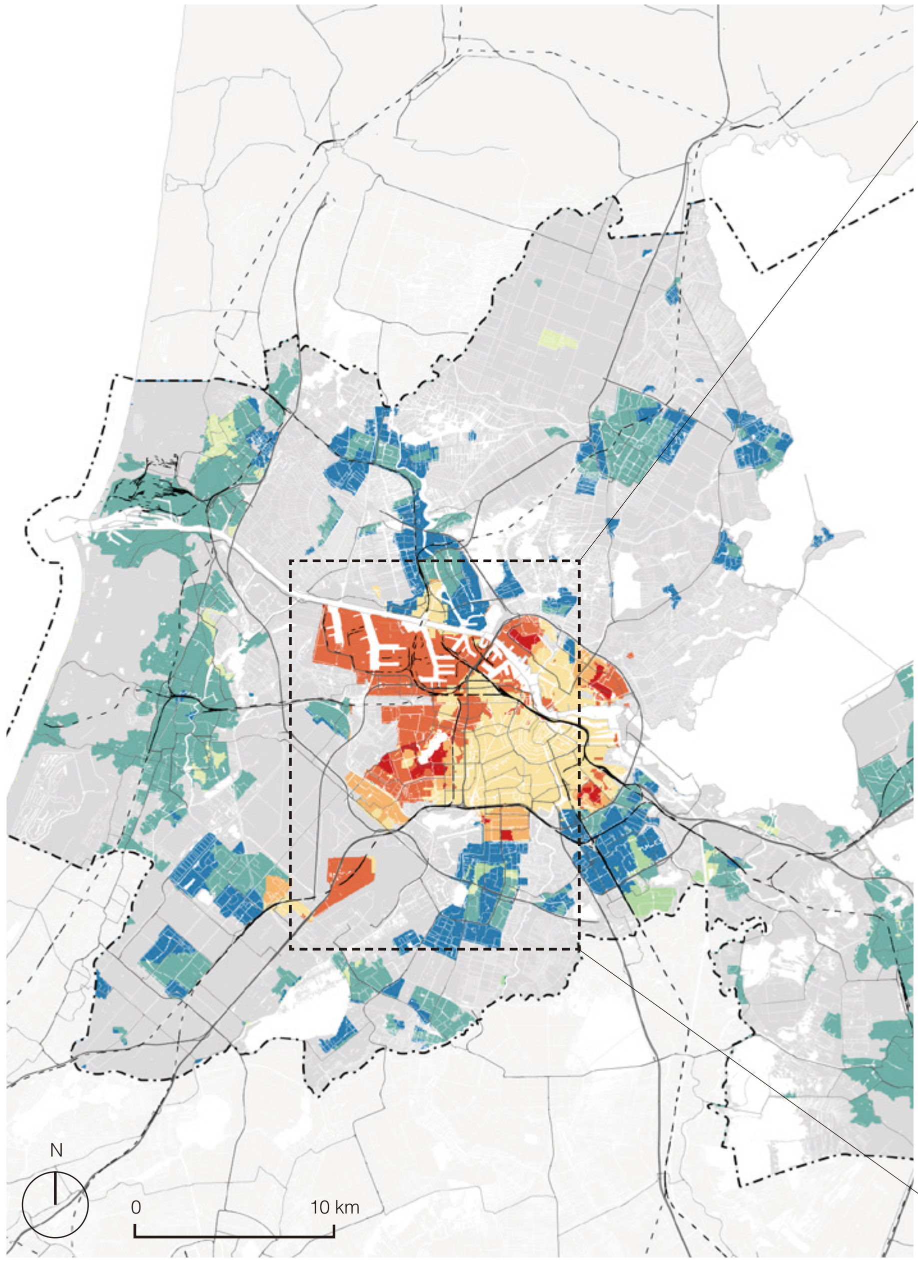


Fig. 6.1.1. Typological vulnerability in metropolitan scale. Made by author.

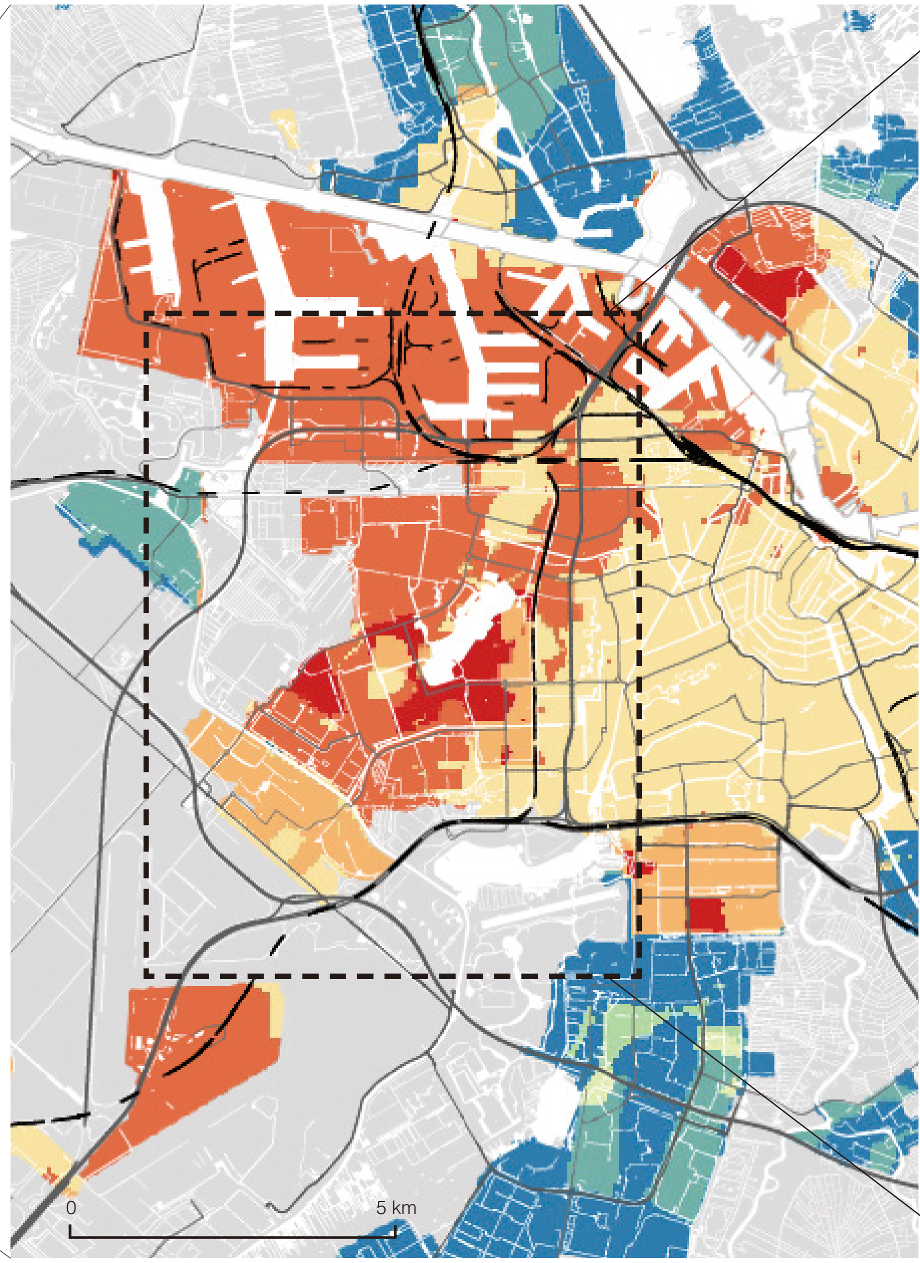


Fig. 6.1.2. Typological vulnerability in urban scale. Made by author.

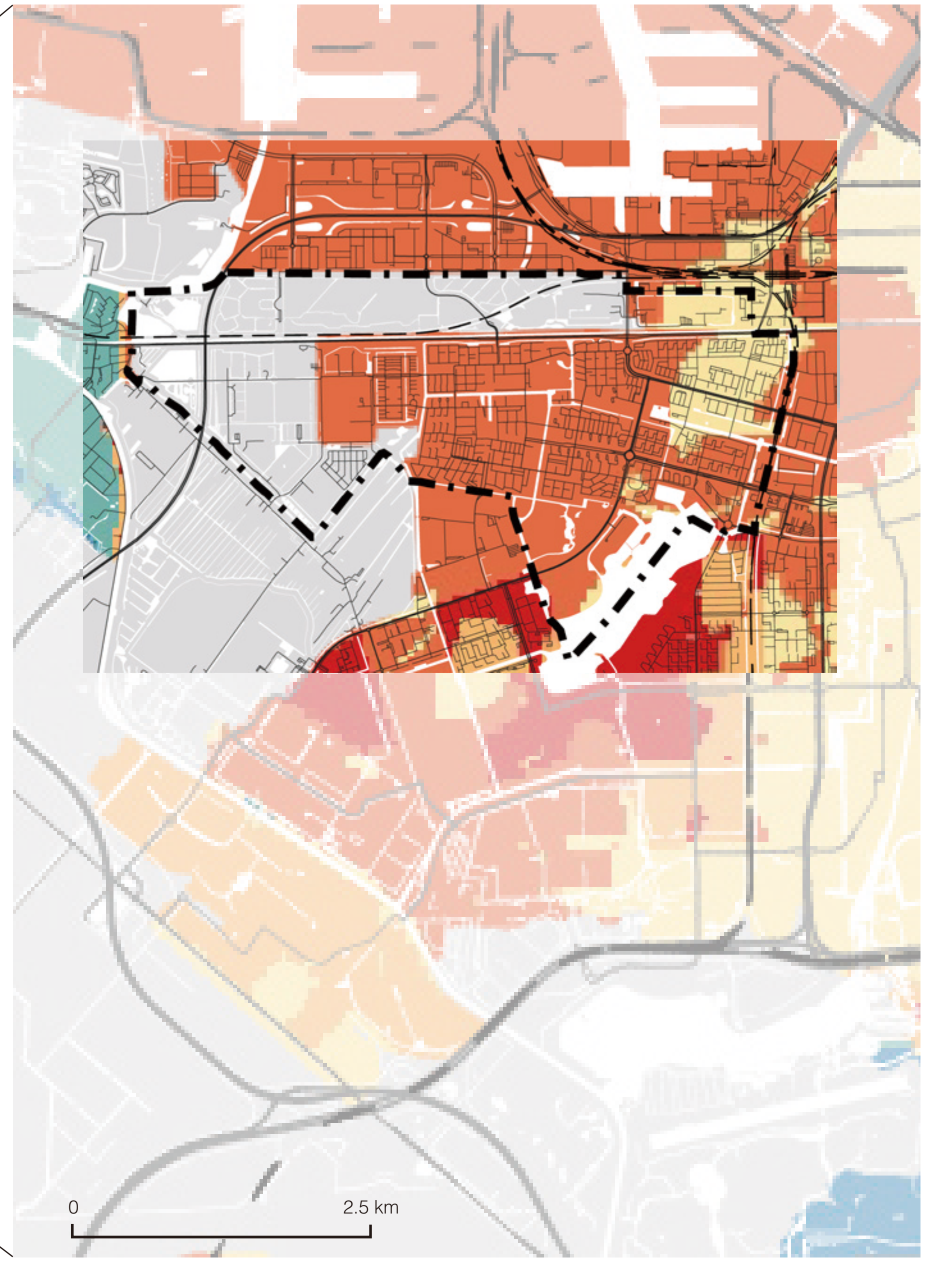


Fig. 6.1.3. Typological vulnerability in local scale. Made by author.

Metropolitan scale: MRA

Most of the existing policies focus on increasing the adaptive capacity in MRA while neglecting to reduce exposure and sensitivity. Therefore, at the metropolitan scale, this project chose the west side of Amsterdam as the main research object, including Westpoort, Nieuw-West, and Schiphol Airport (Fig. 5.7.1). They are areas with high exposure and high sensitivity, which need to be solved through planning and related policy to improve their pandemic resilience.

Urban scale: Amsterdam Nieuw-West

For urban scale, this project will focus on Amsterdam Nieuw-West. It is the most vulnerable residential area in Amsterdam city with more corona cases than the average (Engen, 2020). Fig. 5.7.2 shows that the majority of neighborhoods in Amsterdam Nieuw-West are in high exposure and high sensitivity. Therefore, it is urgent to improve the living condition of this area for not only the residents here but the inhabitants of Amsterdam.

Local scale: Geuzenveld-Slotermeer

Geuzenveld-Slotermeer is a neighborhood in the north of Amsterdam Nieuw-West. It is selected as the site at a local scale because residents are mostly immigrants with a non-Europe background. Besides, it is close to the Westpoort and the Amsterdam Sloterdijk station, which have become the main exposed nodes connected with other cities. However, the abundant green resources in the neighborhood can be one of the development potentials to increase its pandemic resilience.

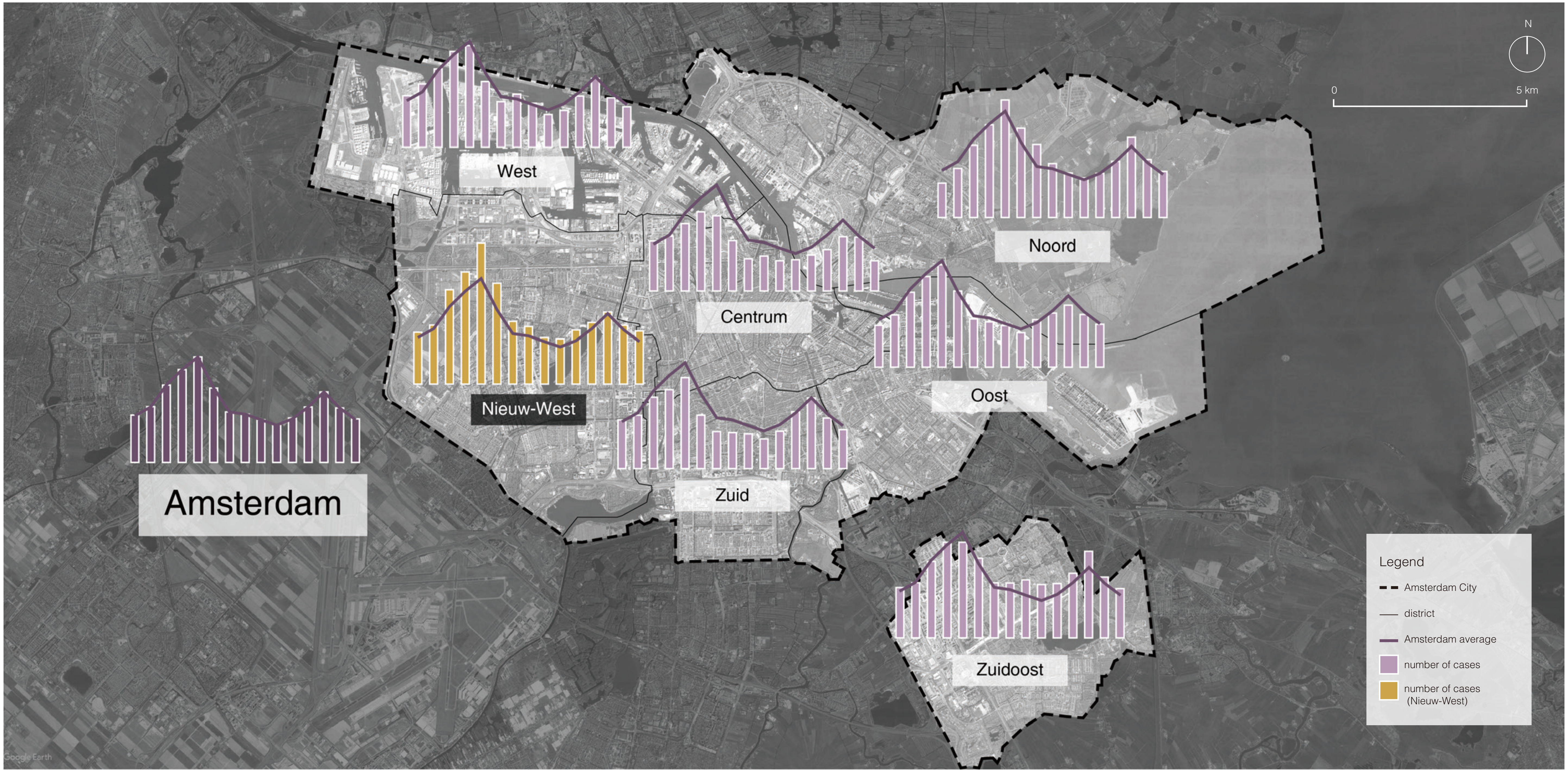
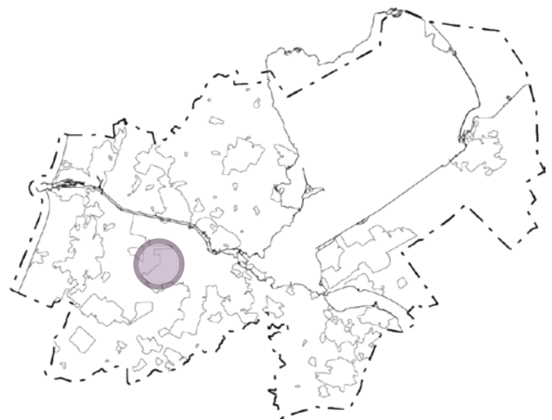


Fig. 6.2.1. The positive-tested people per districts per 10,000 inhabitants from week 39 (Sep. 21-27, 2020) to week 53 (Dec. 28, 2020 - Jan. 3, 2021). Made by author, data source: GGD Amsterdam, 24/1/2021.

2 AMSTERDAM NIEUW-WEST



Nieuw-West is a district in the west of Amsterdam City. The neighborhoods in this district are built according to the open construction method, with a lot of greenery between the buildings. It followed the Western Garden Cities in the fifties and sixties of the 20th century (Mulders, 2008). The narrow streets and floating population in the capital city make it one of the most exposed and sensitive areas to the COVID-19.

The number of infections in the Amsterdam Nieuw-West is significantly higher than in other districts. Fig. 6.2.1 shows that the share of positive-tested people from September (week 39) to December (week 51) in 2020 in Nieuw-West is above the average. The number of hospital admissions is also relatively high. The number of corona cases is consistent with preliminary findings from the spatial analysis: Amsterdam Nieuw-West is one of the most vulnerable areas of the city for the pandemic.

Fig. 6.2.6 compares all the indicators of pandemic vulnerability in Nieuw-West and Amsterdam city, highlighting more vulnerable factors that need to be improved in the area.

Firstly, Nieuw-West exposed more to the pandemic through polluted air and import/ export nodes. It is on the south of Amsterdam Westpoort, which is not only the main point of import and export but also an important source of pollution in the region (Fig. 6.2.2). The full exposure of the port exposes Amsterdam Nieuw-West to a greater danger of pandemic.

Secondly, it is sensitive in all the aspects of society, economy, infrastructure, and biophysics. The average residential density is much higher than Amsterdam, as the home of poor immigrants (Fig. 6.2.3). Over 150,000 inhabitants officially live in Nieuw-West (CBS, 2017). Only one-third of the inhabitants (36%) are Dutch, and around half of the inhabitants (46%) are non-western people. Beyond that, the infrastructure here is well below the average of Amsterdam. High traffic density and fewer utilities also make it an area of the city with the lowest levels of cycling (BYCS, 2019) (Fig. 6.2.4).

Last but not least, although Amsterdam city is more adaptable than other cities in MRA, there are still some aspects that need to be improved in Nieuw-West. The general level of education and health of the residents here is relatively poor (Fig. 6.2.5). More residents have health problems such as for overweight and disorders in Nieuw-West (GGD Amsterdam, 2018). It is known about the coronavirus that obesity can be dangerous for patients. And disorders with physical limitations need more help from their families and society.

Fig. 6.2.2. Westpoort Amsterdam. Photographed by author.

Fig. 6.2.3. Social housing in Slotervaart. Photographed by author.

Fig. 6.2.4. Highway in Nieuw-West. Photographed by author.

Fig. 6.2.5. Children in Slotermeer. Photographed by author.

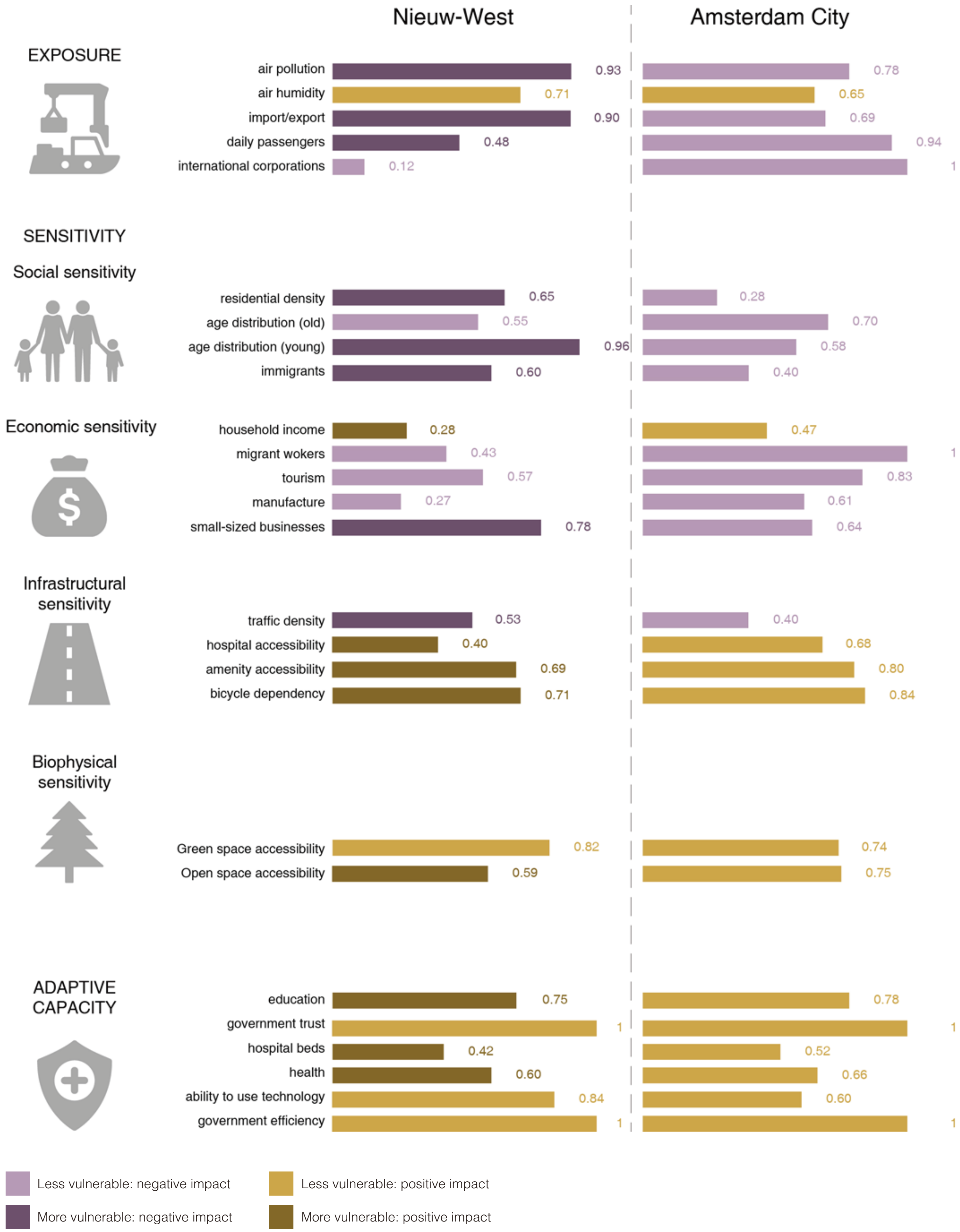
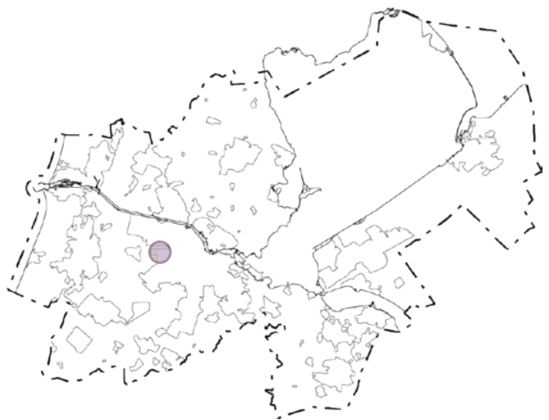


Fig. 6.2.6 Comparing score of vulnerability between Nieuw-West and Amsterdam. Illustrated by author.

Fig. 6.3.1. Aerial panoramic view of Geuzenveld-Slotermeer. Source: https://www.shutterstock.com.

3. GEUZENVELD-SLOTERMEER



Geuzenveld-Slotermeer is a community where most residents have a non-European background. Immigrants are more vulnerable than domestic residents during an infectious pandemic (OECD, 2020). The high density of living and their culture makes it difficult for this group to maintain social distance. Most of them work in the service sector, which means the difficulty of remote working, and more likely to lose their jobs during COVID-19. The economic pressures of unemployment and growing discrimination have stressed inhabitants here with more urgent problems during the pandemic. Besides, language barriers and unawareness of policy documents have left many residents beyond the latest corona measures and assistance. They are generally more difficult to reach because of their less communication with the government and institutions.

3.1 BASIC INFORMATION

Geuzenveld-Slotermeer is located to the southwest of the Amsterdam Sloterdijk railway station and is surrounded by highways and railways with heavy traffic (Fig. 6.3.6). Many residents are worried about traffic pollution and safety in the area. The danger of the streets becomes one of the main factors that prevent people from walking or cycling. However, there are abundant green space and water resources around the site, which is appreciated by residents.

It is one of the main immigrant communities in Amsterdam (Fig. 6.3.2- 6.3.4). Many people with a migration background are living here, who are mostly from Moroccan and Turkish (Claus, 2020). There is a serious problem of discrimination, not only against the minority groups but also the elderly Dutch people who live here often feel uncomfortable. Besides, the household composition in Geuzenveld-Slotermeer is mainly married with children (Fig. 6.3.5), which means a relatively large number of people living densely. As a result, the virus can spread more easily, and home quarantine is harder to enforce.

In addition, the health condition of many residents in Geuzenveld-Slotermeer, especially the old immigrants, is relatively poor. In public places, the difficulties of living together between different groups, the lack of space for activities, and social insecurity have all prevented residents from going out to improve their physical fitness. Furthermore, the pandemic affects not only physical health but mental health. 7% of residents in Geuzenveld-Slotermeer are reported with serious psychological problems, which have not been changed since 2008 (GGD Amsterdam, 2018). It can severely impair functioning and lead to long-term absenteeism especially exacerbated by lock-down measures of COVID-19.

Fig. 6.3.2. A market . Photographed by author.

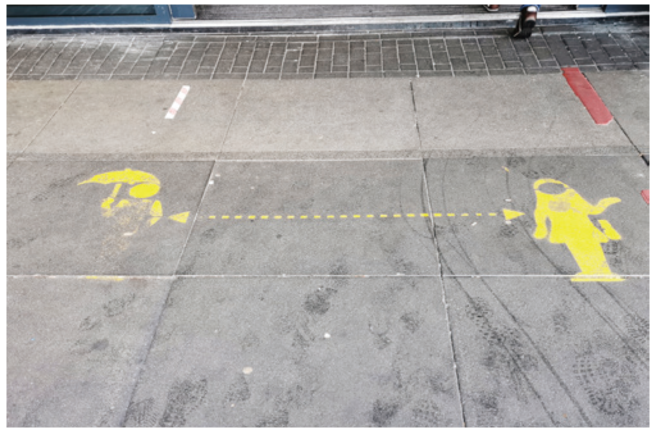


Fig. 6.3.3. A sign of social distancing. Photographed by author.

Fig. 6.3.4. An entrance with different languages. Photographed by author.

Fig. 6.3.5. Children in the neighborhood. Photographed by author.

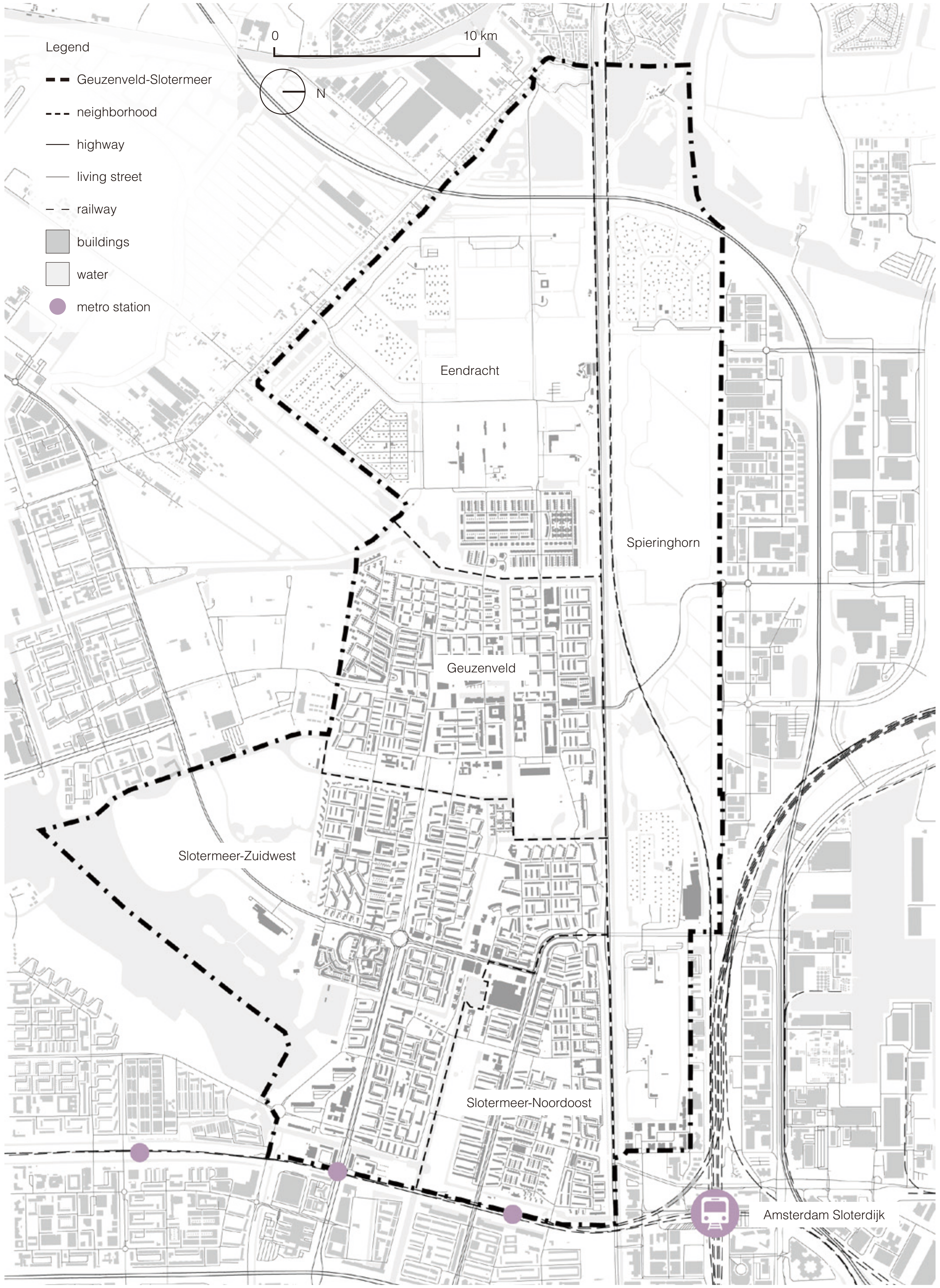
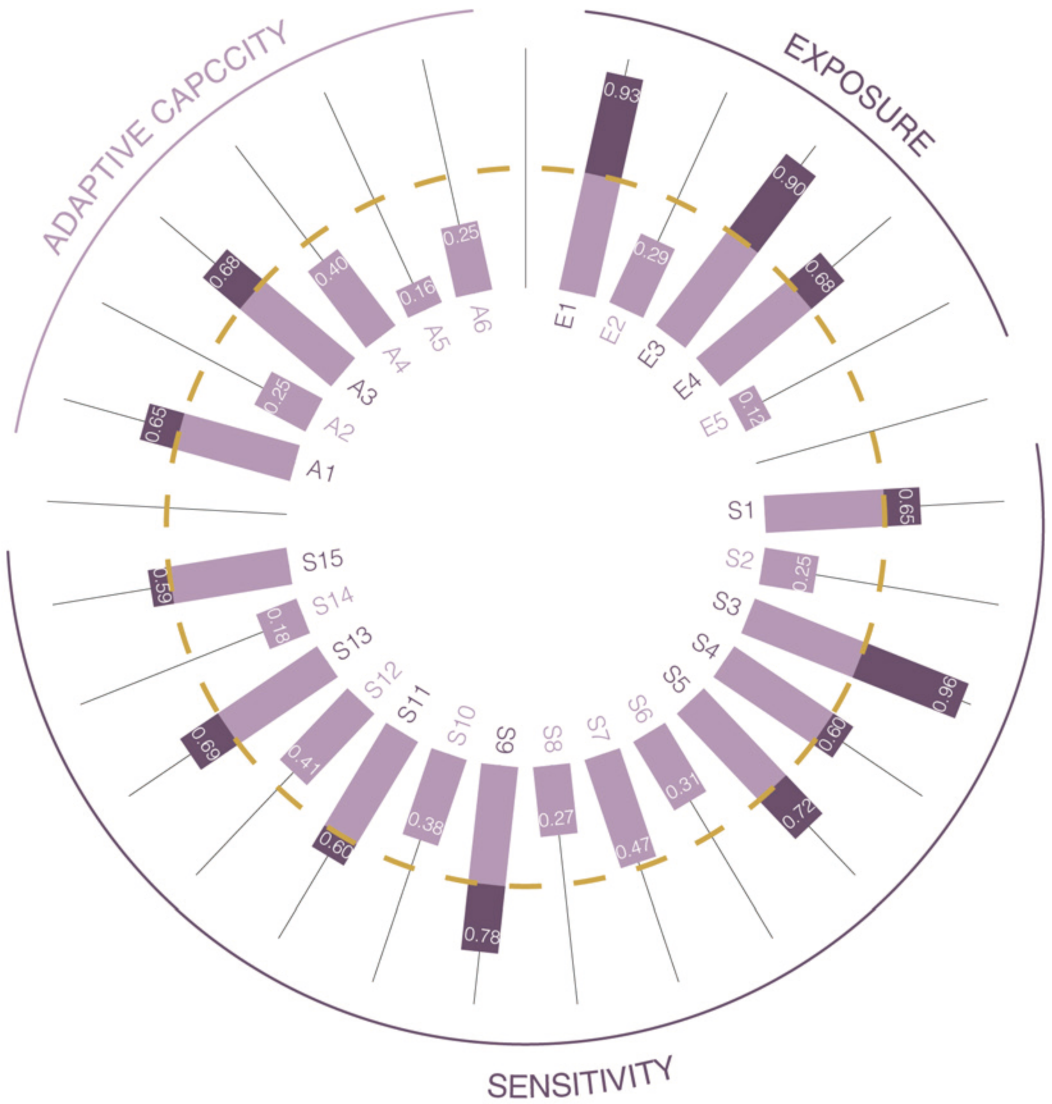


Fig. 6.3.6 Basic conditions of Geuzenveld-Slotermeer. Made by author.

3.2 QUATITATIVE INDEX



EXPOSURE

E1	air pollution
E2	air humidity
E3	import/export
E4	daily passengers
E5	international corporations

SENSITIVITY

S1	residential density
S2	age distribution (65+)
S3	age distribution (18-)
S4	immigrants
S5	household income
S6	migrant workers
S7	tourism
S8	manufacture
S9	small businesses
S10	traffic density
S11	hospital accessibility
S12	amenity accessibility
S13	motorized transport
S14	green space
S15	open space

ADAPTIVE CAPACITY

A1	education
A2	government trust
A3	hospital beds
A4	health
A5	ability to use technology
A6	government efficency

Fig. 6.3.7 Analytical indicators of pandemic vulnerability in Geuzenveld-Slotermeer. Made by author.

According to the previously established assessment framework on pandemic vulnerability, the evaluation indicators and scoring results of Geuzenveld-Slotermeer are shown in Fig. 6.3.7. All indicators are normalized from 0 to 1, where the higher the value, the more vulnerable the corresponding factor is. In the absence of concrete evidence to calculate the vulnerability thresholds, this study follows the assumption that the median of the regional indicator is a standard of high vulnerability. It means that a score above 0.5 is a high-vulnerability indicator, while a score below 0.5 is the opposite. Therefore, 13 indicators of Geuzenveld-Slotermeer were finally listed as high-vulnerability indicators, including 3 for exposure, 8 for sensitivity, and 2 for adaptive capacity.

Then, this project proposed the corresponding strategy and planning indexes according to the responses of indicators. Based on the previous discussion, Geuzenveld-Slotermeer belongs to the second type of vulnerability, with high exposure, high sensitivity, and high adaptive capacity. Meanwhile, according to the political strategy proposed by Amsterdam for COVID-19, adaptive capacity can be easier to improve rapidly in a short time. Thus, this study mainly focuses on solving problems of exposure and sensitivity.

The main strategy of decreasing exposure is to full use local resources by building a circular network. It aims to achieve self-sufficiency, reduce the damage to the external environment and the possibility of being affected by risks. Firstly, due to its proximity to Westpoort, Geuzenveld-Slotermeer is severely affected by air pollution from the construction industry. Therefore, it is necessary to reduce the use of raw materials by 43% to reduce air pollution. Secondly, the community is one of the main destinations for imported food, so it is to reduce the amount of import by 40% through urban agriculture, and short food chain. Finally, there is a need to reduce daily commuting by 18% by providing access to remote working.

The main strategy to reduce the sensitivity is to improve the quality of life for residents through community renovation. For example, provide more affordable housing to increase the per capita housing area by 15%, and to reduce the risk of infection among residents. Besides, the mental health of children can be protected by increasing the number of their activity space by 46%. By promoting the recycling, repairing and reuse of consumer goods, it will decrease the cost of living for residents with more job opportunities. Finally, the flexible use of community space can reduce the vulnerability of small businesses, improve hospital accessibility, reduce the dependence on motorized transport, and increase open space.

POLICY RESPONSE	INDICATOR	CURRENT POINT	STRATEGY	PLANNING INDEX
decreasing exposure	air pollution	0.93	decrease new raw materials	43%
	import/export	0.90	shorten food chains	40%
	daily passengers	0.68	promote remote/community working	18%
decreasing sensitivity	residential density	0.65	more affordable housing	15%
	age distribution (18-)	0.96	more activity space for children	46%
	immigrants	0.60	cultural diveristy	40%
	household income	0.72	increase recycling and repairing with job oppotunities	22%
	small businesses	0.78	increase combination with e-commerce	28%
	hospital accessibility	0.60	increase community clinics	10%
	motorized transport	0.69	promote cycling	19%
	open space	0.59	increase safe open space	9%
increasing adaptive capacity	education	0.65	promote education for residents	15%
	hospital beds	0.68	increase (temporary) hospital beds	18%

Table 6.3.1 Planning strategies and indexes in local scale in Geuzenveld-Slotermeer. Made by author.

4. MICRO DESIGN PRINCIPLES

4.1 ADAPTABILITY

Dynamic planning mainly includes two parts: adaptability and transformability. Adaptability emphasizes the ability to adapt and persist (Adger, 2003, P1). It lies in facilitating the efficient flow of ideas and resources through flexible networks while increasing the diversity of connections between people and institutions (Janssen et al., 2006). Therefore, in this project, the pandemic resilience is mainly manifested as the urban space, function, and structure which can be reversibly converted for an outbreak. The micro-strategies of 13 indicators are shown in Fig. 6.4.1.

Moreover, as a policy of resilience, this unique construction will lead to winners and losers (Meerow & Newell, 2016). As for the strategy for a particular indicator, this project also needs to focus on the indirect impact on ones that are currently less vulnerable. It explores whether their vulnerability will be increased even beyond the threshold as a result of implementing the policy. Therefore, in each strategy, besides the impact on its own indicator, there is also the main factor indirectly affected. Through flexible change, we can quickly reduce the index of influencing factors to 0.5 in a short time to improve the resilience of the community. Meanwhile, due to the different relationships among factors, this project takes the average value, linear 0.5 times, as an estimation formula of indirect influence to simplify the calculation and comparison.

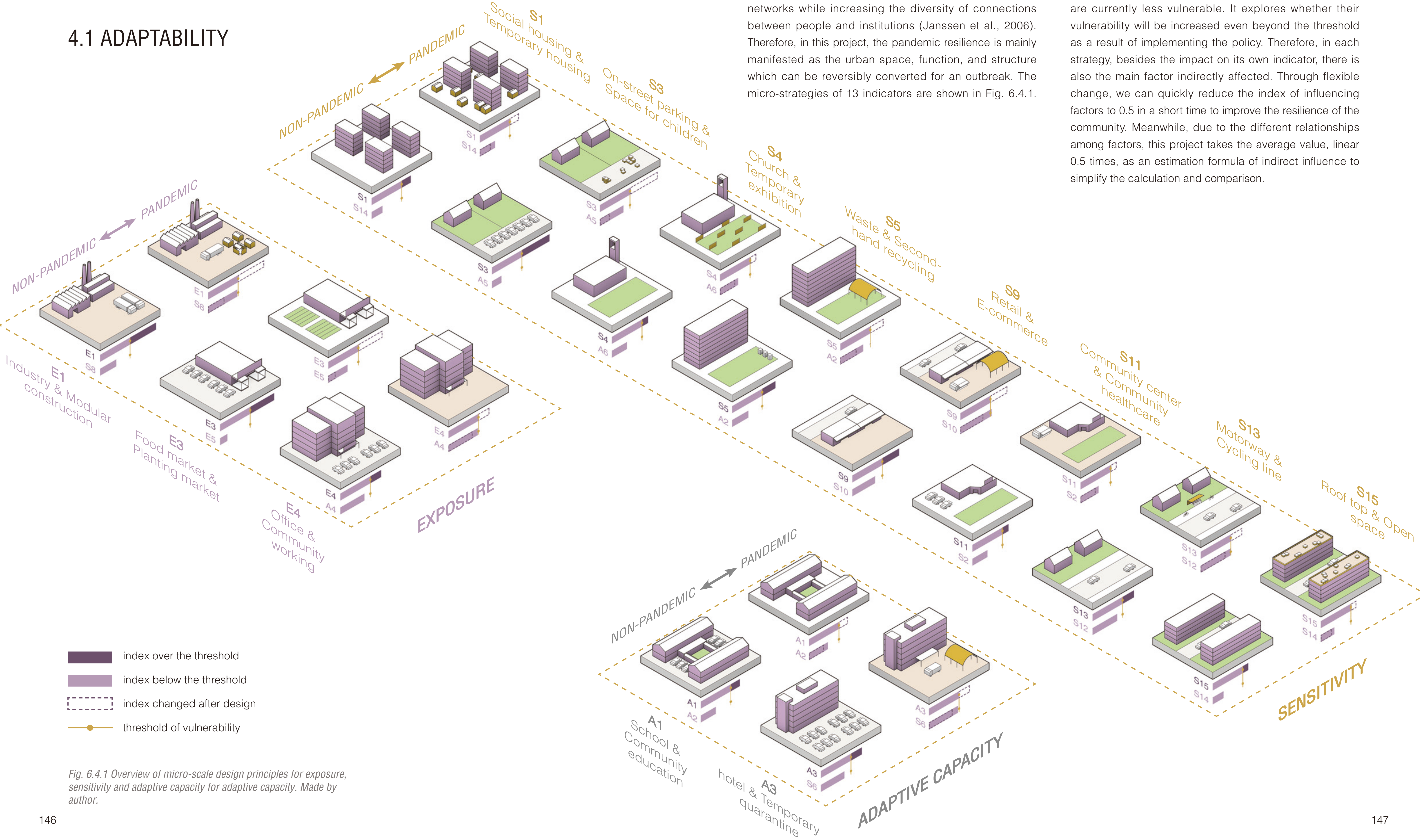


Fig. 6.4.1 Overview of micro-scale design principles for exposure, sensitivity and adaptive capacity for adaptive capacity. Made by author.

4.2 TRANSFORMABILITY

Transformability considers the process from creative destruction 'Ω' to reorganization 'α'. This stage is difficult to control in the ecosystem. However, in the socio-ecological ecosystem, Ω can be regarded as a potential and opportunity for transformation, through policies to guide the population activities to transfer into new systems (Davoudi, 2012). Therefore, strategies of transformability are mainly long term, slow, and future-oriented. It can improve SESs not only in response to the pandemic but more generally in terms of urban resilience (Fig. 6.4.2).

Besides, different from adaptability, the strategy of transformability focuses on improving urban resilience by changing the threshold. Reflected by the data in this project, it means that the threshold for determining whether a particular indicator is a high vulnerability can be raised to over 0.5. Accordingly, indicators are less vulnerable through the change of thresholds, which can also reduce the indirect negative impact on other factors. Therefore, for calculation in this project, the change of threshold is equal to the former data of indicators without indirect impacts on others.

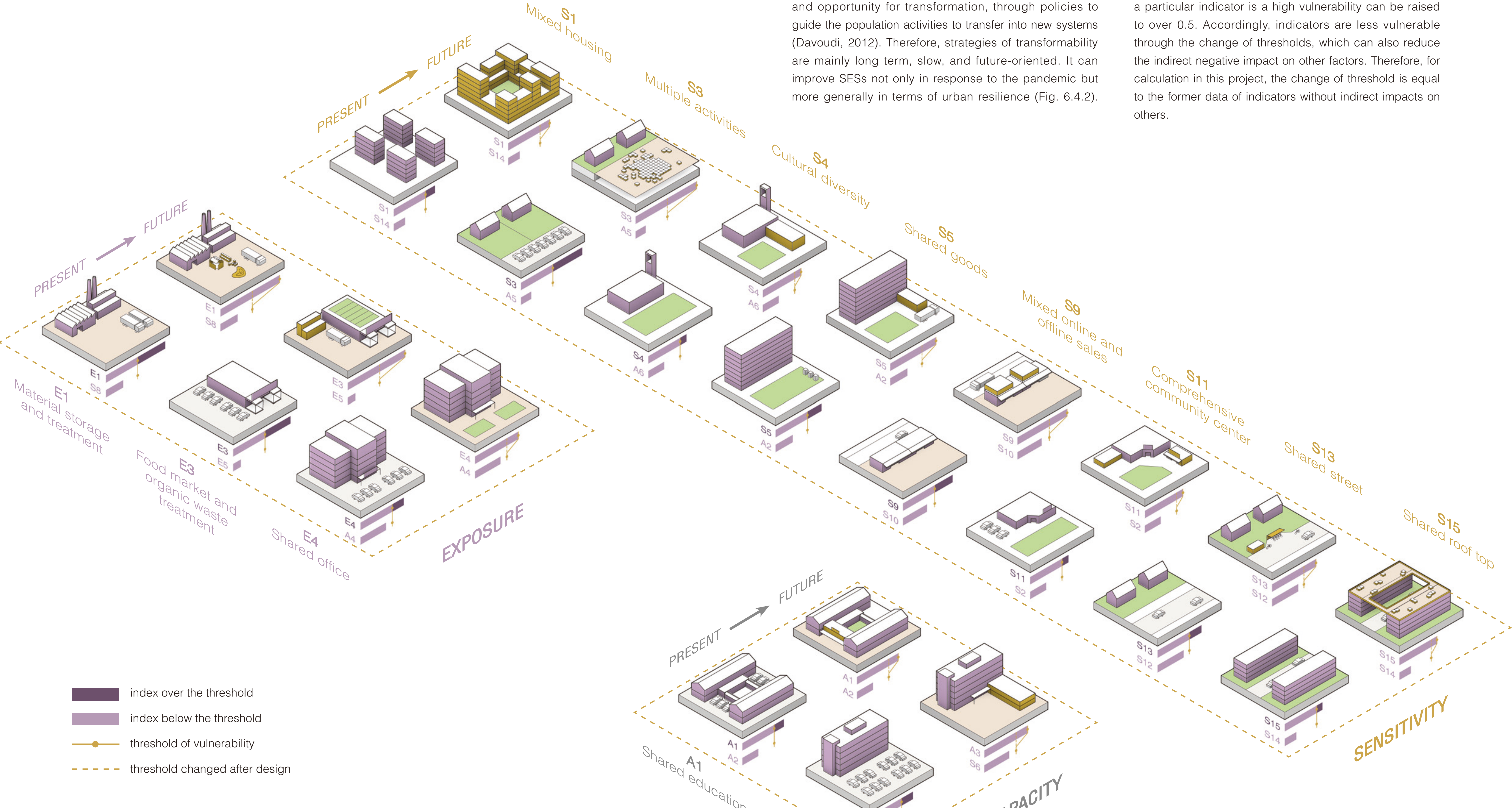


Fig. 6.4.2 Overview of micro-scale design principles for exposure, sensitivity and adaptive capacity for transformability. Made by author.

4.3 APPLICATION IN DIFFERENT AREAS

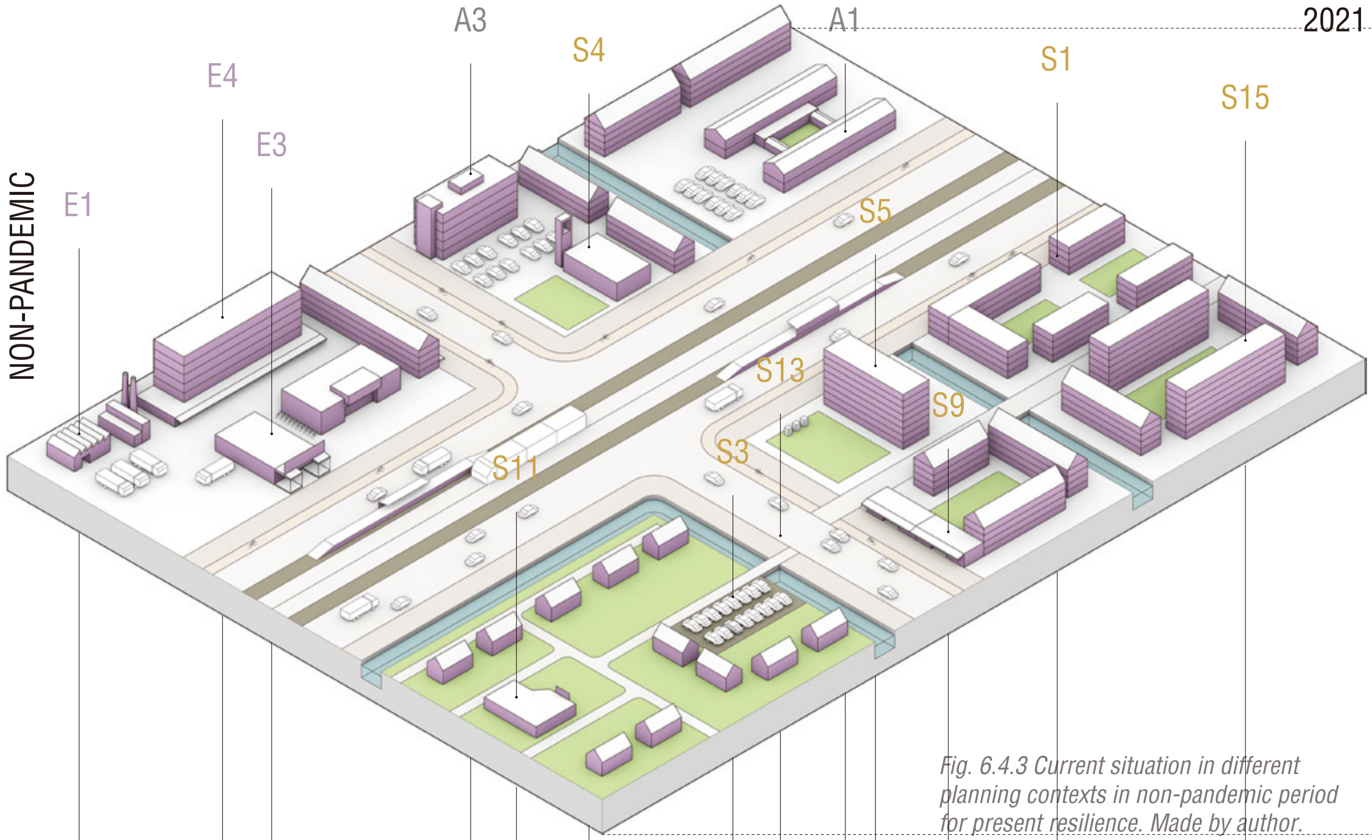


Fig. 6.4.3 Current situation in different planning contexts in non-pandemic period for present resilience. Made by author.

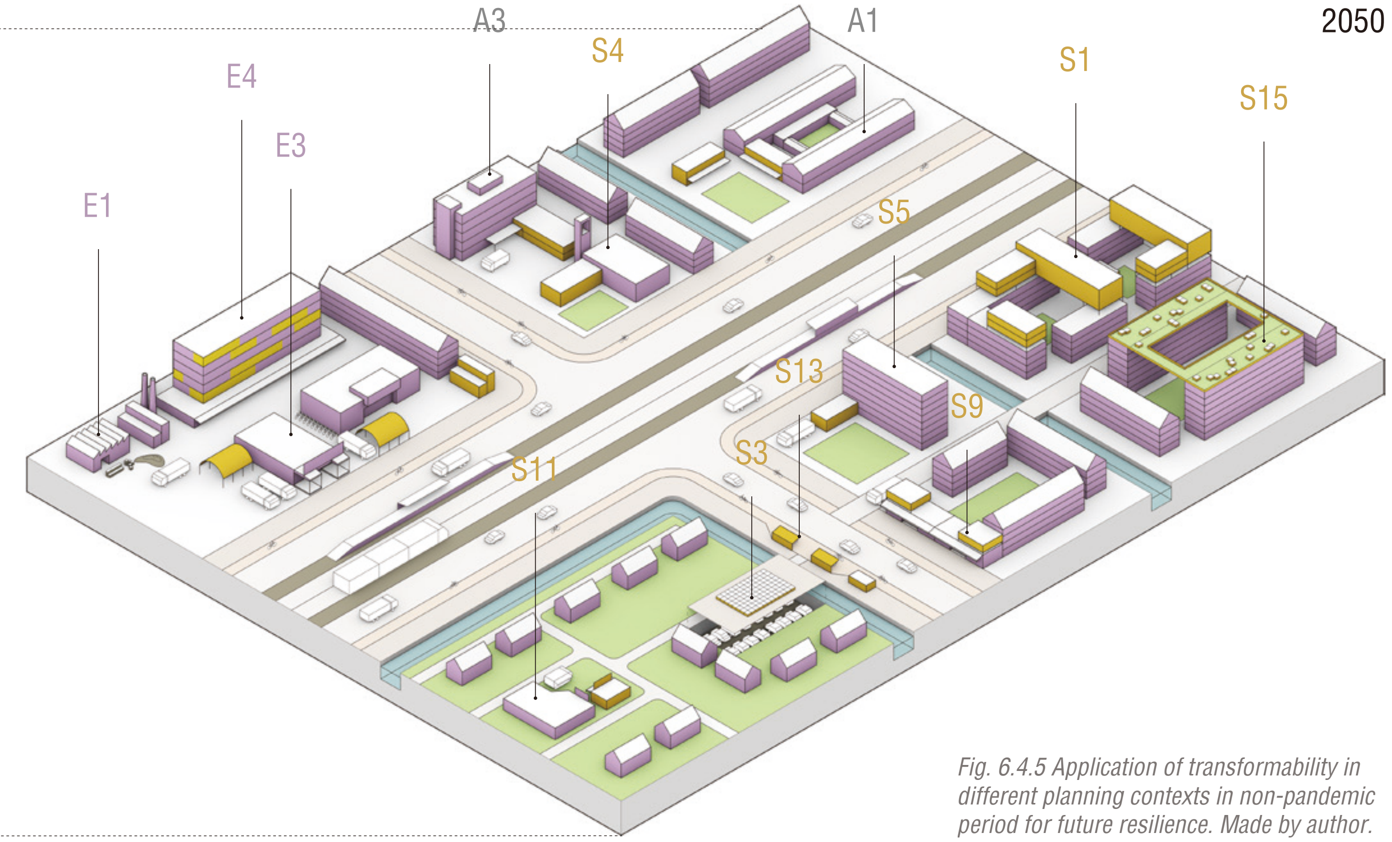


Fig. 6.4.5 Application of transformability in different planning contexts in non-pandemic period for future resilience. Made by author.

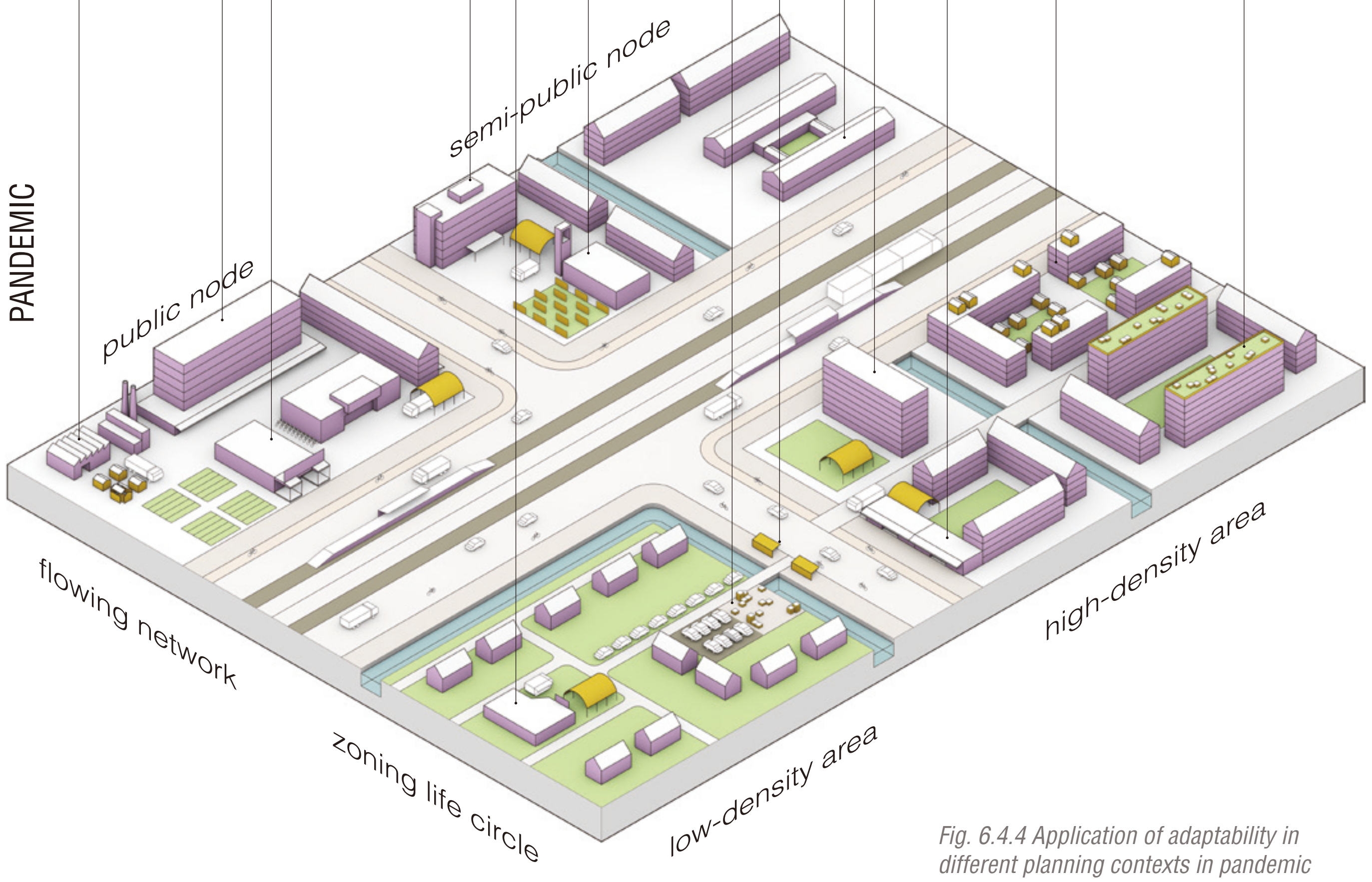


Fig. 6.4.4 Application of adaptability in different planning contexts in pandemic period for present resilience. Made by author.

Not all design principles can be used in any location or context. The dynamic planning in this project emphasizes the dynamic change between the flowing network and the zoning life circle under different periods and different resilient demands of the city. Fig. 6.4.3-6.4.5 show where each design principle should be used in the four types.

In the flowing network, this project focuses on the spatial design of nodes: full public nodes and semi-public nodes. Full public nodes refer to urban functions and spaces that can cover or affect the most citizens, such as the construction of factories, plazas, food markets and office buildings. These places are also the primary spaces for determining the community's exposure to the pandemic. Semi-public nodes are places where buildings, such as schools, hotels, churches, or mosques, can only affect the lives of a certain number of residents at a certain time. Because they can only be used for certain activities, they are mostly affected during a pandemic and also have the greatest potential for spatial conversion.

The strategy for life cycles is mainly to reduce the sensitivity of residents, which can be divided into two categories according to the density: low-density areas and high-density areas. Low-density areas are characterized by scattered, low-rise housing and private open spaces. They are isolated from the main community structure, and because of low accessibility, residents rely on cars for their daily commuting. Therefore, the design principles for low-density areas are mainly about the efficient use of open space, community center, and reducing the reliance of residents on motor traffic. High-density areas are characterized by the opposite: multi- or high-rise buildings, while public facilities are distributed along the street. Therefore, the design here firstly needs to solve the conflict between the high-density construction and the social space required by the pandemic. Then, there is the need to solve the economic problems of residents here and provide them with enough available necessities.

5. LOCAL APPLICATION

According to the design principles in different contexts, the project then selected four places for the application of the micro-scale design. They correspond to the public node of the network, the semi-public node of the network, the high-density life circle, and the low-density life circle (Fig. 6.5.6). All locations have big impacts, not only on the resilience of specific pandemics but also on the resilience of the community in general over the long term.

The public node Plein '40-'45 is in the east of Geuzenveld-Slotermeer, as the intersection of the main public transport lines within the community. This site is now the public center of the community. It includes not only a series of public buildings such as shopping malls, supermarkets, banks, and office buildings, but also a plaza, the site of an open market in the community. The design here explores how it can quickly support the service and resource during the pandemic, and how it can undertake urban functions outside the community in the future to facilitate the efficient flow of resources.

Semi-public node Lambertus Zijlplein is in the center of Geuzenveld-Slotermeer, which is the terminus of the tram line within the community. There are some fully public urban functions, such as shopping malls, but most of them are semi-public spaces, including hotels, schools, and mosques. This design explores how it can move from semi-public to fully public, and finally take over some functions of public nodes in the system, forming a more flexible network.

The high-density life cycle Burg. V. Leeuwenlaan is in the east of Geuzenveld-Slotermeer, close to the central public node. There are mainly Postwar social housing, characterized by high density with little public space. Most of the residents here have low income and are highly sensitive to the pandemic. This design, thus, explores its community renewal. It aims to quickly meet the social distance during a pandemic, reduce the density of population activity, and form a more resilient and diverse community in the future.

The low-density life cycle Garden Park TIGENO is in the southwest of Geuzenveld-Slotermeer, away from the community's main public spaces and public transport. It is a neighborhood of single housing, with only one neighborhood center serving the residents. Due to the traffic conditions and location, residents here are mostly disconnected from the whole community. This design explores the possibility of sharing in the neighborhood with high privatization, to enhance communication between people and achieve the full utilization of resources.

Therefore, a simplified schematic of the urban system will firstly present the current 'urban systems' on sites (Fig. 6.5.1). According to the analysis of the current situation, the local design will be proposed based on the definition of socio-ecological resilience. Design principles in microscale are to improve the adaptability and transformability. Moreover, these two design approaches will be illustrated by the '5 Ws' framework to clarify who for whom? Where? What? When? And why?

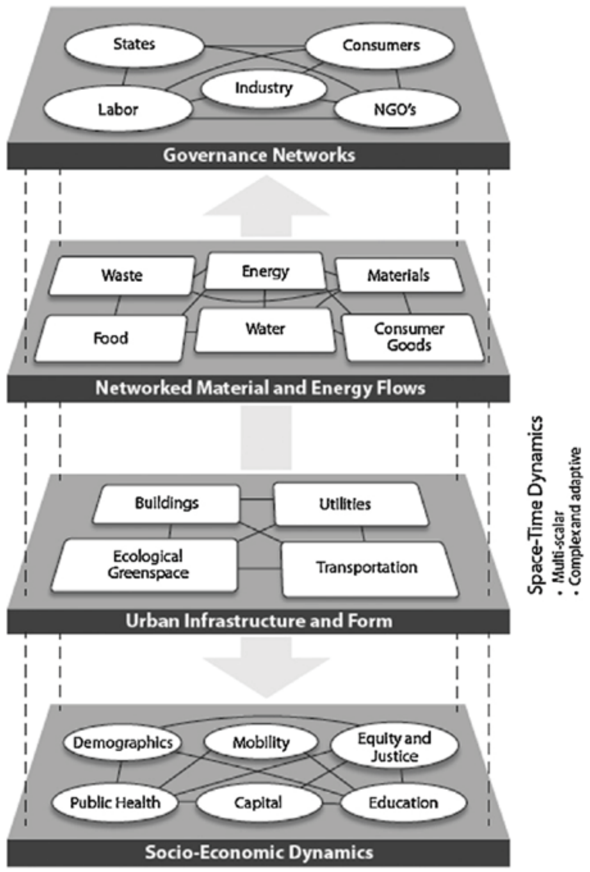


Fig. 6.5.1 A conceptual schematic of the urban system proposed by Meerow et al. (2016) and inspired by Dicken (2011).

Fig. 6.5.2-6.5.5 Current situation of focused areas. Photographed by author, 2020.

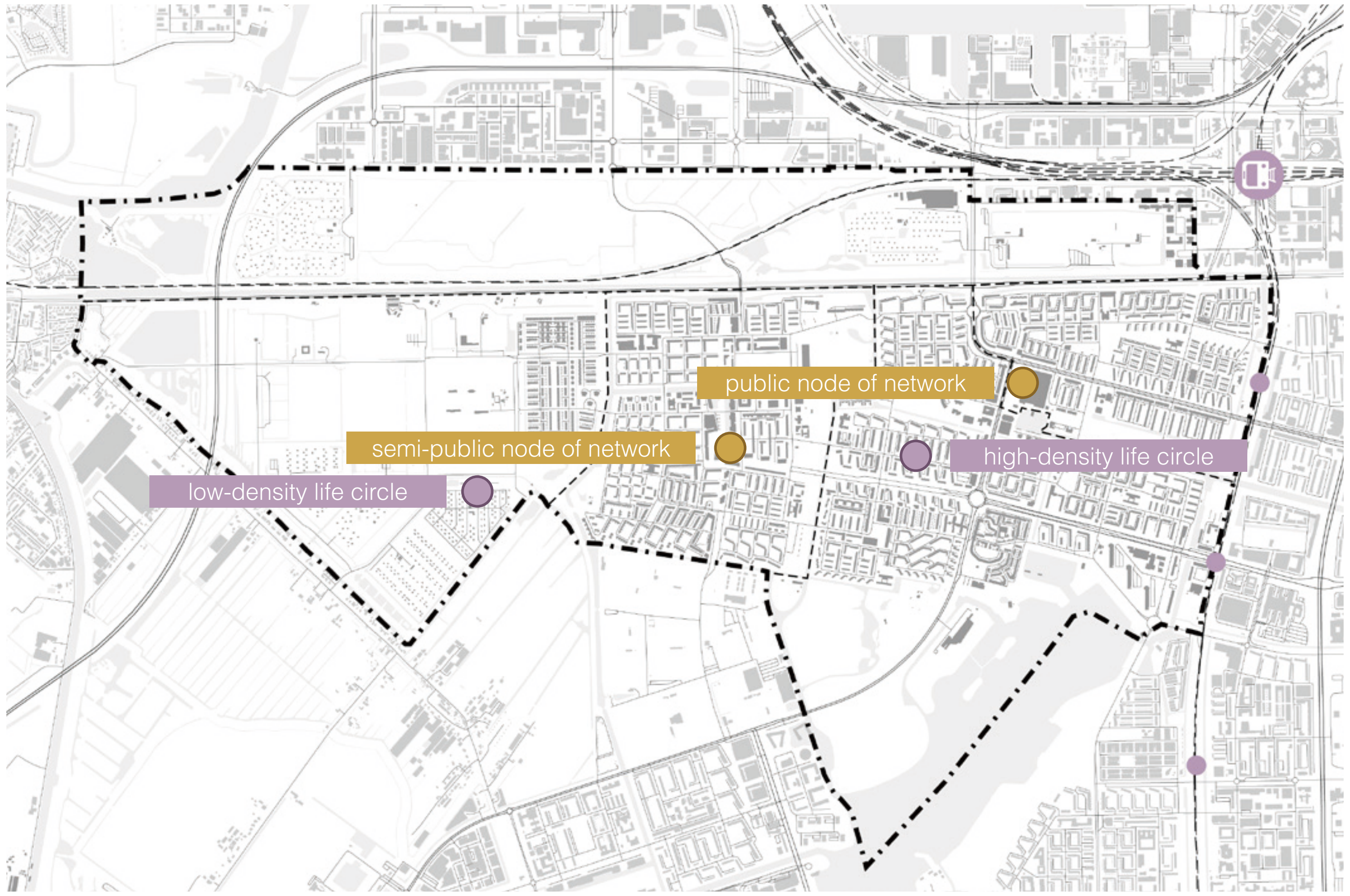


Fig. 6.5.6 Location of focused areas in Geuzenveld-Slotermeer. Made by author.

5.1 PUBLIC NODE OF NETWORK

5.1.1 Current situation

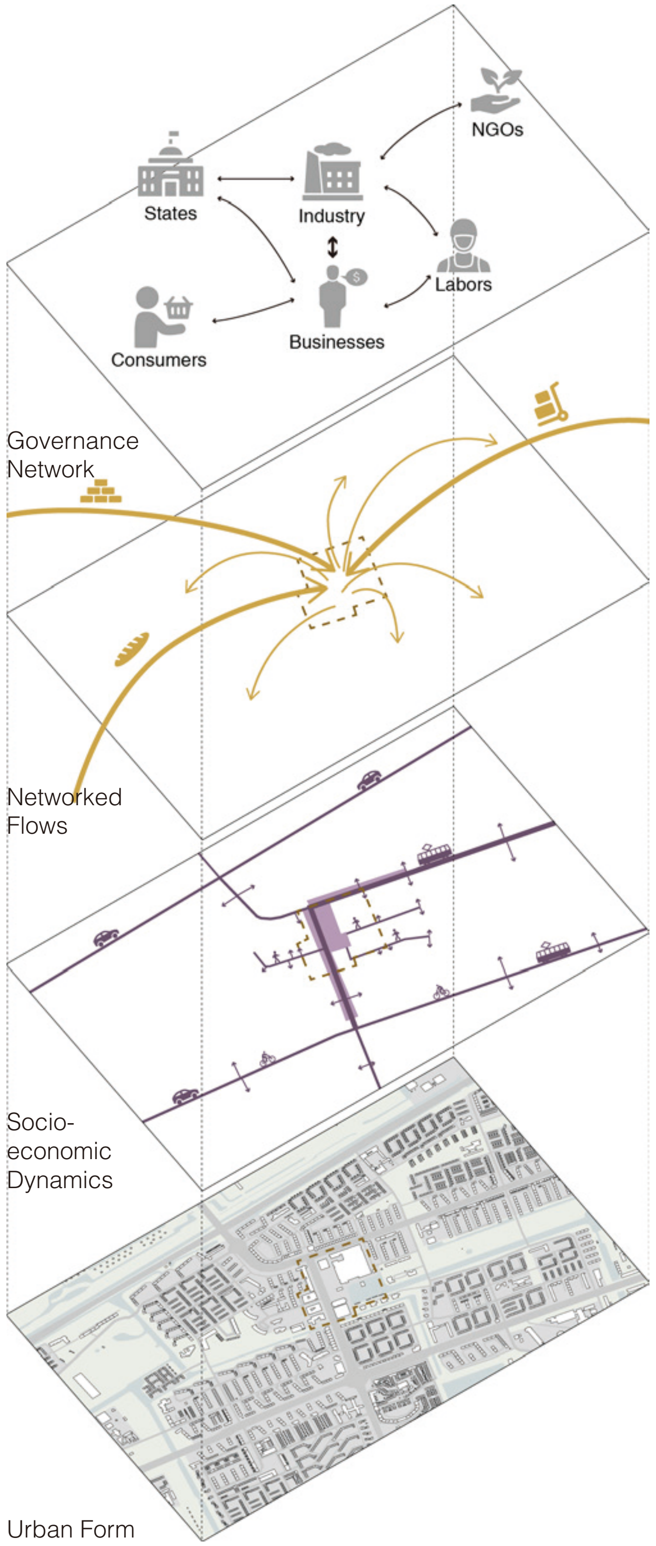


Fig. 6.5.7 Analysis of 'urban system' on the site. Made by author, proposed by Meerow et al. (2016) and inspired by Dicken (2011).

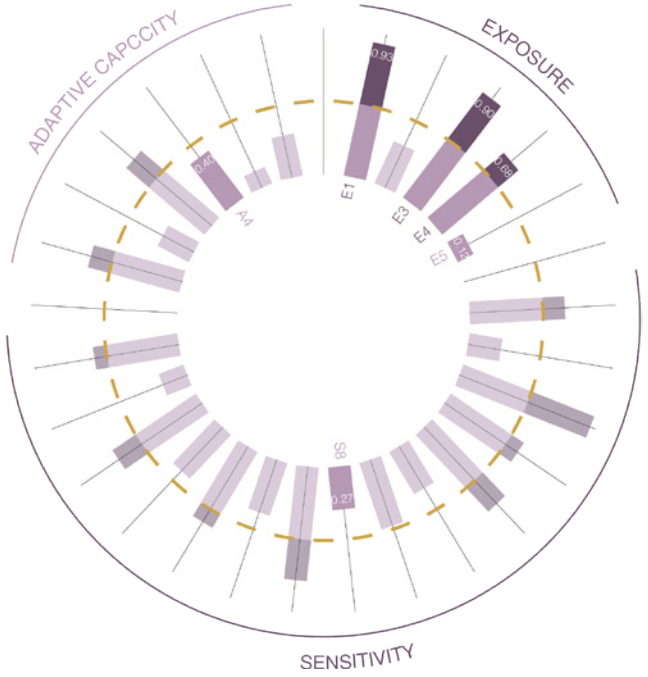


Fig. 6.5.8 The evaluated indicators of current situation for public node of network without pandemic. Made by author.

The Plein '40-'45 is in the east of community Geuzenveld-Slotermeer in Amsterdam Nieuw-west. Currently, it is a community center with mono-functional commercial buildings (Fig. 6.5.9). The open square in front of the market and office building is one of the main public spaces in the community (Fig. 6.5.10). There are four subsystems in the complex and networked systems: urban infrastructure and form, socio-economic dynamics, networked material and energy flows, and governance networks (Fig. 6.5.7). In this schematic, urban infrastructure and form consist of the built environment and green networks. It is shown as not only the center of community amenities but the entrance of green space and parks. The mobility of the population shows the socio-economic dynamics in the community. Besides nearby neighborhoods that can be reached by foot, most of the residents are coming from the east and south along the walkable streets. Networked material and energy flows include materials in the system. The site is a transfer center for materials, where resources move, concentrate, and then distribute to the population, missing all kinds of waste flows. Governance network refers to the different actors and institutions. The main stakeholders on the site are businesses and industries included, connected with laborers and consumers here, and also related institutions like levels of government and NGOs.

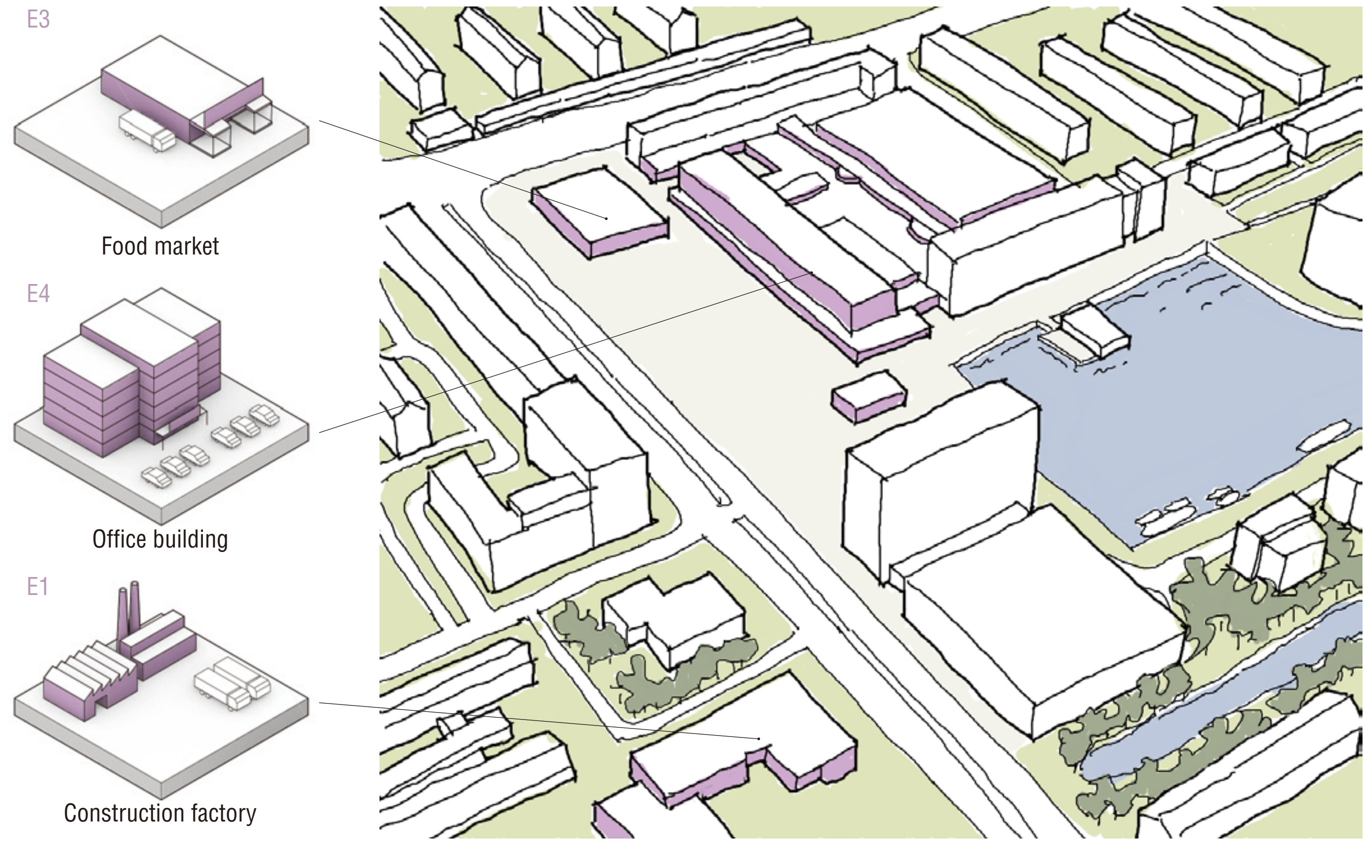


Fig. 6.5.9 Isometric map of current situation for public node of network without pandemic. Made by author.

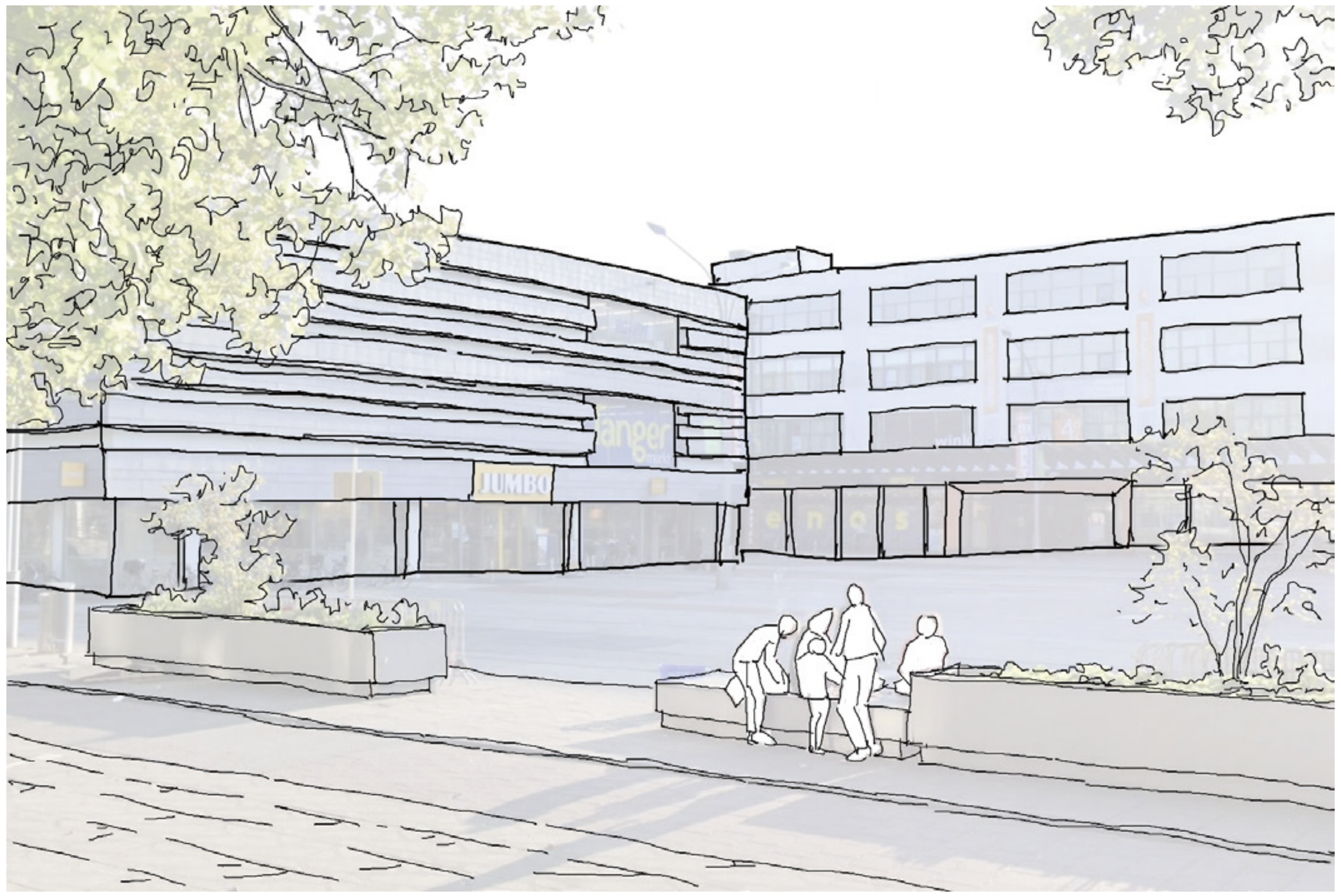


Fig. 6.5.10 Impression of current situation for public node of network without pandemic. Made by author.

5.1.2 Adaptability

WHO		Resilience of current community residents facing the pandemic are prioritized.
WHAT	TRADEOFFS	Specifically focused on pandemic mitigation.
WHEN		Focus on current situation and fast-onset changes for current estimates of risk.
WHERE		Areas with the most resources of utilities exposing to the pandemic.
WHY		Goal is a process: increase persistance, the speed of recovery and reduce investments for pandemic.

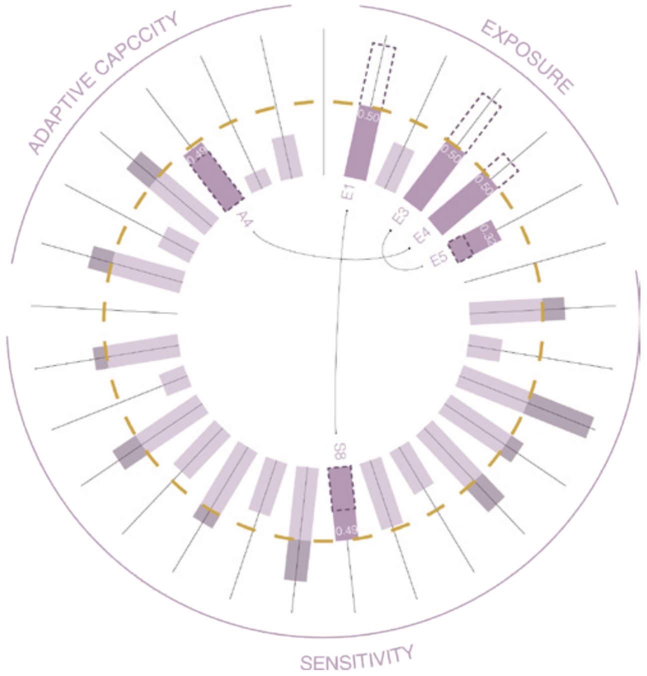


Fig. 6.5.11 The evaluated indicators of adaptability for public node of network during the pandemic. Made by author.

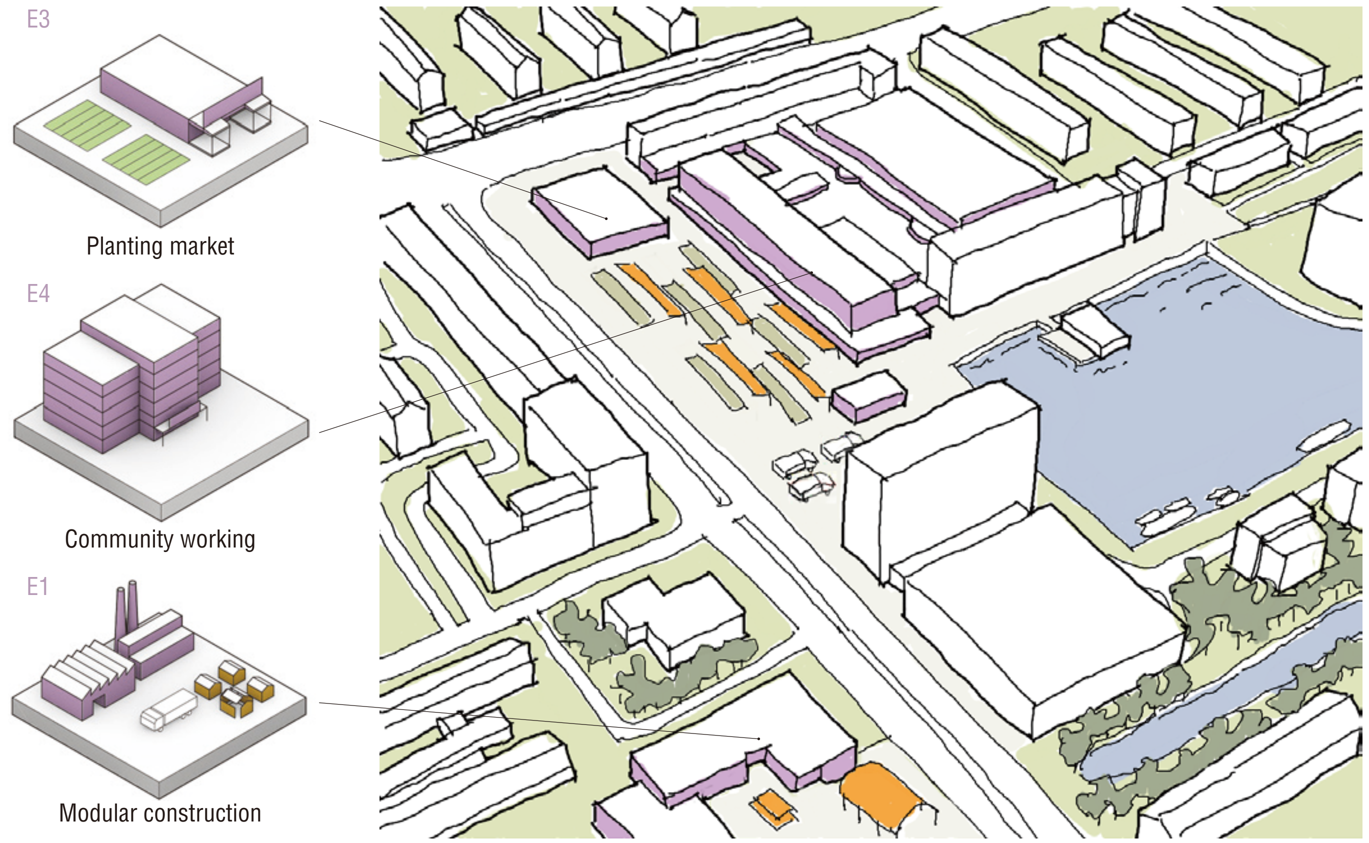


Fig. 6.5.12 Isometric map of adaptability for public node of network during the pandemic. Made by author.

Adaptability focuses on the urban system which can efficiently, safely, and quickly carry out the conversion of space, function, and activities. It is to mitigate the direct or indirect impact of the pandemic. Fig. 6.5.11 explains the tradeoffs on the site. Adaptability emphasizes a quick response to the current situation for the current population in the community. Improving the adaptability of the network public node represents the increased resilience of vulnerable indicators. It will lead to indirect impacts on others below the threshold through a transforming process.

Therefore, the design aims to quickly improve the community's adaptability through the dynamic change of buildings and public spaces and functions, using existing resources (Fig. 6.5.12). First of all, the transition between safe outdoor space and unsafe indoor space during the pandemic determines the trend of public activities moving out. Public activities in the food market currently can be more outdoor as an open market (Fig. 6.5.13). To alleviate the impact of the food import-and-export chain, we can increase businesses of urban farms. Secondly, the office buildings have to become useless because of online working, which can provide a place for local communities to telecommute and reduce commuting during the pandemic. Thirdly, construction industries are forced to stop in an outbreak, with reduced construction activities. However, during the pandemic, there is an increasing demand for housing to meet safe housing densities. Therefore, the industries can promote modular construction, speed up construction, and reduce air pollution through automated factories.

Finally, through flexible spatial and functional changes, this public node can become the center of the community's material flow in a pandemic. It can not only continue to provide existing living facilities for residents but also undertake some functions of cities outside the community, shorten the transportation distance for residents and mitigate the spread of diseases.

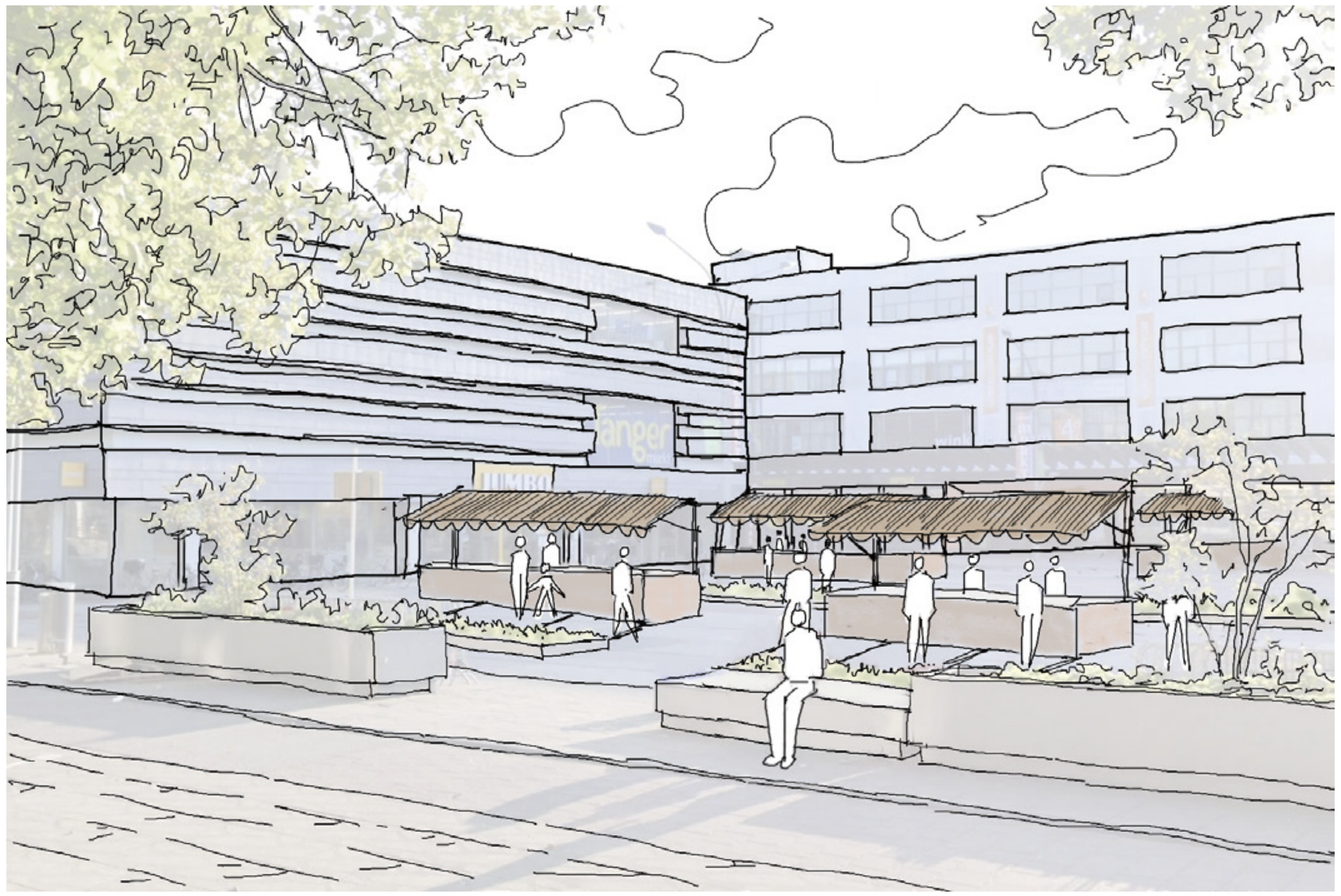


Fig. 6.5.13 Impression of adaptability for public node of network during the pandemic. Made by author.

5.1.3 Transformability

	TRADEOFFS	
WHO		Resilience of future generations with the most limited access to amenities are prioritized.
WHAT		Generically focused on resilience of the community and MRA.
WHEN		Based on slow-onset changes for long-term resilience in the future.
WHERE		Areas with the most flexible and alternative public space within the community boundaries.
WHY		Goal is an outcome: social justice and ecological friendly.

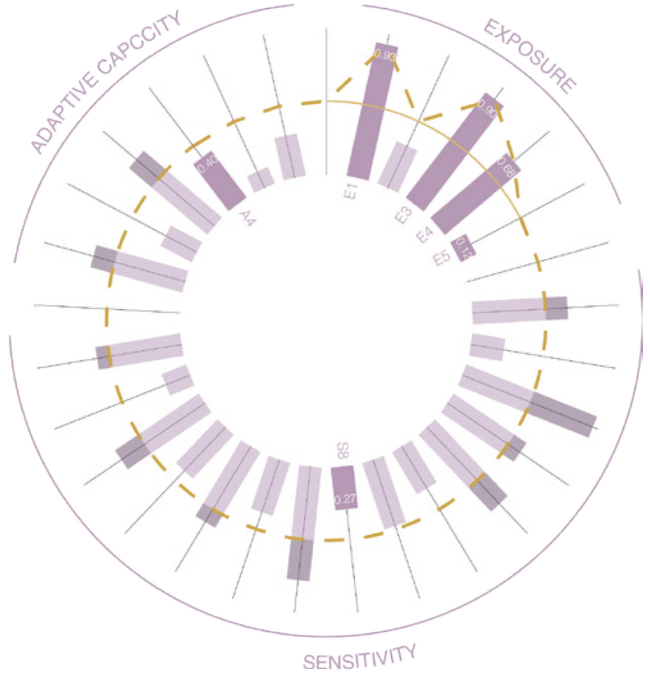


Fig. 6.5.14 The evaluated indicators of transformability for public node of network in 2050. Made by author.

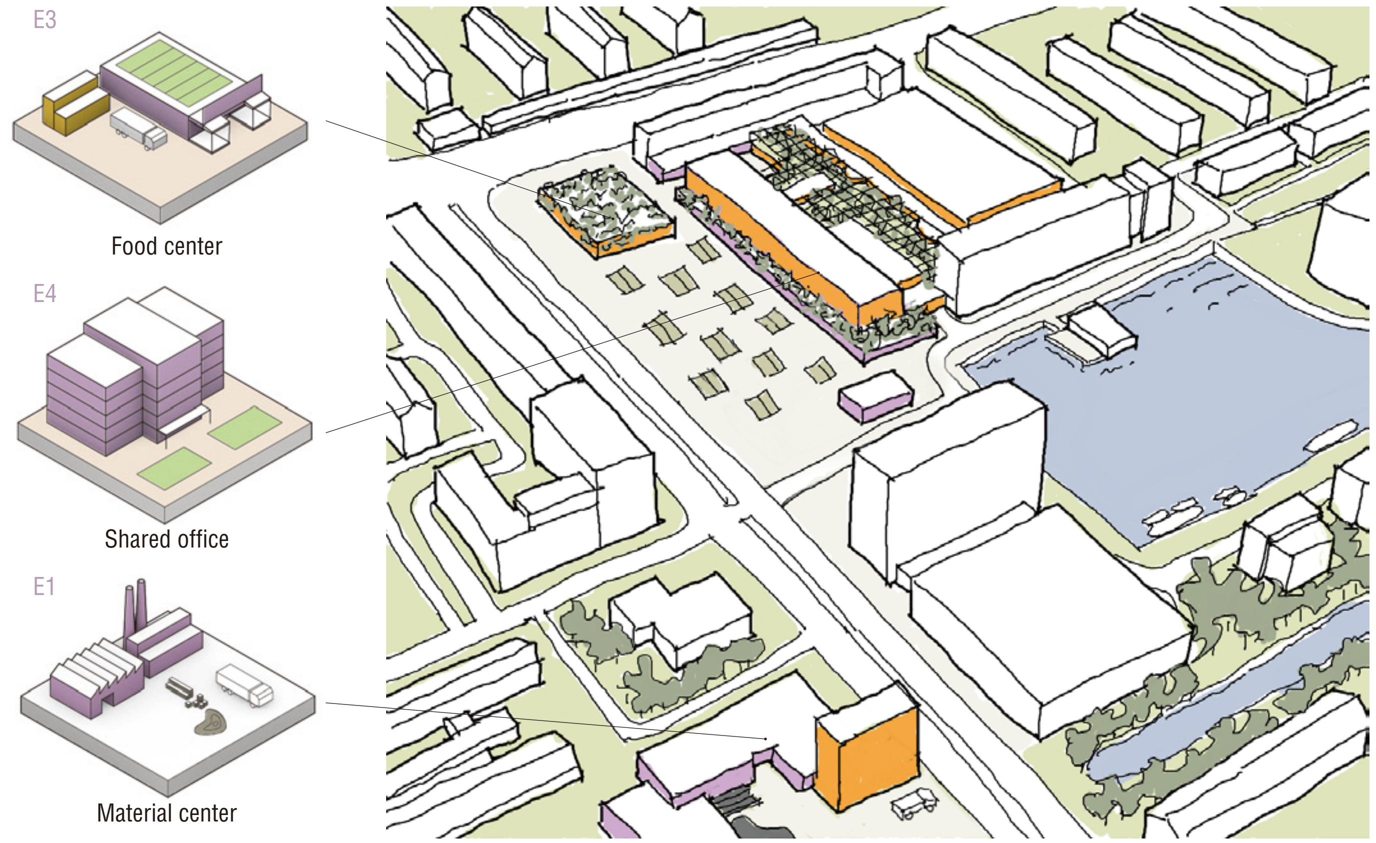


Fig. 6.5.15 Isometric map of transformability for public node of network in 2050. Made by author.

Transformability improves the long-term urban resilience of urban systems by promoting their daily flexibility and resourcefulness. Thereby, it can reduce the likelihood of serious infectious outbreaks by reducing ecological, social, and economic vulnerability. Fig. 6.5.14 shows the evaluated indicators of transformability. Its priority concern is the resilience of future generations and the need to address urban resilience over the long term, from communities to MRA, through a series of slow-onset changes. The space of the public node needs to be flexible and alternative. Therefore, different urban activities can be accommodated on the site to achieve the goals of Doughnut Economics: social justice and eco-friendly. Finally, the thresholds of vulnerable indicators, E1, E3, and E4, will be increased through transformability.

Therefore, the design emphasizes how to improve the flexibility and resourcefulness of the community system through the transformation of this public node (Fig. 6.5.15). First of all, to further shorten and complete the food chain, it can form a food center based on the original food market from planting, selling to the local organic waste recycling. Secondly, there will be an increasing requirement for flexibility of office buildings after COVID-19. Space needs to be transformed from fixed businesses and specific activities into shared office space. They can be used not only for corporations but also for the community residents on weekends. Therefore, the activities in the central square of the community will be more diversified (Fig. 6.5.16), and different public activities will be organized for different users at different times. It can also take advantage of its openness to promote circulation on weekends, further improving social resilience. Thirdly, similar to the food center, construction factories can also be developed into a material center involving production, local material recycle and reuse to reduce air pollution and achieve full circulation.

Finally, by raising transformability, the adaptability of the site can be remembered. Therefore, the public node can be converted from the current spatial with fixed functions and activities, to a center of the circular network with different activities and different functions at different times. Accordingly, the distribution of resources in the community will be more flexible, pollution will be reduced, and the economy will be more diversified to protect from future epidemics. It also makes the urban system easier to change more quickly to improve resilience facing a pandemic again.

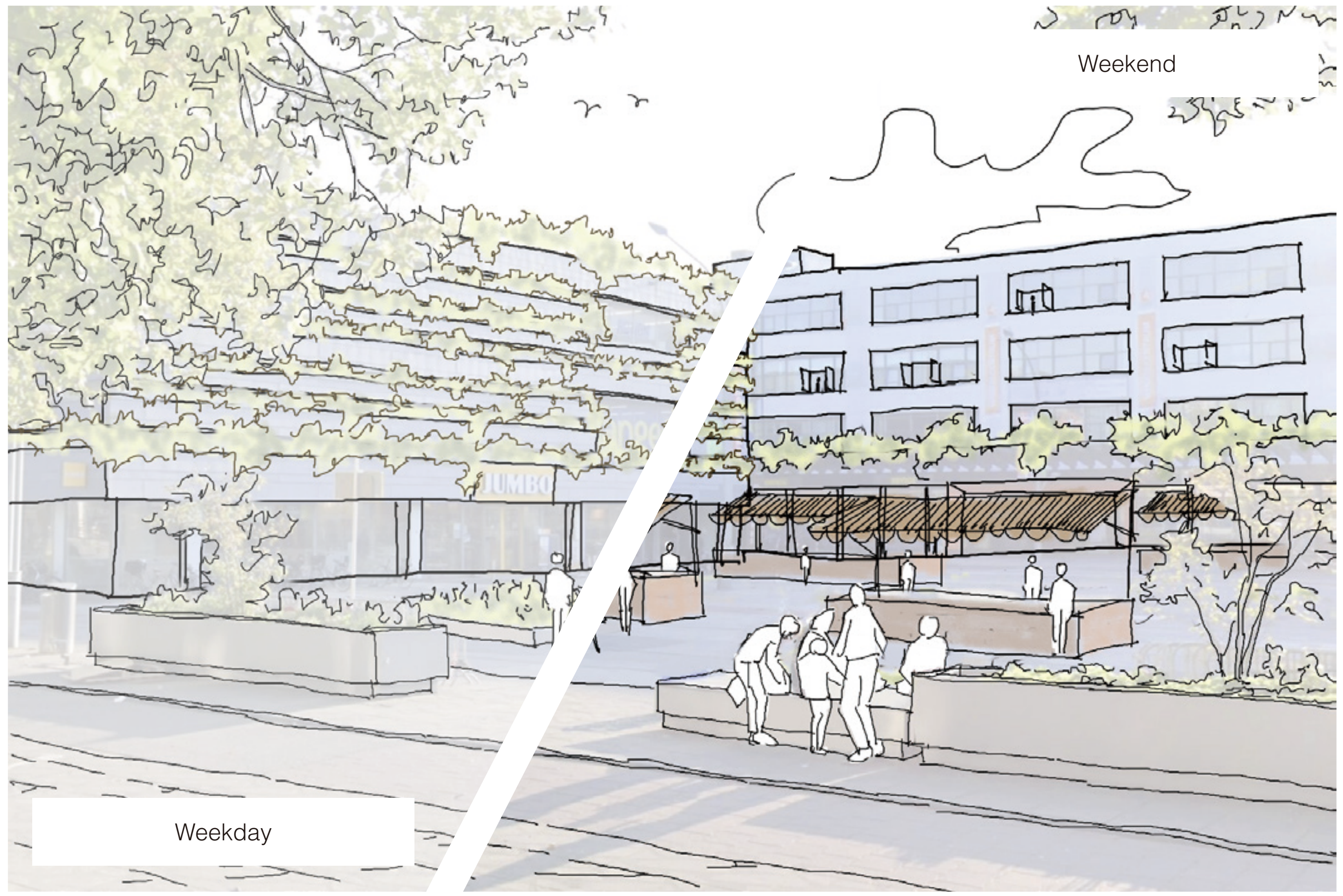
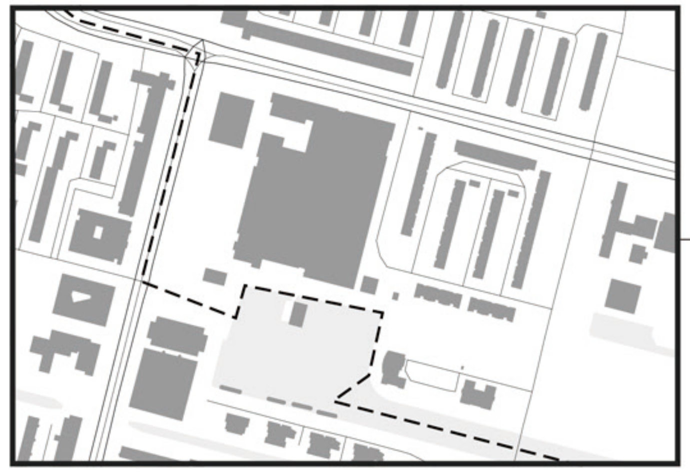


Fig. 6.5.16 Impression of transformability for public node of network in 2050. Made by author.

5.1.4 Implement roadmap



Current situation

Adaptability

Local-led

Transformability

Public-led

Stage 1AP

In the first stage of adaptability, the local-led implementation is released. Customers and labors are going to adapte spontaneously to the pandemic, starting from changing the activities from indoor to outdoor. This is a bottom-up approach to fully use the plaza for different activities, mitigate the spread of virus, and promote the third stage of transformability.

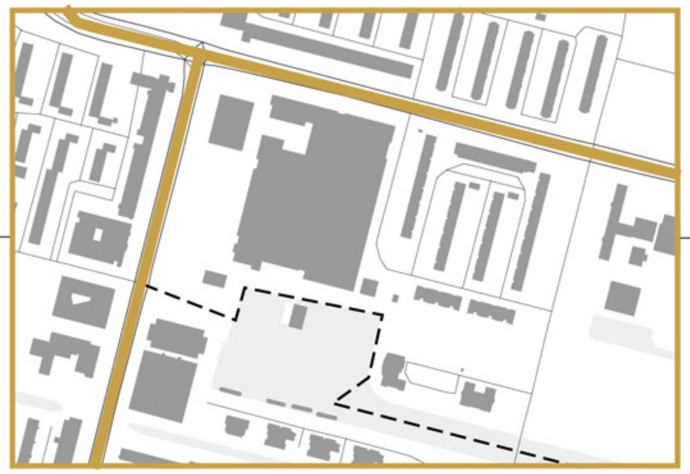
Stage 2AP

The second stage will be implemented through the corporation between businesses, factories, and NGOs to mitigate the pandemic. Most of the industries will be digital and circular. This experimental strategy can promote the circular and efficient use of resources. The adaptation can be also facilitated by the second stage of transformability.

Stage 3AP

The first two stages of the adaptation will reduce population flow and increase the remote delivery and working. Therefore, in the third stage, it is important for municipalities to organize rapid infrastructure improvements for logistics and the Internet. Meanwhile, with the implementation of transformation, this step can adapt to the epidemic more efficiently.

Stage 1TP



Planning for transformability is a long-term and public-led process. In the first phase, municipalities are being organised to work with public transport and industries to facilitate the infrastructure transformation. The construction of connected tram line and pedestrian-friendly street can provide the basis for later strategies. This step is also beneficial to temporary adaptability.

Stage 2TP

In contrast to adaptability, factories, NGOs and businesses will work together to renovate the industry in the public node. The first stage can promote the sharing and flexible use of resources. Therefore, they will transform from a center of output to a center of circulation.

Stage 3TP

In the third stage, residents and labors can participate in the design with businesses. The previously shared infrastructure and circular resources will further facilitate the sharing of private goods and space. At the same time, this step can promote the rapid implementation of adaptability during the epidemic.

Strategic space

Strategic building

Strategic connection/ infrastructure

Implement roadmap

Interactive impact

Fig. 6.5.17 Implement roadmap with different stakeholders in the public node. Made by author.

5.2 SEMI-PUBLIC NODE OF NETWORK

5.2.1 Current situation

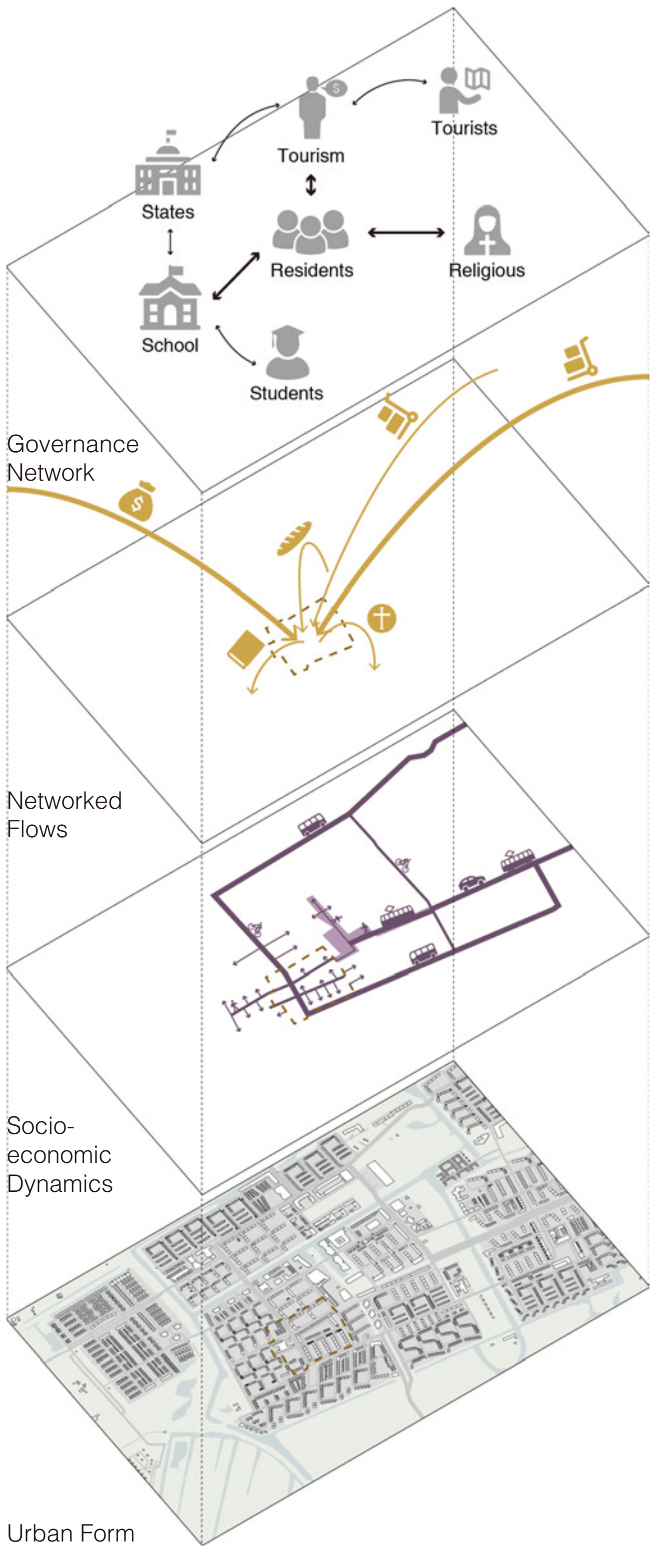


Fig. 6.5.18 Analysis of 'urban system' on the site. Made by author, proposed by Meerow et al. (2016) and inspired by Dicken (2011).

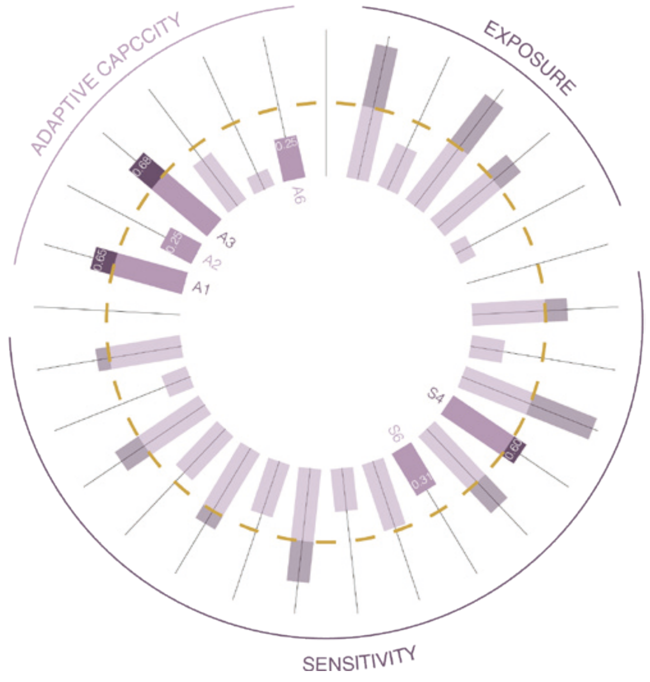


Fig. 6.5.19 The evaluated indicators of current situation for semi-public node of network without pandemic. Made by author.

Lambertus Zijlplein is located at the terminus of tram line 13 in the west of Geuzenveld-Slotermeer. It is the living center for the surrounding population, where most of the buildings and public space can be open to a limited number of people, such as schools, hotels, and mosques (Fig. 6.5.20). The main problems the site facing to solve are education and hospital beds in adaptive capacity, and migration of sensitivity, which correspond to the three spatial forms (Fig. 6.5.18). High traffic accessibility in this area is not fully utilized. It is close to the tram terminal, but the internal public space is not tightly connected to the station. The main street in the site is a north-south road. It serves as an entrance to the surrounding public space and neighborhood units, with no direct connection to the station. Besides, because these common resources are only used by a small number of people, the flow network here is different from Plein '40-' 45 as a resource destination. For example, the school does not distribute educational resources outside but isolates students from residents through fences (Fig. 6.5.21). Such partially privatized management makes them lose their positive role as public resources to society. Finally, the abundance of public functions leads to a diverse set of stakeholders, related to the local population.

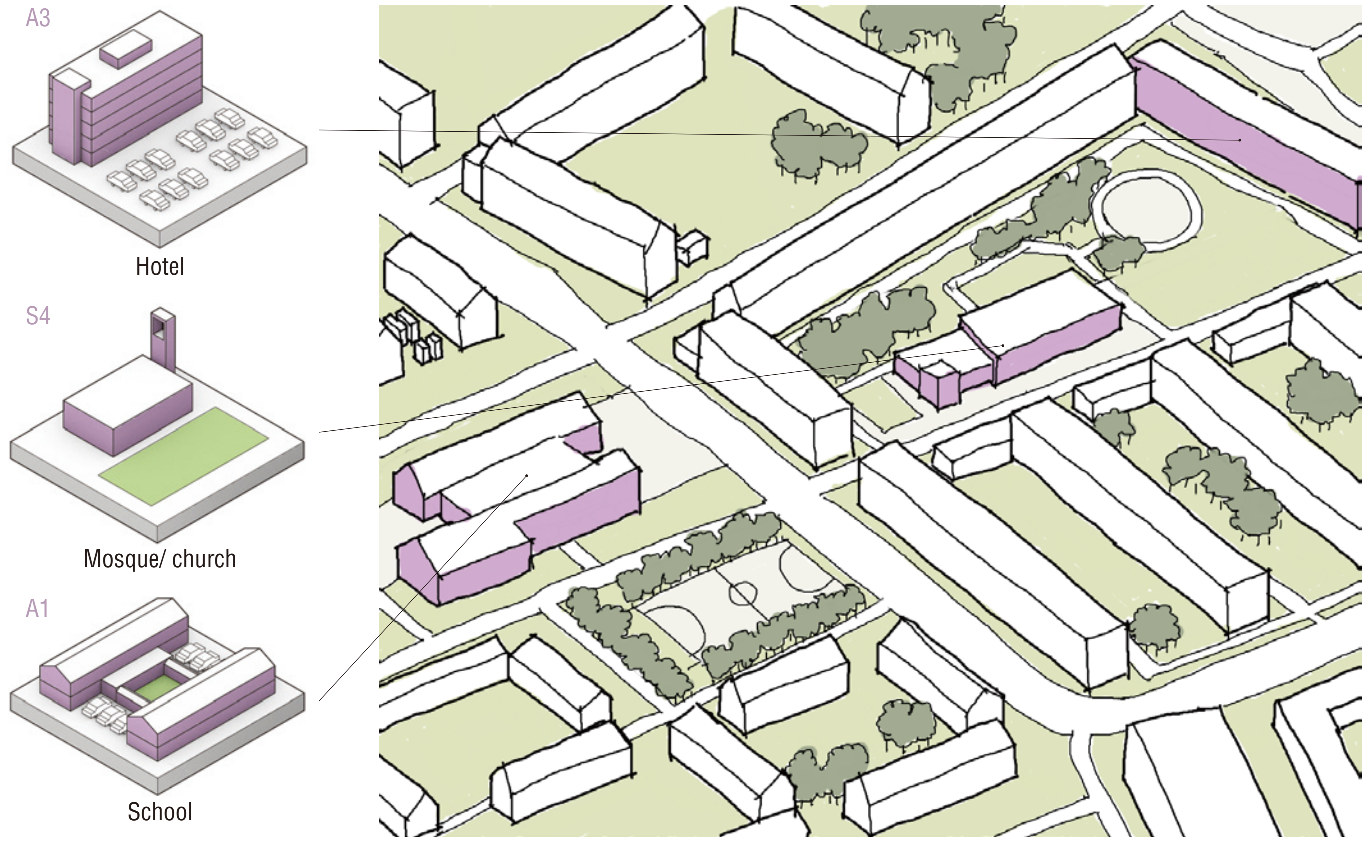


Fig. 6.5.20 Isometric map of current situation for semi-public node of network without pandemic. Made by author.

Fig. 6.5.21 Impression of current situation for semi-public node of network without pandemic. Made by author.

5.2.2 Adaptability

	TRADEOFFS	
WHO		Resilience of current community residents and visitors facing the pandemic are prioritized.
WHAT		Specifically focused on pandemic mitigation.
WHEN		Focus on current situation and fast-onset changes for current estimates of risk.
WHERE		Areas with the potential but underutilized public resources within the community boundaries.
WHY		Goal is a process: increase persistance, the speed of recovery and reduce investments for pandemic.

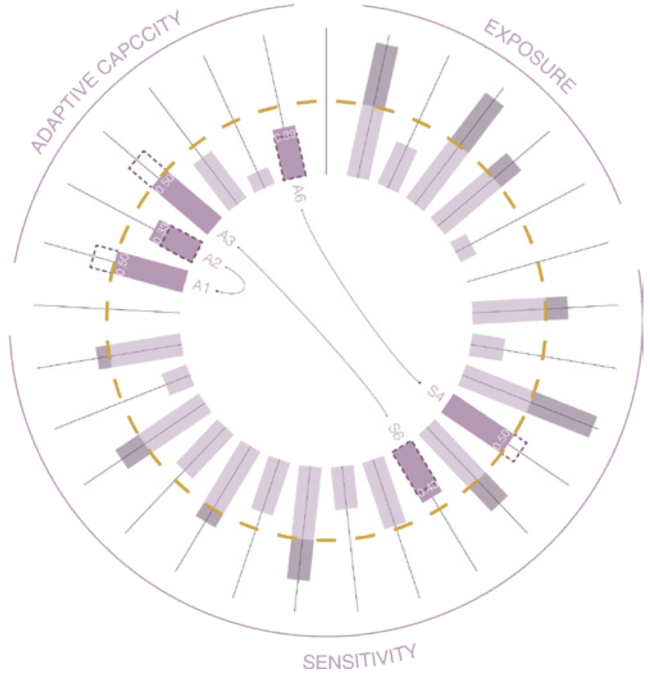


Fig. 6.5.22 The evaluated indicators of adaptability for semi-public node of network during the pandemic. Made by author.

Adaptability in this site emphasizes how to quickly reduce vulnerability indicators in the short term and improve the community's adaptive capacity. These emergency strategies are likely to lead to the growth of several other indicators below the threshold while decreasing vulnerable indicators. As with planning for public nodes, planning for the semi-public node is to focus on current residents and visitors. It aims to rapidly improve the special resilience to the pandemic by taking advantage of existing conditions (Fig. 6.5.22). There is a rich potential of public resources without fully exploited.

Therefore, the design is mainly to provide the needed conditions to deal with the pandemic through some temporary changes in space and management (Fig. 6.5.23). First of all, during the outbreak, the decrease in tourism will leave a lot of empty space in hotels. They can be converted into temporary quarantine places to provide hospital beds for residents. Secondly, the mosque or church can become a cultural center of the community, hosting some cultural activities from outside the community, such as exhibitions, art galleries, museums. They are surrounded by an outdoor space that can be used for temporary publicity. Thirdly, education during the pandemic will be mainly conducted remotely, when public resources within the school can be available to the population. As shown in Fig. 6.5.24, the fences around the school will be removed to increase the openness and accessibility of the school. The outdoor square can be fully utilized to organize some safe educational activities.

Finally, the semi-public node can be quickly opened to the public through the temporary adaptation of spare resources. Adaptive capacity can be improved in a short period. The site will become another node in the network besides the original community center, providing residents with cultural, educational, and health resources to resist. In this way, the flow of people will shift from being concentrated in the city center to ensuring their quality of life within communities. It will not only reduce the pressure on the community center but also mitigate the vulnerability of Amsterdam city.

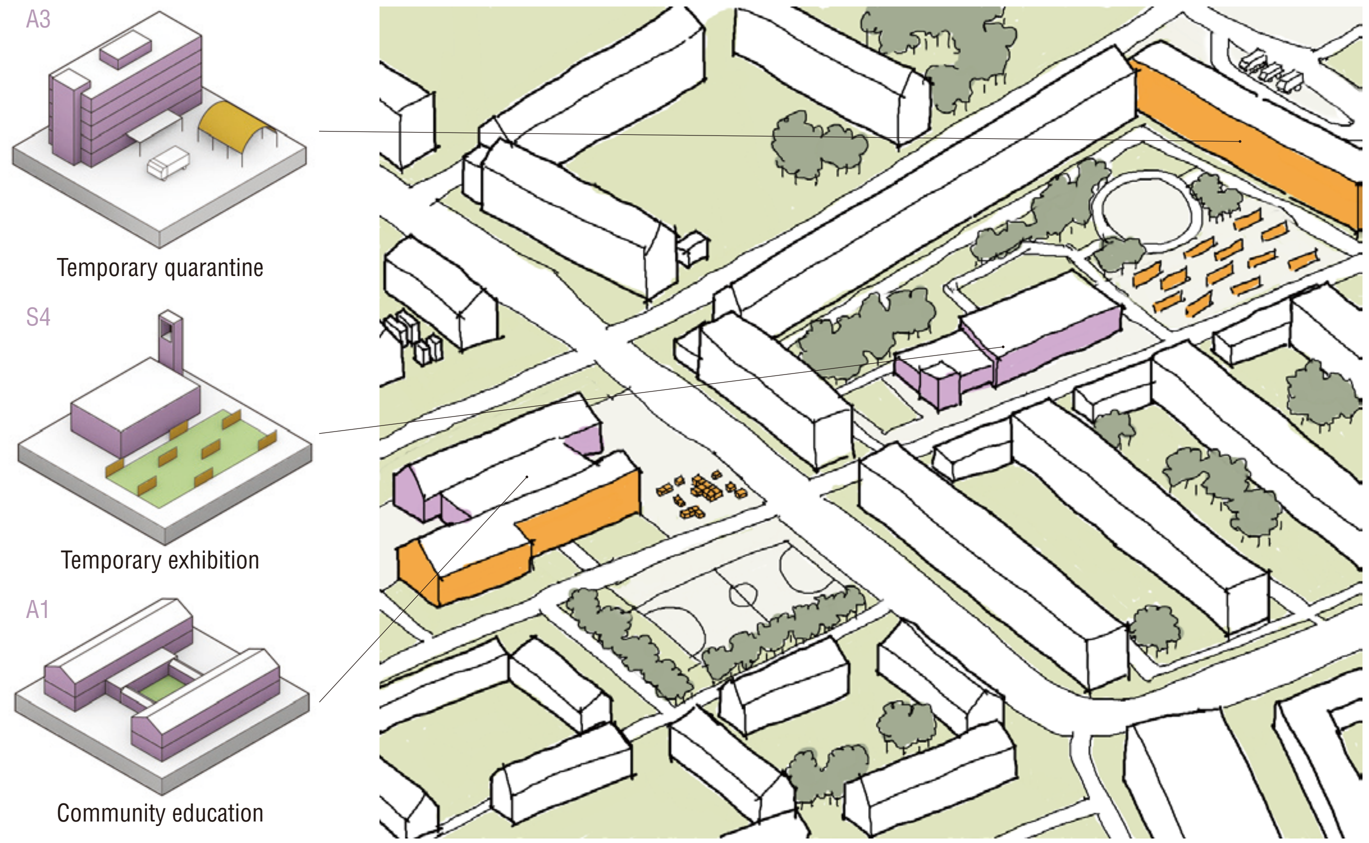


Fig. 6.5.23 Isometric map of adaptability for semi-public node of network during the pandemic. Made by author.

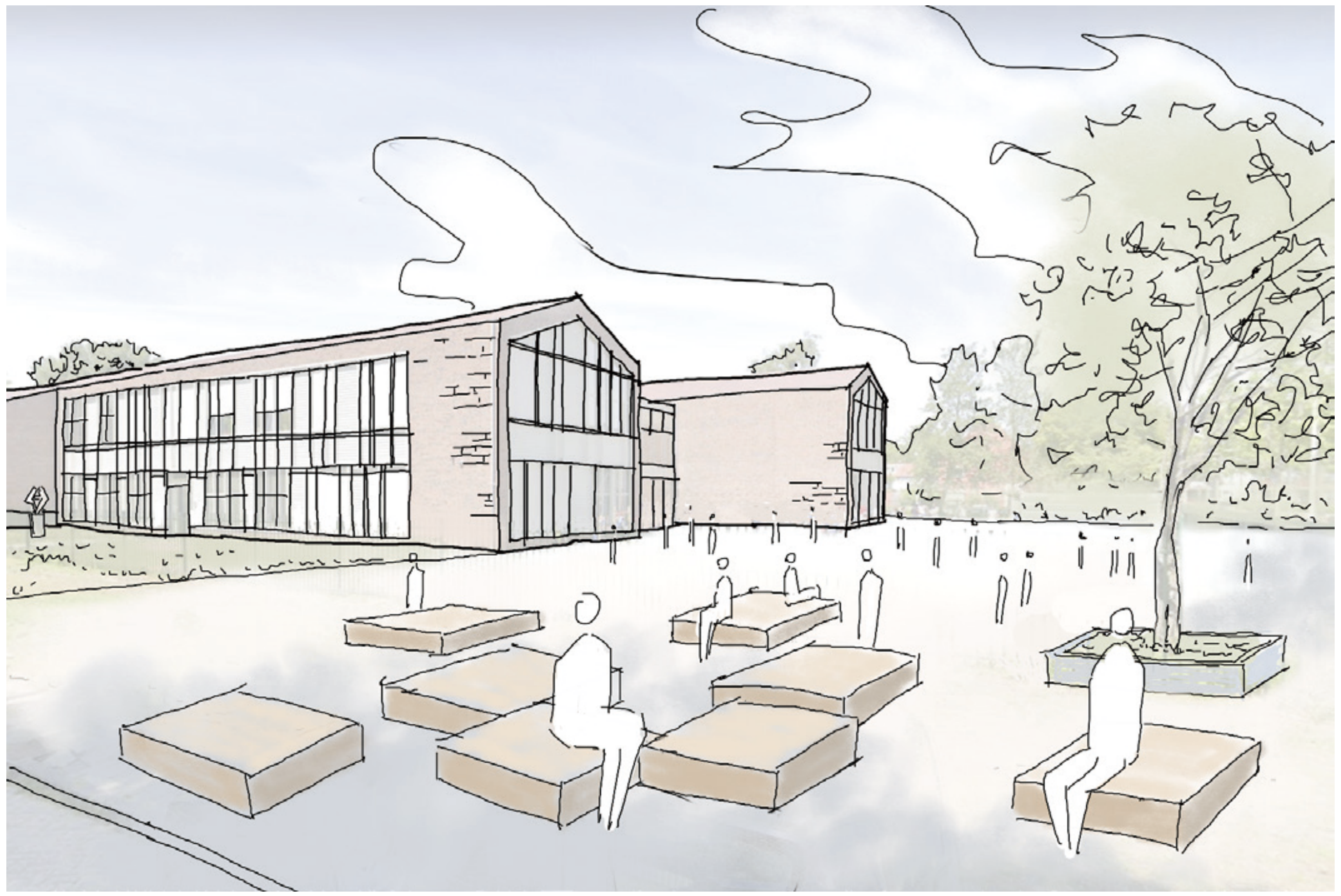


Fig. 6.5.24 Impression of adabtability for semi-public node of network during the pandemic. Made by author.

5.2.3 Transformability

WHO		Resilience of future generations with the most limited access to amenities are prioritized.
WHAT	TRADEOFFS	Generically focused on resilience of the community and MRA.
WHEN		Based on slow-onset changes for long-term resilience in the future.
WHERE		Areas with the potential to be flexible and alternative within the community boundaries.
WHY		Goal is an outcome: social justice and ecological friendly.

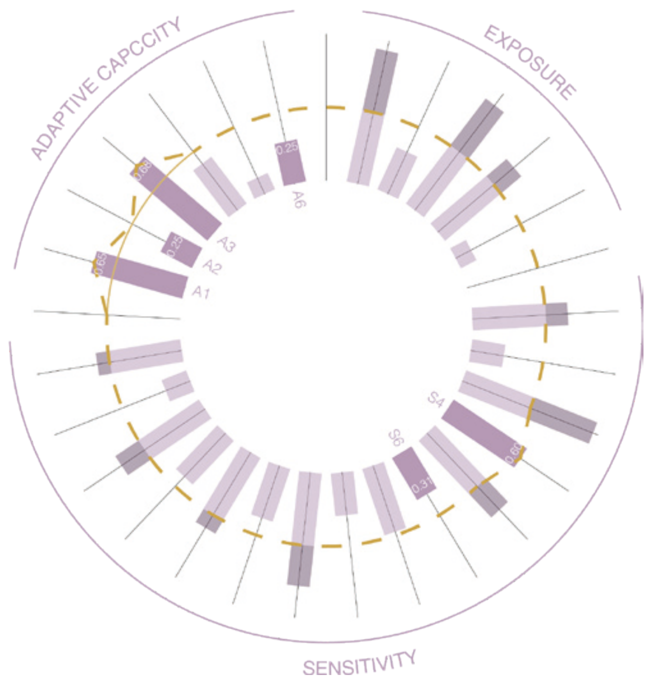


Fig. 6.5.25 The evaluated indicators of transformability for semi-public node of network in 2050. Made by author.

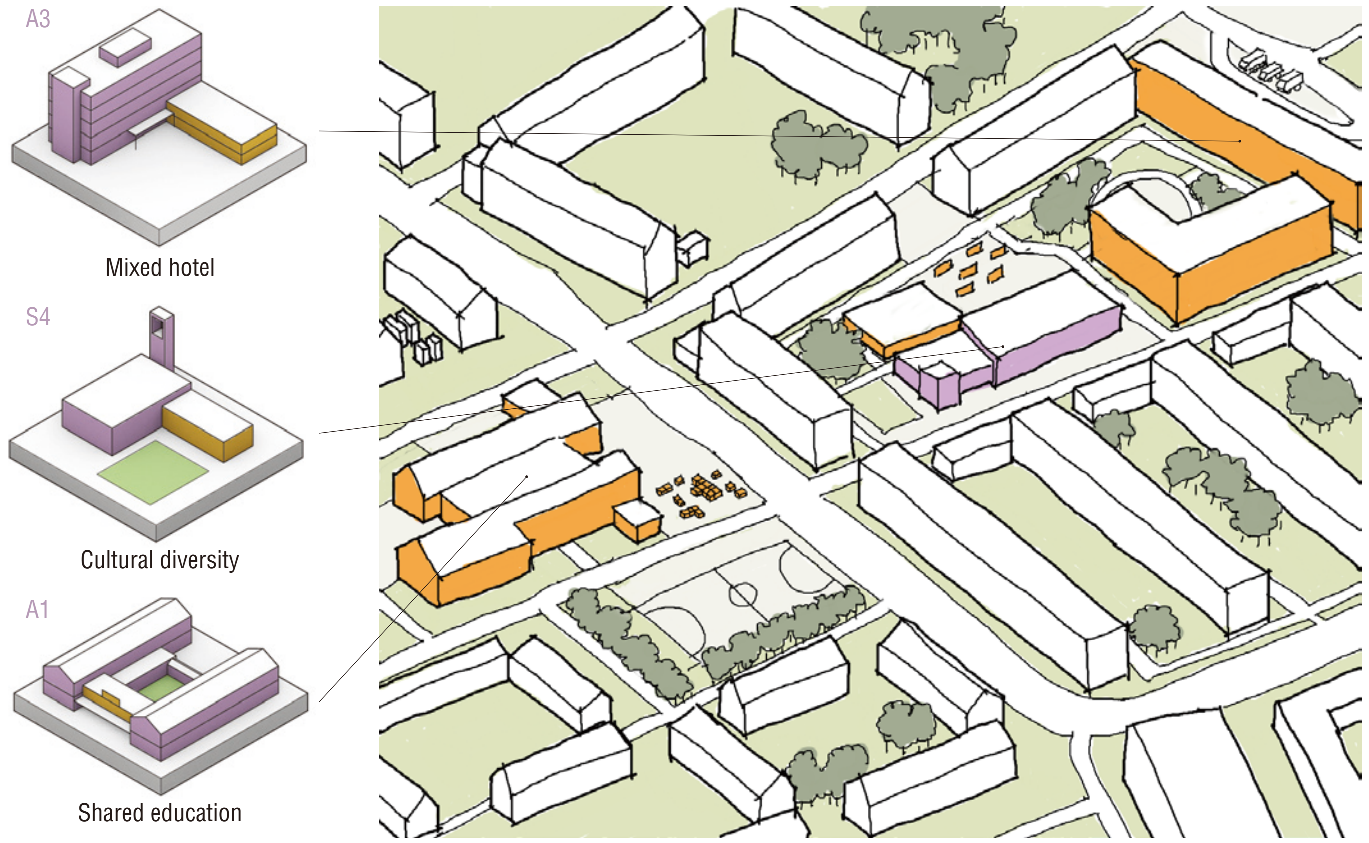


Fig. 6.5.26 Isometric map of transformability for semi-public node of network in 2050. Made by author.

The transformability enhances the diversity and flexibility of the community through shared and mixed resources, which can improve the long-term and more general resilience of the city. It could not only reduce the possibility of serious pandemics in the future but also prevent other socio-ecological crises. Figure 6.5.25 specifically explains the change in vulnerability after transformation. It gives priority to the resilience of the future generation within communities and regions, with the goal of achieving social, ecological, and economic balance. The outcome is the increased vulnerability thresholds of A1, A3, and S4 to improve urban resilience.

Therefore, the design emphasizes how to use the space flexibly to increase the socio-economic diversity to distribute the resources equally. Firstly, hotels will be transformed from single business to a mixed hotel, including B&Bs, hostels, apartments, and business hotels to provide a variety of services. That would make it and tourism more resilient to urban crises such as epidemics. Secondly, the site will form a comprehensive cultural center centered on the mosque, which will include different kinds of religious and cultural activities. The organization of various cultural activities will increase the communication between different groups. It can also attract people from different backgrounds to the community, increasing the diversity of the population. Thirdly, the school will be run as shared education. Residents and students can use educational resources at different times (Fig. 6.5.27). While the school will remain a place for students to study during the daytime, residents will improve their education level in the nighttime through shared reading, the Internet, and technology. Finally, all these public areas will open to the north, which will be directly connected to the tram stop on the east.

Eventually, by increasing transformability, the flexible use of urban resources can be remembered in a safer and faster way. Therefore, the semi-public node can be transformed from open only to a few people to a fully public activity center that provides resources to different groups at different times. As a result, the allocation of resources within the community will be more flexible and richer. It could also enable community structures to respond more quickly to the next pandemic.

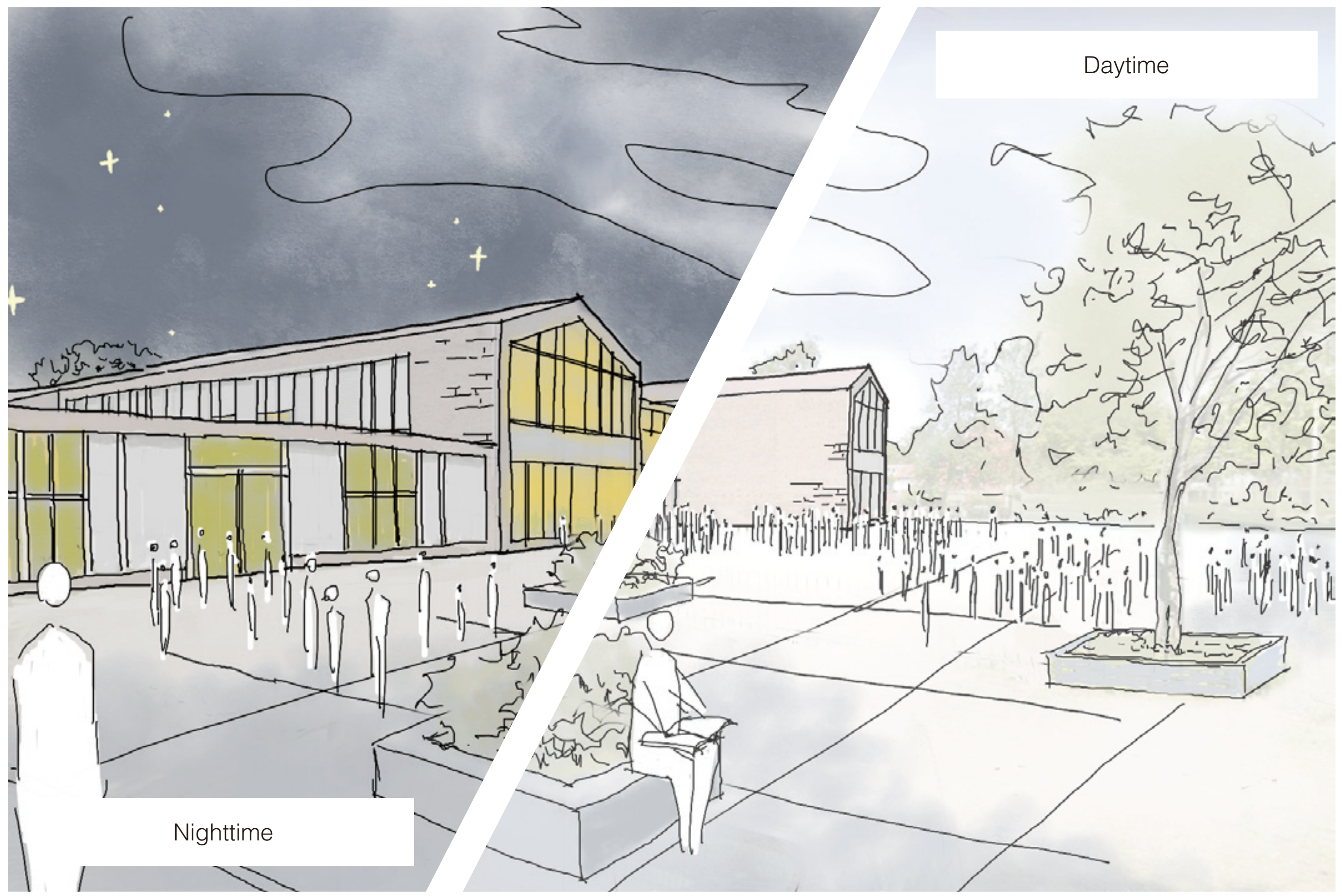


Fig. 6.5.27 Impression of transformability for semi-public node of network in 2050. Made by author.

5.2.4 Implement roadmap

Current situation

Adaptability

Local-led

Stage 1AS

In the first stage of adaptability, residents, students, and religious people will be organized together to activate public space to carry out activities outdoor during the pandemic. This spontaneous adaptation from indoor to outdoor activities can promote the combination and communication between different groups for a better implementation of transformation.

Stage 2AS

In the second stage, the municipality will work with tourism people to adapt the hotel into temporary quarantine space. Along with that, the renovation of infrastructure will start to connect the semi-public node with other public areas in the community. This step consists of adaptation of tourism resources and connection of infrastructure, which will also effect the last stage of transformation.

Stage 3AS

In the last stage, the municipality will consolidate the publicity of the area through further sharing of public services. The school and the mosque will be encouraged to provide more activities with residents in a safe way. This step of adaptation will become faster with the third stage of transformability.

Tramsformability

Public-led

Stage 1TS

In the first stage of the process, the local institutions will be empowered around the renovation of infrastructure. The main road in the neighborhood will be reconstructed to increase the connection with public center. The implementation of the first step in adaptation will also increase the need of accessibility.

Stage 2TS

In the second stage, the municipality will give access to the school, mosque, and hotel. The living unit will be open to the main street to facilitate the sharing of public resources. Besides, the shared community library, flexible religious space, and mixed hotel will start to be built, increasing the diversity of business and functions in this area. Therefore, it will also increase the adaptability.

Stage 3TS

In the last stage, more community activities will emerge in case of the transformation from semi-public services to public services. In this regard, public space could be used by making a new agreement between residents, students and tourists. Therefore, different groups of people can use the resources in different time. This step can be promoted due to the short-term sharing.

Strategic space

Strategic building

Strategic connection/ infrastructure

Implement roadmap

Interactive impact

Fig. 6.5.28 Implement roadmap with different stakeholders in the semi-public node. Made by author.

5.3 HIGH-DENSITY LIFE CIRCLE

5.3.1 Current situation

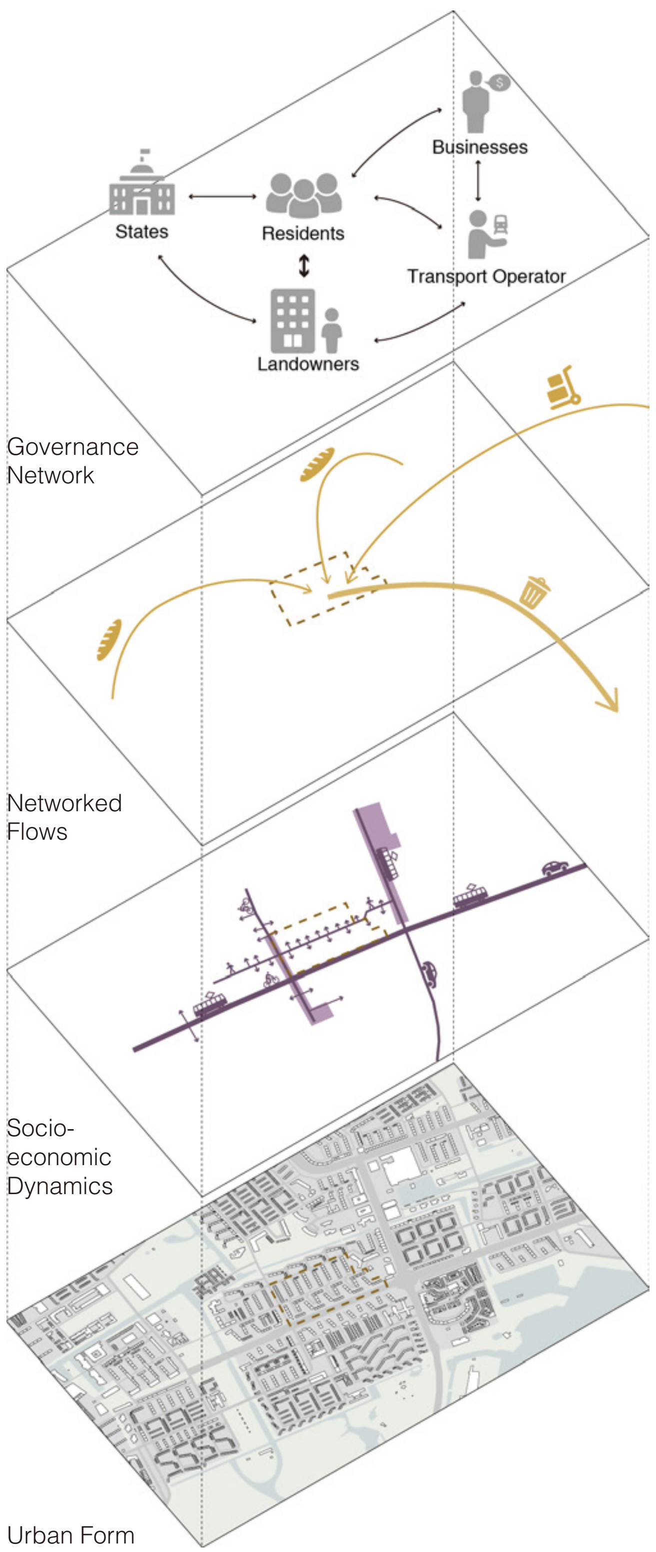


Fig. 6.5.29 Analysis of 'urban system' on the site. Made by author, proposed by Meerow et al. (2016) and inspired by Dicken (2011).

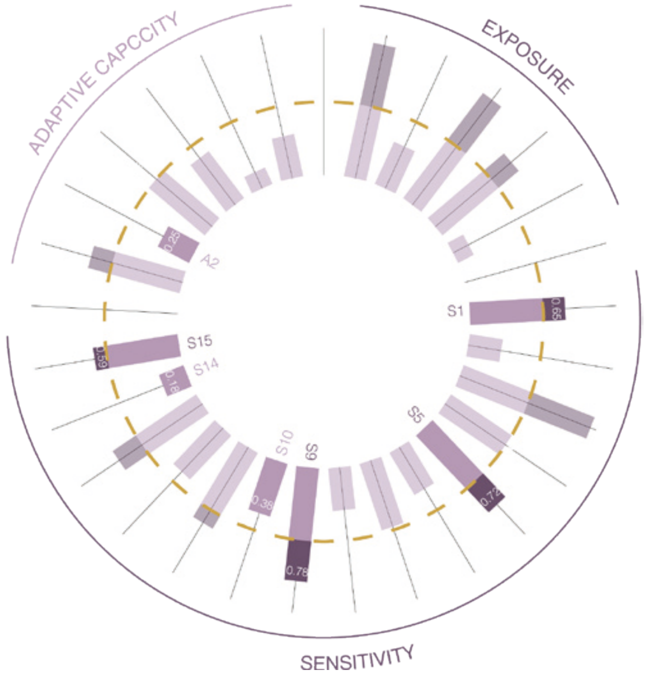


Fig. 6.5.30 The evaluated indicators of current situation for high-density life circle without pandemic. Made by author.

The Burg. v. Leeuwenlaan is located in the middle of Geuzenveld-Slotermeer. It is now a high-density neighborhood dominated by high-rise social housing, with a small number of retail stores along the street (Fig. 6.5.29). Due to the compact construction, there are a series of problems such as lack of open space and low living quality (Fig. 6.5.31). It also makes the population more sensitive to a pandemic. Urban systems in this neighborhood are shown in Fig. 6.5.32. Areas around the site are mostly high-density neighborhoods with little open space. The socio-economic dynamics of the site reflect a lack of connection with the transport infrastructure. The south of the site is close to one of the community's main streets, which serves as the main public transport route. However, houses in the site are not directly connected with this road but accessed through an east-west road in the middle. It leads directly to the path with low vitality. The networked flow of the site has the characteristic of decentralization. Most daily necessities, such as food, are obtained from the two community centers, while some consumer goods flow from the further city center. Finally, the stakeholder network is smaller, centered on residents and landowners. In addition, the government and transportation operators also have some indirect impacts on the site, and the commercial value of the land will change accordingly.

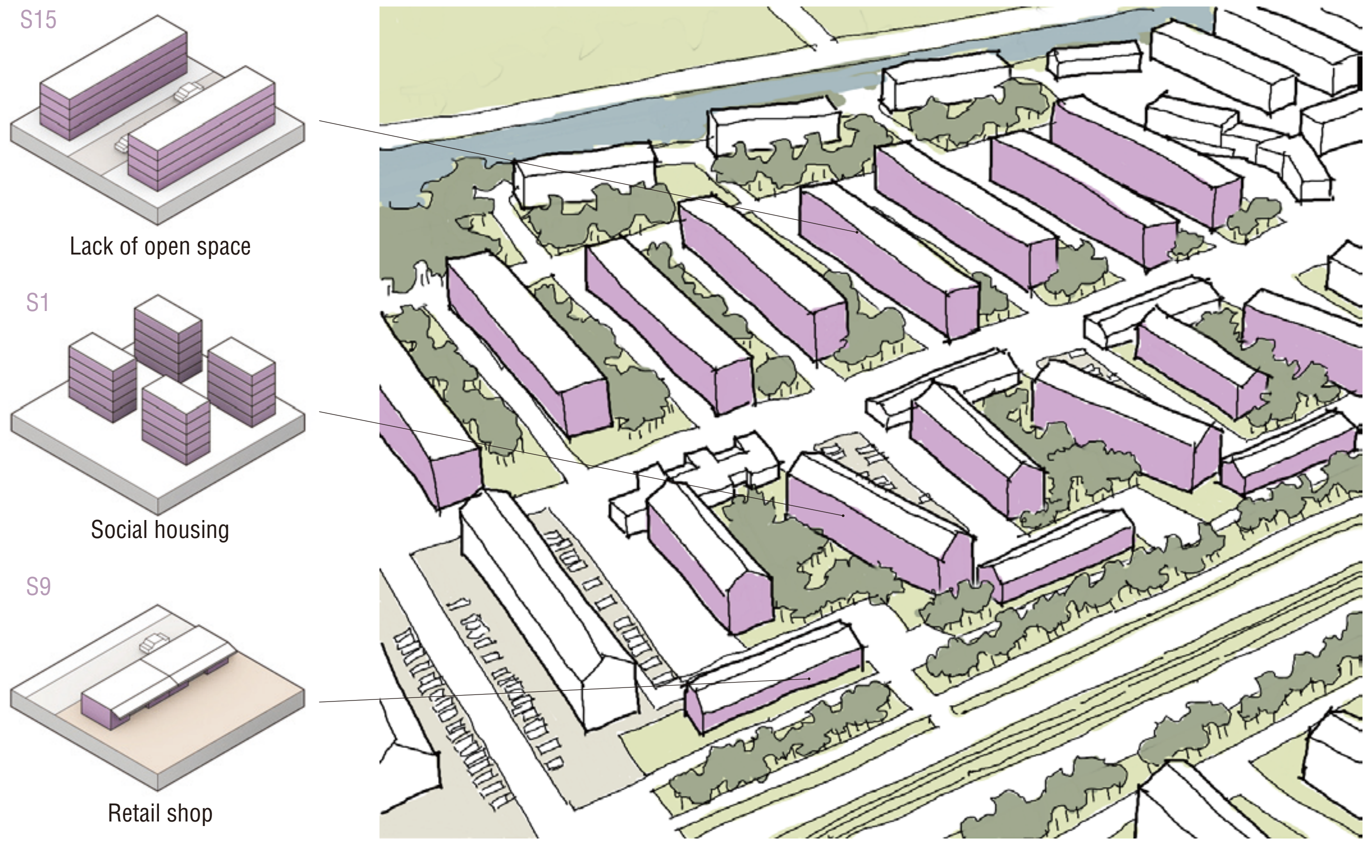


Fig. 6.5.31 Isometric map of current situation for high-density life circle without pandemic. Made by author.

Fig. 6.5.32 Impression of current situation for high-density life circle without pandemic. Made by author.

5.3.2 Adaptability

TRADEOFFS

WHO	Resilience of current neighborhood residents with the highest sensitivity are prioritized.
WHAT	Specifically focused on pandemic mitigation.
WHEN	Focus on current situation and fast-onset changes for current estimates of risk.
WHERE	High-density neighoborhoods with the lowest living quality within the community boundaries.
WHY	Goal is a process: increase persistance, the speed of recovery and reduce investments for pandemic.

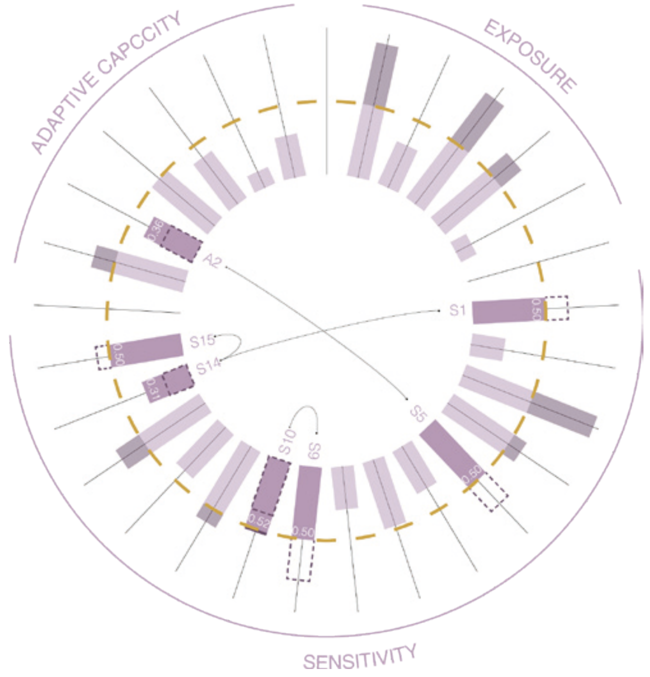


Fig. 6.5.33 The evaluated indicators of adaptability for high-density life circle during the pandemic. Made by author.

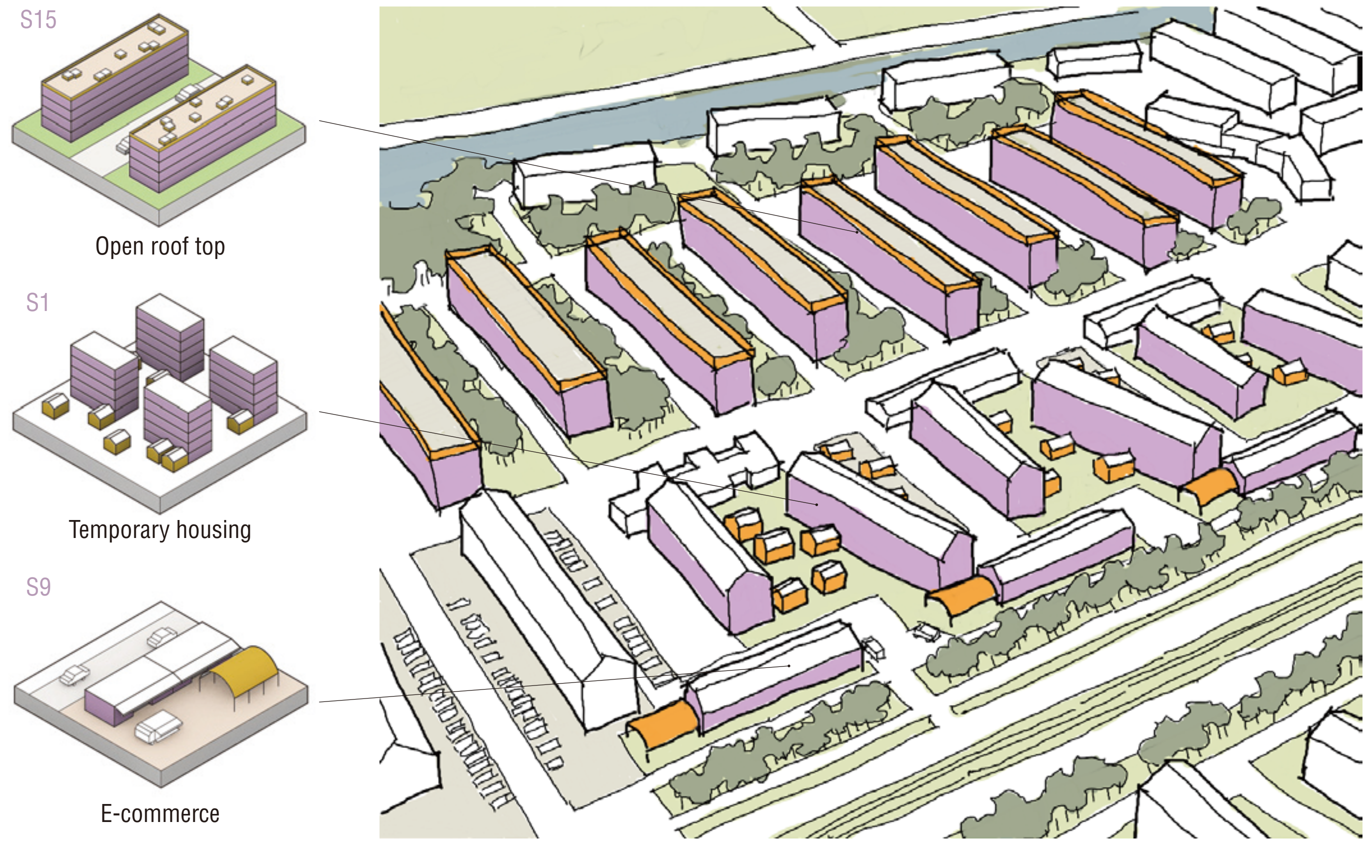


Fig. 6.5.34 Isometric map of adaptability for high-density life circle during the pandemic. Made by author.

The adaptability of this site focuses on how to quickly reduce the sensitivity of the community during a pandemic. Fig. 6.6.33 explains that it puts the resilience of the current residents in the first place. Like the former design for adaptability, it can also reduce indexes of vulnerable indicators through rapidly functional and spatial changes with related negative impacts to some extent. Besides, the design of the life circle needs to pay more attention to those communities with insufficient resources. Therefore, they can get enough materials to ensure physical and mental health during the pandemic.

Therefore, the design placed more emphasis on temporary community regeneration to improve resistance (Fig. 6.5.34). First of all, for housing lack of open space on the ground, the roofs of apartment buildings can be fully used. They have both openness for social distancing and privacy that is relatively independent, providing additional activity space for residents. Secondly, for social housing with low density but large population, residents can quickly provide more housing space through unified modular construction in the open space. It is going to increase the housing area per capita, while ensuring the need for home quarantine during the pandemic and prevent the mutual infection between families (Fig.6.5.35). Thirdly, small businesses along the street are the main form of commerce that will be hit by the pandemic. Therefore, to reduce their vulnerability, online commerce can be fully developed during the pandemic, and the original stores can be used temporarily as storage warehouses for goods delivery.

Finally, through this efficient way of community renewal, the space needs of anti-pandemic in the residential area can be met in a short time. It can form a small life cycle, combining with fair distribution of resources which can reduce the traffic for residents' daily life. The reduction of population flow can greatly reduce the spread range and speed of the infection, reduce the impact of the pandemic on the urban system, and facilitate recovery.

Fig. 6.5.35 Impression of adabtability for high-density life circle during the pandemic. Made by author.

5.3.3 Transformability

WHO	TRADEOFFS	Resilience of future generations with the lowest living quality are prioritized.
WHAT		Generically focused on resilience of the community and MRA.
WHEN		Based on slow-onset changes for long-term resilience in the future.
WHERE		High-density neighborhoods with the most vulnerable groups and space within the community boundaries.
WHY		Goal is an outcome: social justice and ecological friendly.

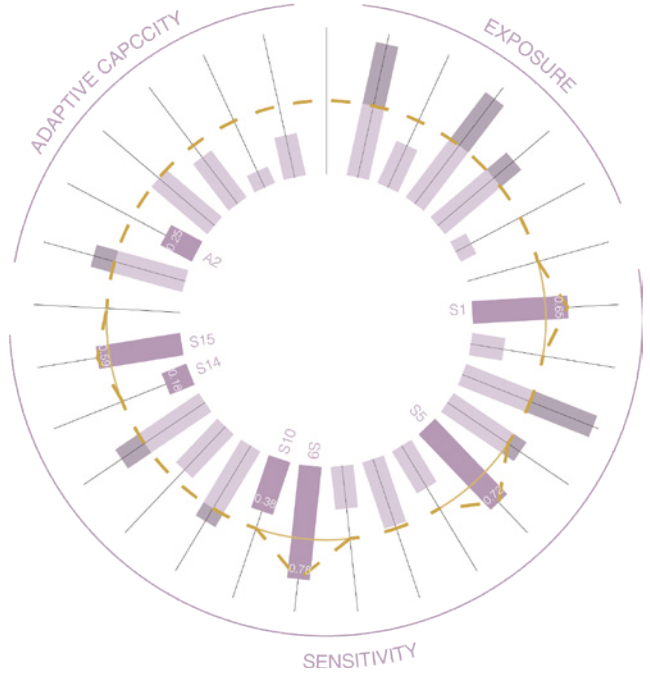


Fig. 6.5.36 The evaluated indicators of transformability for high-density life circle in 2050. Made by author.

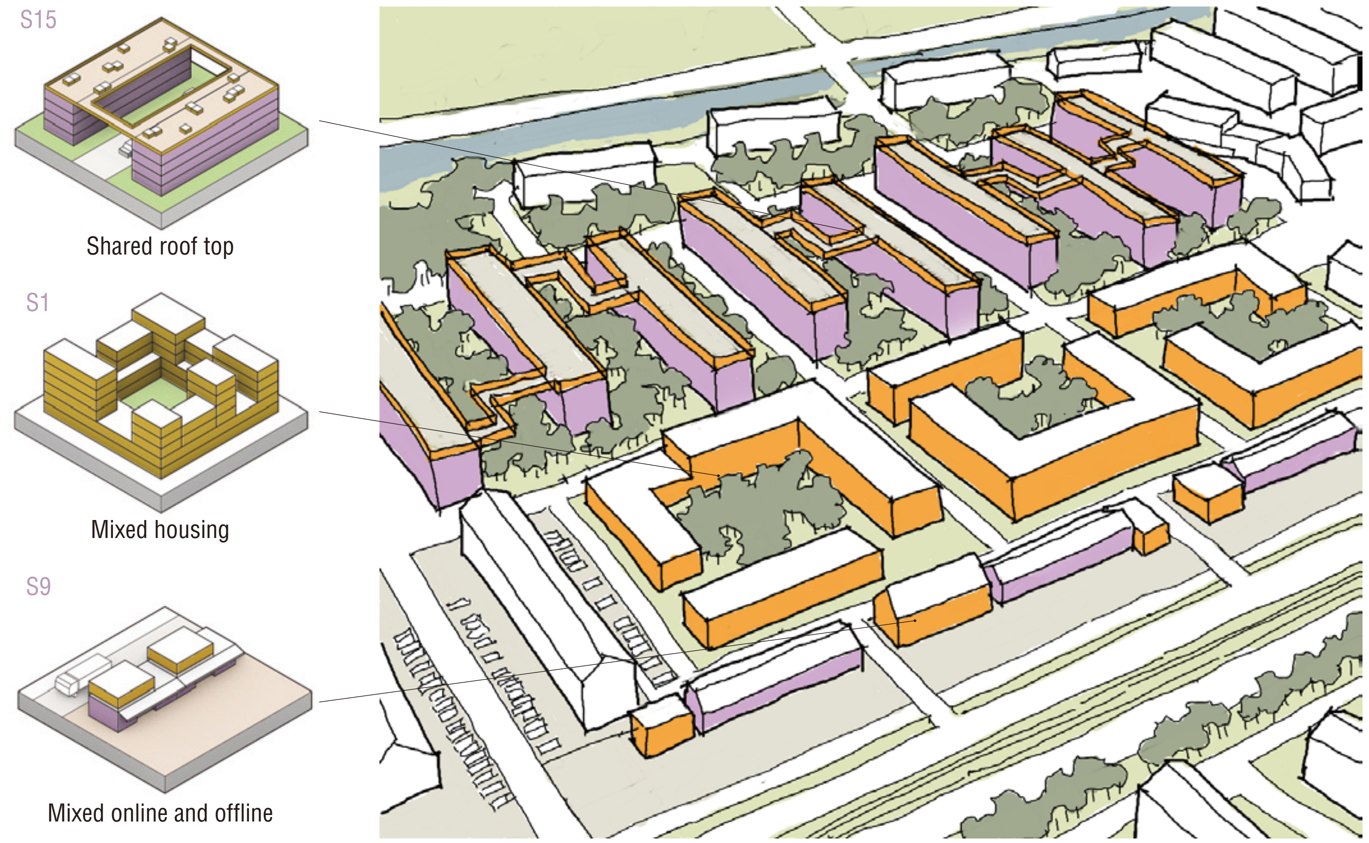


Fig. 6.5.37 Isometric map of transformability for high-density life circle in 2050. Made by author.

Transformability is to full use the limited community resources through flexible use of space to pay attention to the residence of the future generation in the neighborhood (Fig. 6.5.36). This design focuses on improving general urban resilience through the transformation of thresholds. The renewal of high-density communities should improve the social equity and ecological balance of the whole city, and can also resist the impact of future pandemics or other crises.

Therefore, the renewal of the neighborhood emphasizes the efficient and flexible use of resources to improve the transformability of the community (Fig. 6.5.37). First of all, the neighborhood not only needs to increase the connection to the green space on the ground but the roof of the high-density housing. It can also be further developed for a shared roof. With limited ground space, the rooftop can be developed to form a semi-private open space. Secondly, low-density and crowded social housing can be rebuilt into mixed housing. A variety of areas and housing types can increase the diversity of the neighborhood population and stimulate the different use of space at different times (Fig. 6.5.35). During holidays or pandemics, for example, some wealthy people may choose to move out from their homes in the city to their second homes in the suburbs or rural areas. In this way, the spare space can be temporarily transferred to other people in the city who need more living space through short-term rent or unified distribution. Thus, it can improve the overall living standard of residents (Fig.6.5.38). Thirdly, the main traffic road on the south needs to be formed into a walkable street by changing the entrance of residential clusters and improving the pedestrian environment. Small businesses along the street will increase as a result. Meanwhile, to improve their resilience and prevent future epidemics from causing serious impacts, small businesses can operate through a mixture of online and offline modes. In terms of space, these street stores not only need retail space but also can increase storage for online sales by raising or underground space.

Finally, a series of community renewal designs can enhance the diversity, flexibility, and resourcefulness of the life cycle, thus improving its systemic resilience. At the same time, this flexible and mixed model can be more alternative and respond to future outbreaks to mitigate the impact efficiently.

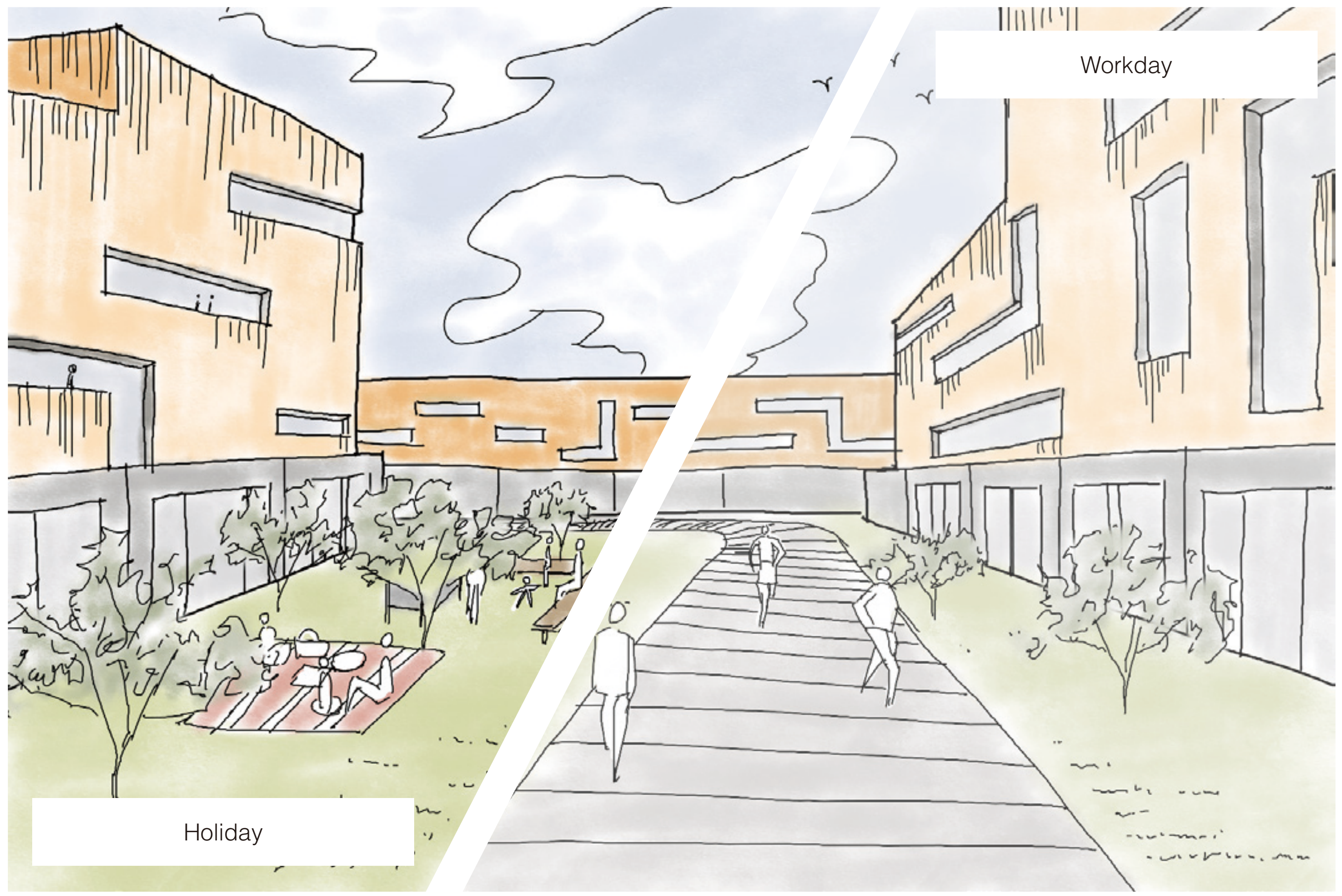


Fig. 6.5.38 Impression of transformability for high-density life circle in 2050. Made by author.

5.3.4 Implement roadmap

Current situation

Adaptability

Local-led

Stage 1AH

The implementation of adaptability is local-led. The first stage is dominated by residents and landowners. Shortages of housing during the pandemic can prompt residents to temporarily increase housing space to reduce disease transmission. This step can also promote the long-term implementation of transformability for community renovation.

Stage 2AH

The second stage will be implemented through the corporation between landowners and businesses to improve the living quality. All of the open spaces will be fully used, especially the roof top of high-rise buildings. This experimental strategy can promote the transformation of increasing public space shared public resources. The adaptation can be also facilitated by the third stage of transformability.

Stage 3AH

The last stage of adaptability is to provide convenient, affordable and safe infrastructure for residents. The adaptation of small businesses along the street will increase the demand of public transport and delivery industry. It will be organized by transport operators and municipalities. This step can be promoted by the second stage of transformability.

Tramsformability

Public-led

Stage 1TH

The planning for transformability is a public-led process. Firstly, the environment of the main street and the high connection with the green space will be a basis for further transformation. The corporation between the institutions and transport operators will increase service efficiency and promote the use of public transport.

Stage 2TH

The second stage of transformability will be facilitated by not only the former step, but the short-term adaptation during the pandemic. The improved environment will facilitate the transformation of businesses and the renovation of communities. Therefore, the land owners and business owners will participate to increase the resilience of the neighborhood.

Stage 3TH

According to the network of public space and green space in the neighborhoof, the third stage of transformability will be organized by residents themselves to increase the accessibility and connectivity. Therefore, the roof top can be connected with each other to integrate into the public space on the ground. This step can in return accelerate the adaptation for the pandemic.

Strategic space

Strategic building

Strategic connection/ infrastructure

Implement roadmap

Interactive impact

Fig. 6.5.39 Implement roadmap with different stakeholders in high-density life circle. Made by author.

5.4 LOW-DENSITY LIFE CIRCLE

5.4.1 Current situation

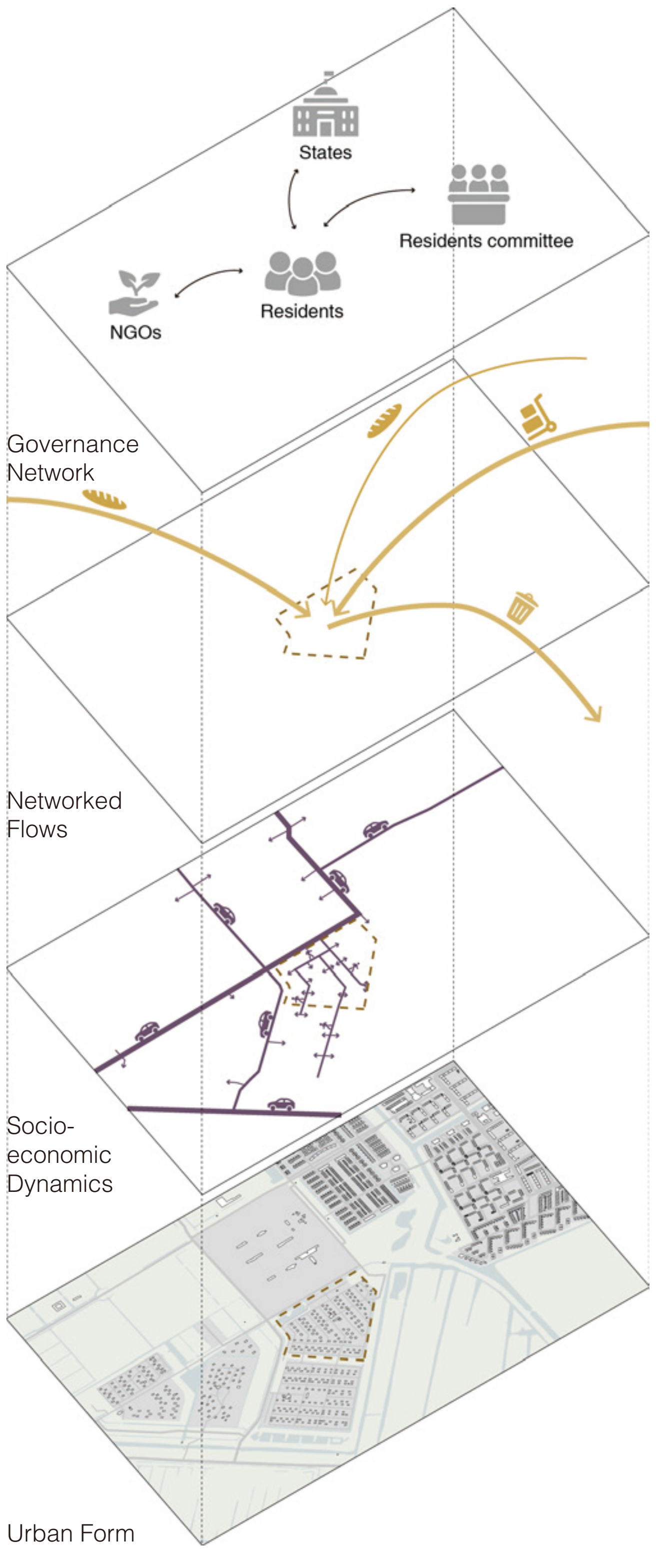


Fig. 6.5.40 Analysis of 'urban system' on the site. Made by author, proposed by Meerow et al. (2016) and inspired by Dicken (2011).

Fig. 6.5.41 The evaluated indicators of current situation for low-density life circle without pandemic. Made by author.

Garden Park TIGENO is located in the west of Geuzenveld-Slotermeer. It is a low-density neighborhood consisting of detached houses (Fig. 6.5.40). However, the private gardens of each family make the public space scarce in the neighborhood. The neighborhood center on the site becomes the main service point for residents. It is isolated from the main structure of the community with low traffic accessibility, which leads to a greater reliance on motor vehicles for residents. Therefore, the main problems faced by the neighborhood are low hospital accessibility, high motor traffic, and the resulting unsafe activities for children in the urban periphery areas. Fig. 6.5.42 systematically analyzes the layered structure of the site. First of all, the site is surrounded by abundant green space, mostly similar low-density residential areas, and farmland. Secondly, its main traffic road is the motorway on the north, as the only entrance to the neighborhood. The street is pleasant, but the lack of bike lanes and sidewalks further reduces the likelihood of cycling and walking (Fig. 6.5.43). Thirdly, the remote location of the site results in a long-distance flow of daily necessities and waste between the residents and supply centers. Finally, the governance network is simple, centered on the local population and related official and unofficial organizations.

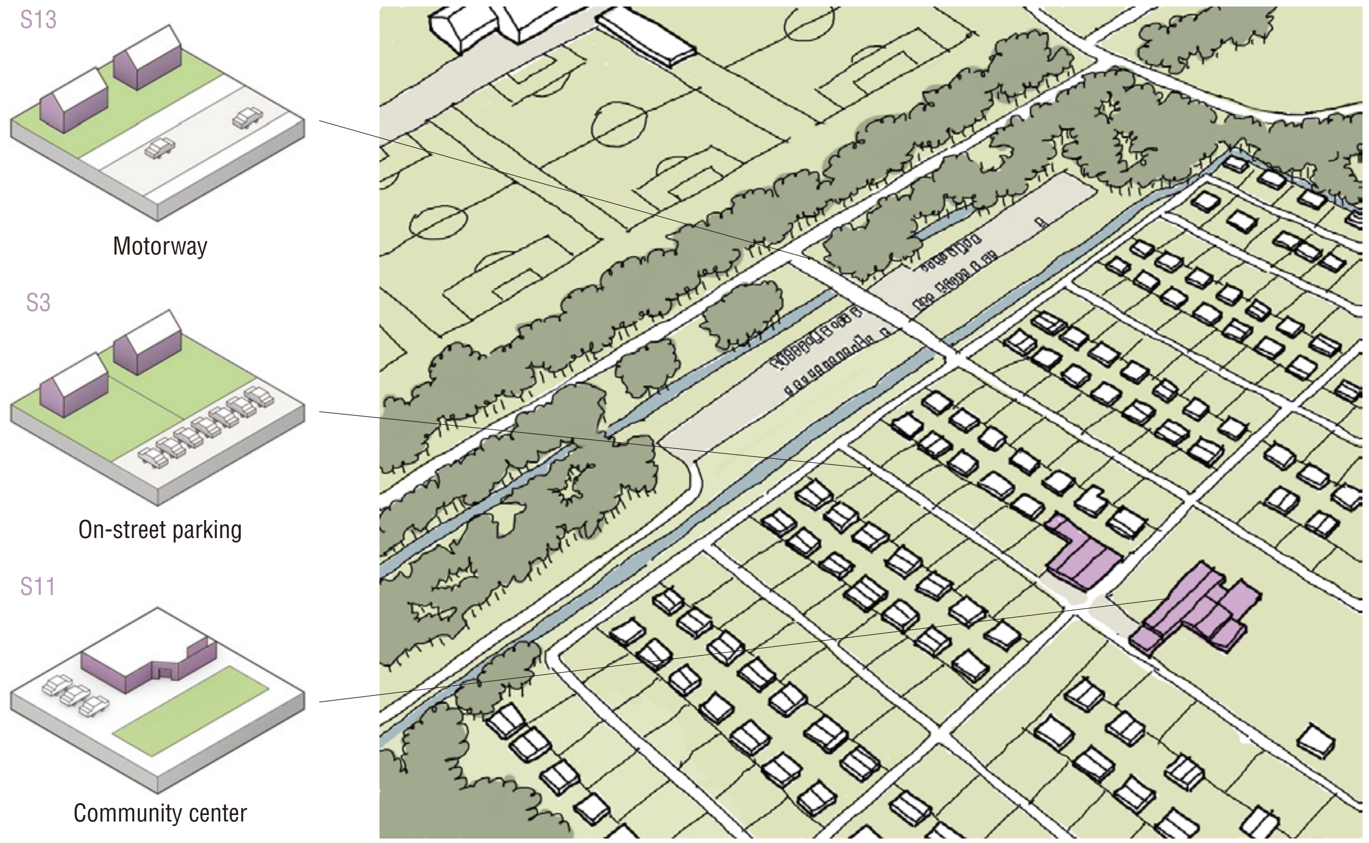


Fig. 6.5.42 Isometric map of current situation for low-density life circle without pandemic. Made by author.

Fig. 6.5.43 Impression of current situation for low-density life circle without pandemic. Made by author.

5.4.2 Adaptability

	TRADEOFFS	
WHO		Resilience of current neighborhood residents with the highest sensitivity are prioritized.
WHAT		Specifically focused on pandemic mitigation.
WHEN		Focus on current situation and fast-onset changes for current estimates of risk.
WHERE		Low-density neighoborhoods with the lowest average accessibility to utilities within the community boundaries.
WHY		Goal is a process: increase persistance, the speed of recovery and reduce investments for pandemic.

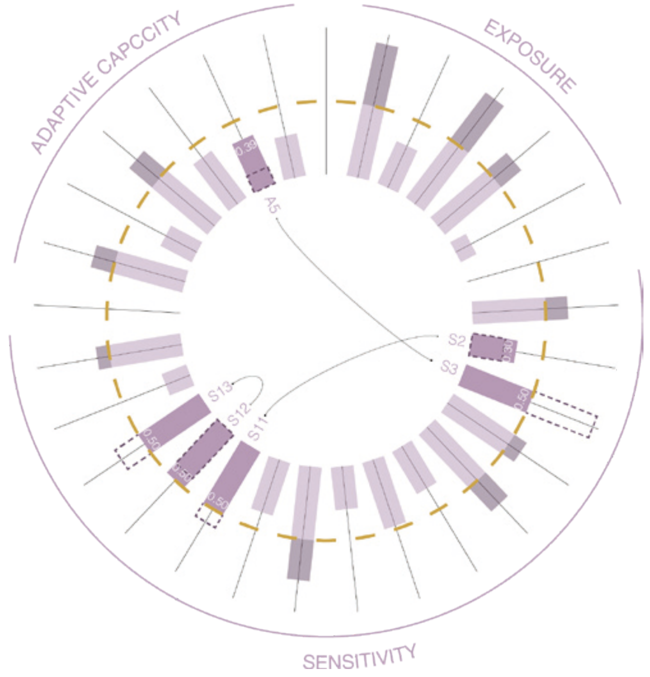


Fig. 6.5.44 The evaluated indicators of adaptability for low-density life circle during the pandemic. Made by author.

The adaptability of this site is similar to that of public nodes before. How the current residents can quickly improve the resilience of the city facing the challenge of the pandemic? However, this design focuses on a low-density neighborhood with low accessibility to public facilities, so that residents can easily obtain resources within the life circle (Fig. 6.5.44). Therefore, the strategy to improve adaptability is to reduce high-vulnerability indicators through rapid change of space, and it will bring indirect influence on other indicators.

The strategy focuses on the efficient use of scarce public space, due to the privatization of the site. First of all, bicycle lanes will be added to the main traffic street on the north with bike rental points at the entrance of the neighborhood. This strategy will reduce residents' reliance on motor vehicles. The original lane close to the site can be quickly turned into a cycling and walking path, leaving only the other one for the vehicle (Fig. 6.5.46). Street furniture will be added along the road to optimize the pedestrian environment. However, reducing their use of motor vehicles will indirectly reduce their accessibility to amenities, so it is necessary to increase public services within the life circle to meet the demand. Therefore, secondly, the neighborhood center needs to increase its diversity as the only place in the neighborhood to provide services to residents. It will serve as a healthcare center for the community, especially during outbreaks, by adding temporary medical facilities. Thirdly, reduce motor vehicle traffic inside the site. Parking space along the road in front of the homes used to take up a lot of lacking public space. Inner streets can become an open space for safe activities for children if parking issues can be solved at the gate.

Finally, through the strategies to public space, the low-density neighborhood can quickly adapt to the pandemic and become a basic life circle in a short time. It could meet residents' needs for medical care and space, reduce their reliance on motor vehicles, and reduce the movement of people to ease the spread of the virus.

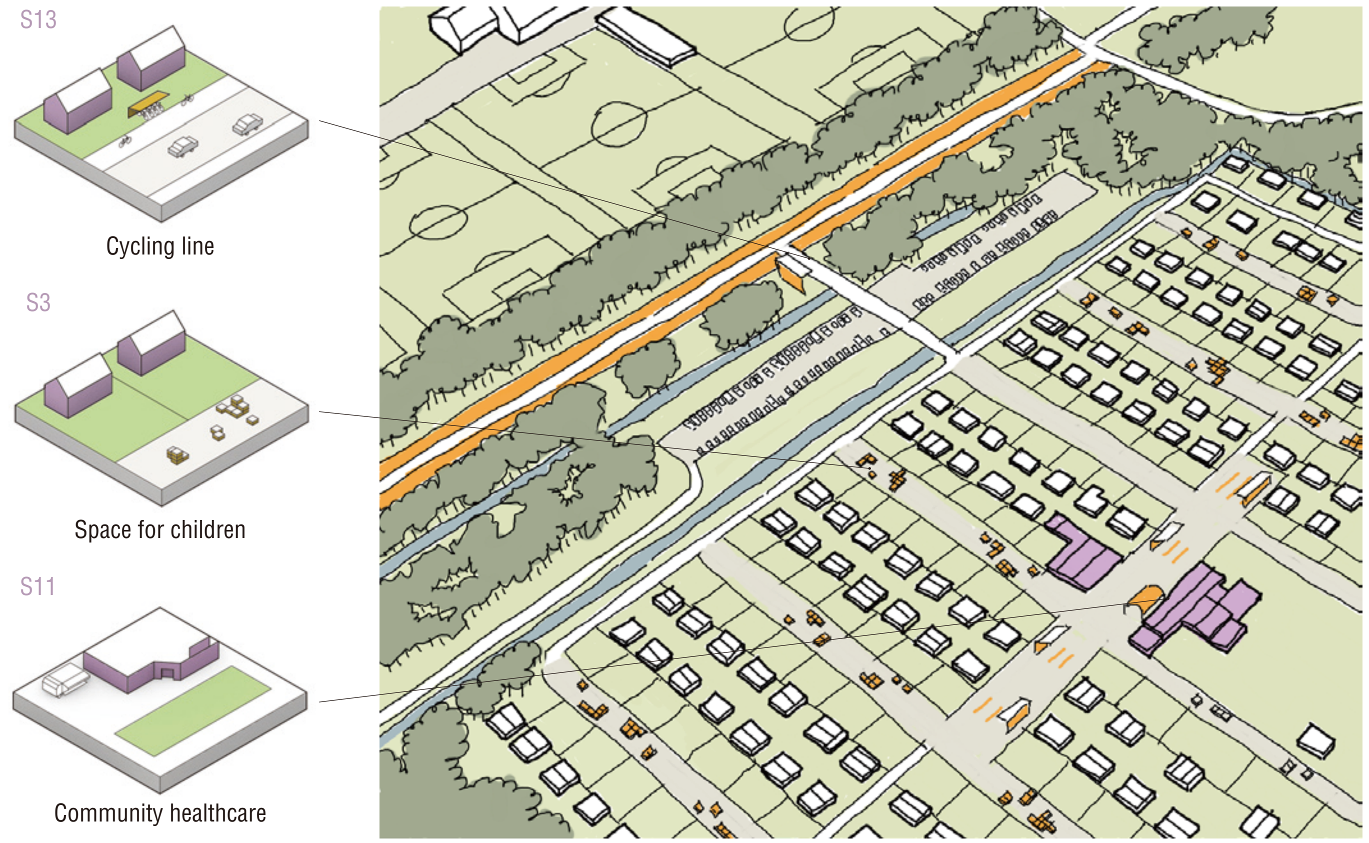


Fig. 6.5.45 Isometric map of adaptability for low-density life circle during the pandemic. Made by author.

Fig. 6.5.46 Impression of adabtability for low-density life circle during the pandemic. Made by author.

5.4.3 Transformability

WHO		Resilience of future generations with the lowest accessibility to public life are prioritized.
WHAT	TRADEOFFS	Generically focused on resilience of the community and MRA.
WHEN		Based on slow-onset changes for long-term resilience in the future.
WHERE		Low-density neighborhoods with the most vulnerable groups and space within the community boundaries.
WHY		Goal is an outcome: social justice and ecological friendly.

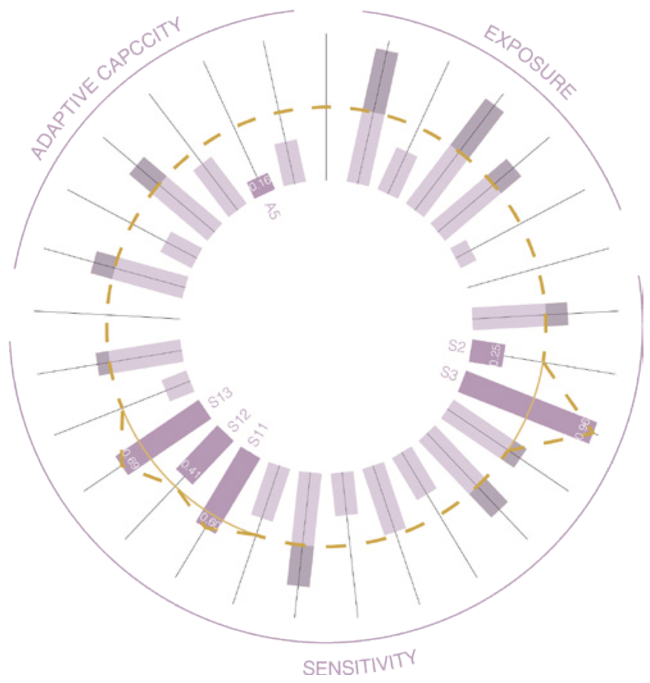


Fig. 6.5.47 The evaluated indicators of transformability for low-density life circle in 2050. Made by author.

The transformability of this site is to emphasize the general urban resilience through long-term community renewal. It is aimed at the future generation, who are sensitive to crisis due to their low accessibility to public life living in urban periphery areas (Fig. 6.5.47). Therefore, the goal of the design is to increase its resilience through the changing of the threshold by sharing limited resources.

Fig. 6.5.48 shows the design vision of low-density life circles in 2050 through three main strategies. Firstly, the threshold of motorized traffic will be raised by sharing streets. Shared streets can improve the flexibility and safety of street space by mixing different modes of transportation. The strategy is particularly suited to low-density residential areas, where children can play and people can walk and cycle, sharing the road with drivers. It is used to meet the needs of the adjacent residents and to increase its public function as entertainment, socializing, and leisure. In addition, shared streets can be used flexibly. During peak hours it will be occupied by more cars, while during off-peak hours it can become a pleasant public space (Fig. 6.5.49). Secondly, gardens, which are completely private, can be further shared with the neighbors, creating a series of more open space for activities. It will cater to children's activity needs through flexible furniture arrangements. Thirdly, the community center will become a mixed center with retail, medical, reading, local waste disposal, and other infrastructure. This integrated site will provide convenient resources for residents in the low-density life circle.

Finally, this series of community renewal strategies can increase the flexibility and resourcefulness of the site to improve its ability to withstand the crisis. In addition, if the next outbreak occurs, this mixed and shared space can respond and adapt more quickly to mitigate both direct and indirect impacts.

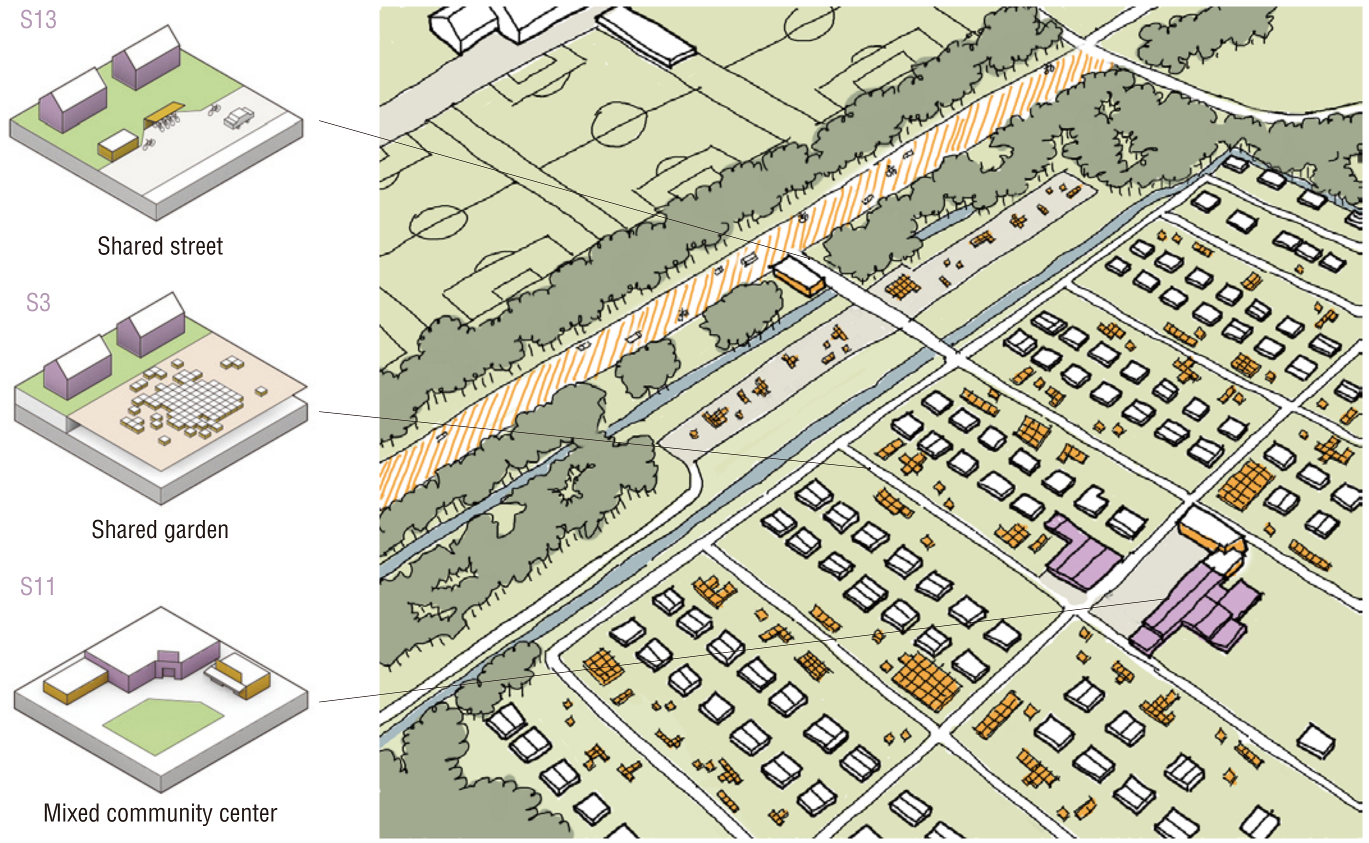


Fig. 6.5.48 Isometric map of transformability for low-density life circle in 2050. Made by author.

Fig. 6.5.49 Impression of transformability for low-density life circle in 2050. Made by author.

5.4.4 Implement roadmap

Current situation

Adaptability

Local-led

Stage 1AL

In the first stage of adaptability, the local-led implementation is released. Local residents are going to participate spontaneously in the renovation of their community, starting from the public streets at their doorways. This is a bottom-up approach to provide more public space for activities, mitigate the spread of virus, and promote the second stage of transformability.

Stage 2AL

In the second stage, community committees and NGOs will be organized to provide residents with essential supplies and medical care during the outbreak. They allow temporary public services to be implemented through the use of the community centre and its common land. This step will promote the right to use and transform the public land, which is beneficial to the long-term transformation.

Stage 3AL

The first two stages of the adaptation will reduce the distance of population flow and encourage residents to cycle and walk. Therefore, in the third stage, it is important for municipalities to organize rapid infrastructure improvements for cycling and pedestrians. Meanwhile, with the implementation of transformation, this step can adapt to the epidemic more efficiently.

Tramsformability

Public-led

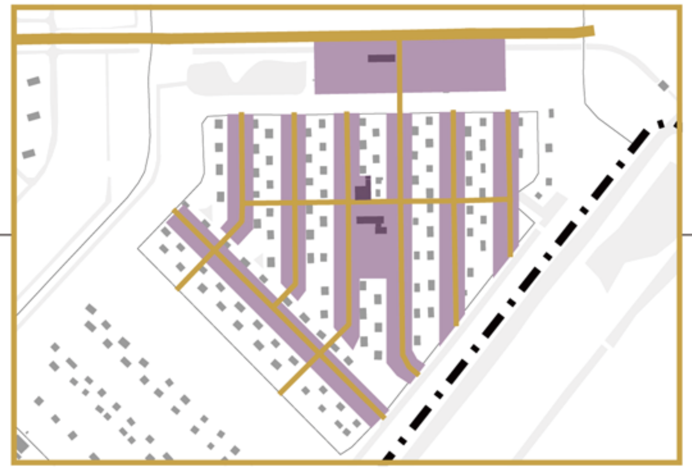
Stage 1TL

Planning for transformability is a long-term and public-led process. In the first phase, NGOs are being organised to work with municipalities to facilitate the road-sharing transformation. The construction of municipal infrastructure firstly can provide the basis for later strategies.

Stage 2TL

In the second stage, the residents committee will work with the municipality to renovate the community center and public land. The first stage can promote the sharing within the community. Increased service in community centers can reduce the use of motor vehicles. This step is also influenced by short-term and temporary experiments for adaptability.

Stage 3TL



In the third stage, residents can participate in the design with the committee. The previously shared infrastructure and public space will further facilitate the sharing of private gardens on both sides of the street within the community. Residents can remodel their own gardens and expand the shared street. At the same time, this step can promote the rapid implementation of adaptability during the epidemic.

Strategic space

Strategic building

Strategic connection/ infrastructure

Implement roadmap

Interactive impact

Fig. 6.5.50 Implement roadmap with different stakeholders in low-density life circle. Made by author.

6. LOCAL COMMUNITY

6.1 CURRENT SITUATION

Based on four types of local design, this project will then propose planning strategies of the urban system and the evaluation of the Geuzenveld-Slotermeer at the urban scale. Fig. 6.6.1 shows the present urban structure. There is only one center Plein '40- '45 in the community, where public functions are located, such as the food market and office building. Most resource delivery lines in the community are sparsely around the community center, concentrated in the east, reflecting its main connection with the city center of Amsterdam. Meanwhile, semi-public areas, high-density neighborhoods, and low-density neighborhoods are basically on the same level, where the population needs to move to the community center for living materials. Among them, the low-density communities in the southwest have the longest distance. The low traffic accessibility and long-distance population mobility there determine that they are more dependent on motorized transportation.

Fig. 6.6.2 shows the current vulnerability assessment results of Geuzenveld-Slotermeer in this urban structure. With the same threshold for all indicators, 13 indicators are classified as high vulnerability. Most of them belong to the categories of exposure and sensitivity, thus leading to the characteristics of high exposure, high sensitivity, and high adaptive capacity in the community during COVID-19.

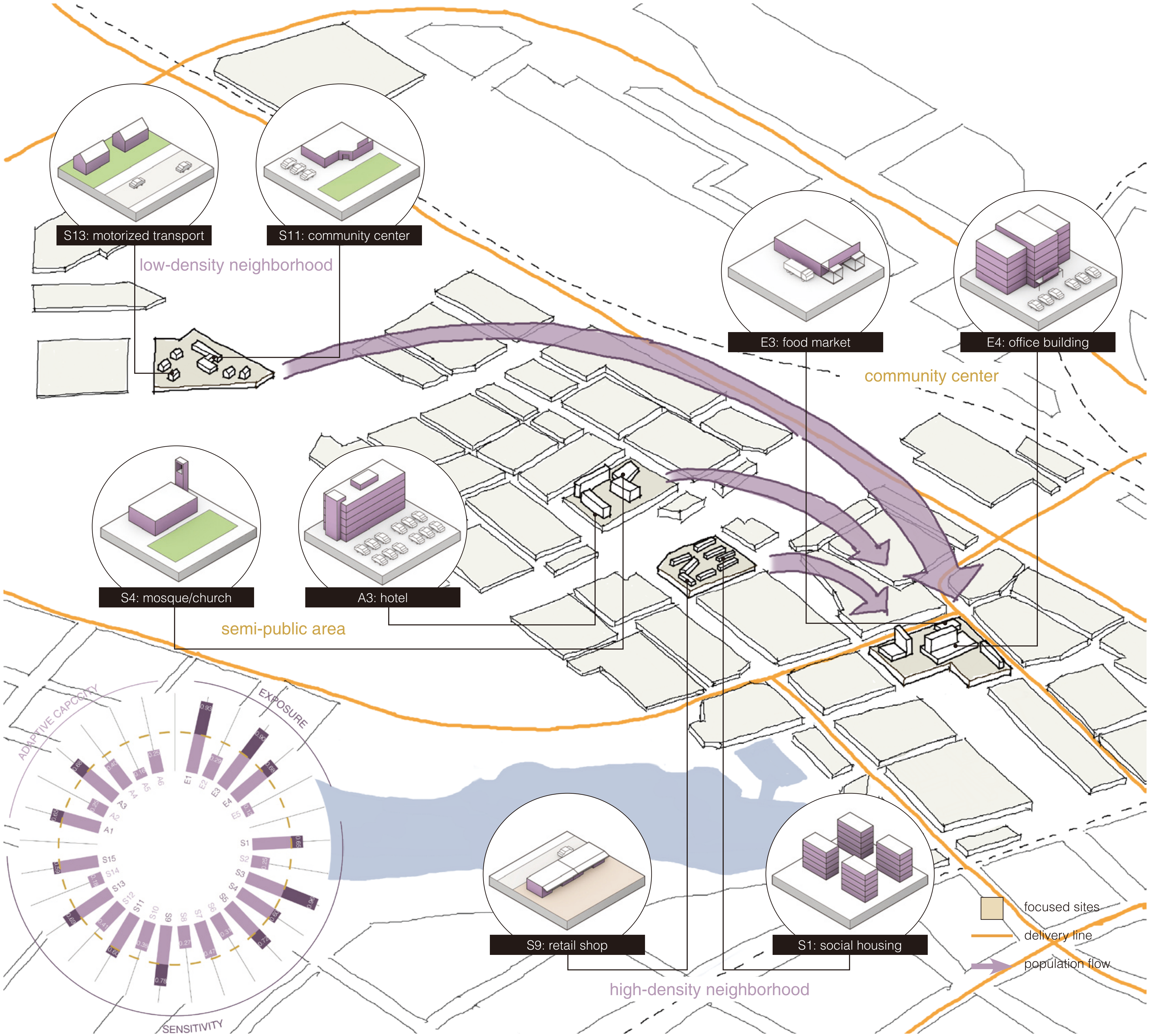


Fig. 6.6.1 The life circles and urban flow in Geuzenveld-Slotermeer at present. Made by author.
Fig. 6.6.2 The evaluated indicators in Geuzenveld-Slotermeer at present. Made by author.

6.2 ADAPTABILITY

The planning of adaptability is to rapidly reduce the transportation distance of residents for relatively independent life cycles in their living neighborhoods during an outbreak (Fig. 6.6.3). Firstly, public and semi-public nodes will become centers for the material flowing network. Resources in the public node such as food, materials, and urban space can be used more efficiently. The previously private areas in the semi-public node, such as mosques, churches, and hotels, can be open to the public through some temporary activities. Secondly, there will be a denser delivery network in the community, through the main traffic roads to form a fair distribution of existing resources. And a variety of other small businesses will be distributed along with the network, together to provide resources for the residents with nodes. Thirdly, residential areas will become individual life circles. Necessities can be accessed from public facilities along the delivery lines, and other resources can be obtained from community or city centers through online shopping and transportation. High-density life circles can decrease the density for living and quarantine by temporary living space and open space. Low-density life cycles will reduce the dependency on motor vehicles to reduce air pollution through street renewal and improve hospital accessibility through temporary medical facilities in community centers.

Each design and planning strategy will directly change the corresponding indicators with an indirect impact on others. Finally, through superposition calculation, the vulnerability index of Geuzenveld-Slotermeer is shown in Fig. 6.6.4 after the planning of adaptability. All indicators are below or equal to 0.5. Although some low-vulnerable indicators will be increased due to these strategies, they can remain below 0.5. It means that during the pandemic, through the planning of adaptability, all the impact factors studied in this project in Geuzenveld-Slotermeer can be decreased under the threshold of low vulnerability.

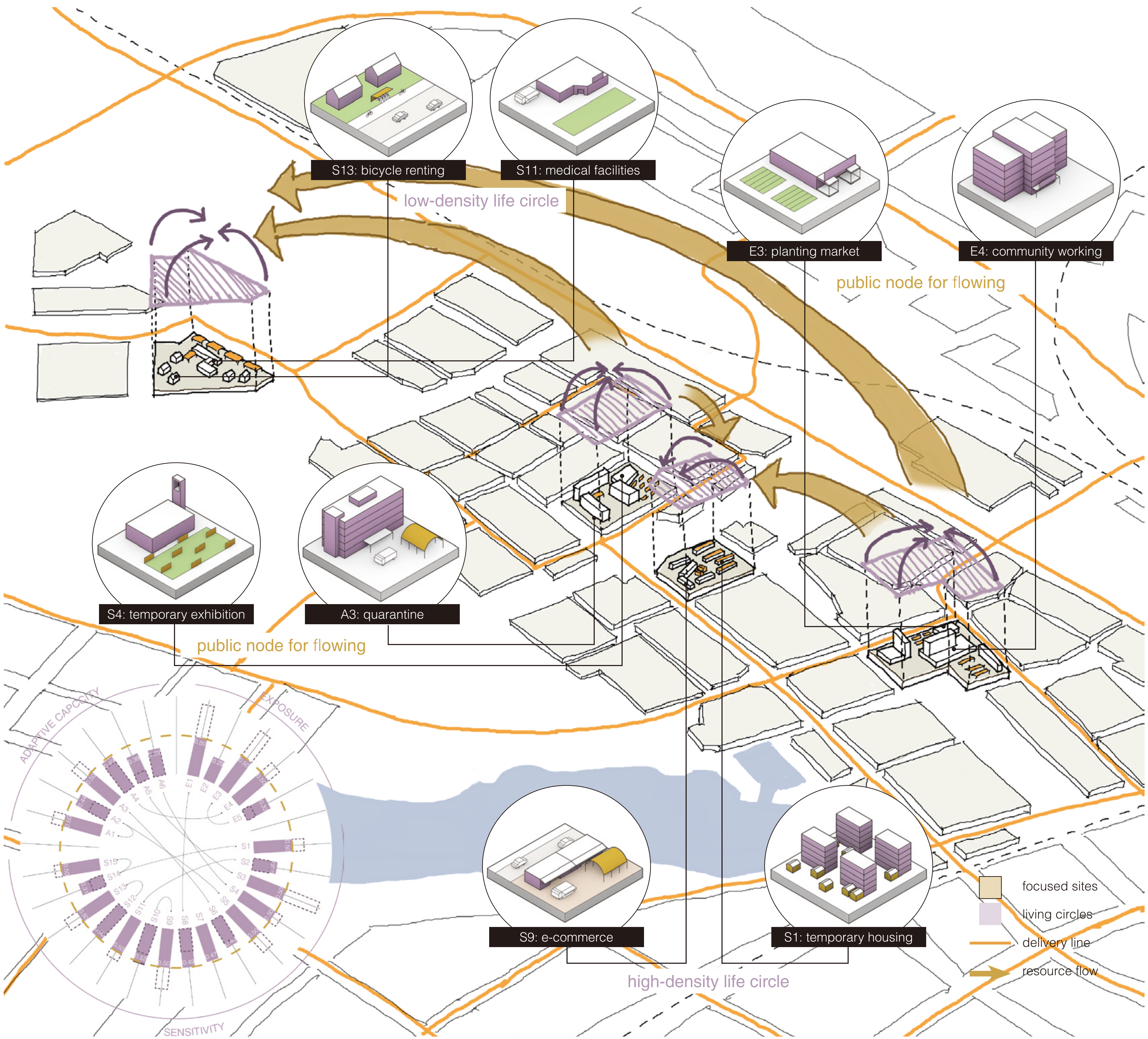


Fig. 6.6.3 The life circles and urban flow of adaptability in Geuzenveld-Slotermeer. Made by author.
Fig. 6.6.4 The evaluated indicators of adaptability in Geuzenveld-Slotermeer. Made by author.

6.3 TRANSFORMABILITY

The planning for transformability is to undertake various socio-economic activities in the community through more flexible-used and shared space, so the material flow can replace population flow (Fig. 6.6.5). Firstly, the public node will become the community center of material and spatial circulation. Food malls, for example, will become food hubs that integrate urban farming, processing, marketing, storage, and local treatment of organic waste. The office building will become a shared workspace for both employees and residents. Secondly, the current semi-public node will be modified for mixed-used to improve its efficiency. A mosque or church, for example, could increase the diversity of its cultural activities. And mixed hotels can offer affordable rooms for different levels of customers. Thirdly, the life circles based on the neighborhoods will be expanded to the ones bordered by the delivery lines. Their diameter will not exceed the comfortable distance of one kilometer for walking or cycling. Both high- and low-density life cycles will increase their diversity of the population. Boundary space between life cycles will be developed based on public transport and delivery lines, forming streets with access to integrated infrastructure. And the public nodes of traffic will be in the overlap of cycles.

Through the planning of transformability, the vulnerability assessment of Geuzenveld-Slotermeer is shown in Fig. 6.6.6. The strategy of this planning differs from the strategy for adaptability, which reduces the indicators in the short term through the direct intervention of these factors. This planning improves their critical thresholds through long-term transformation and regeneration. Therefore, those indicators selected as high vulnerability at the beginning can be reduced to low vulnerability even if the values are higher than 0.5 due to the increase of thresholds. Meanwhile, since the change of these indicators is smaller than that of the planning for adaptability, they will have a less indirect negative impact on other indicators.

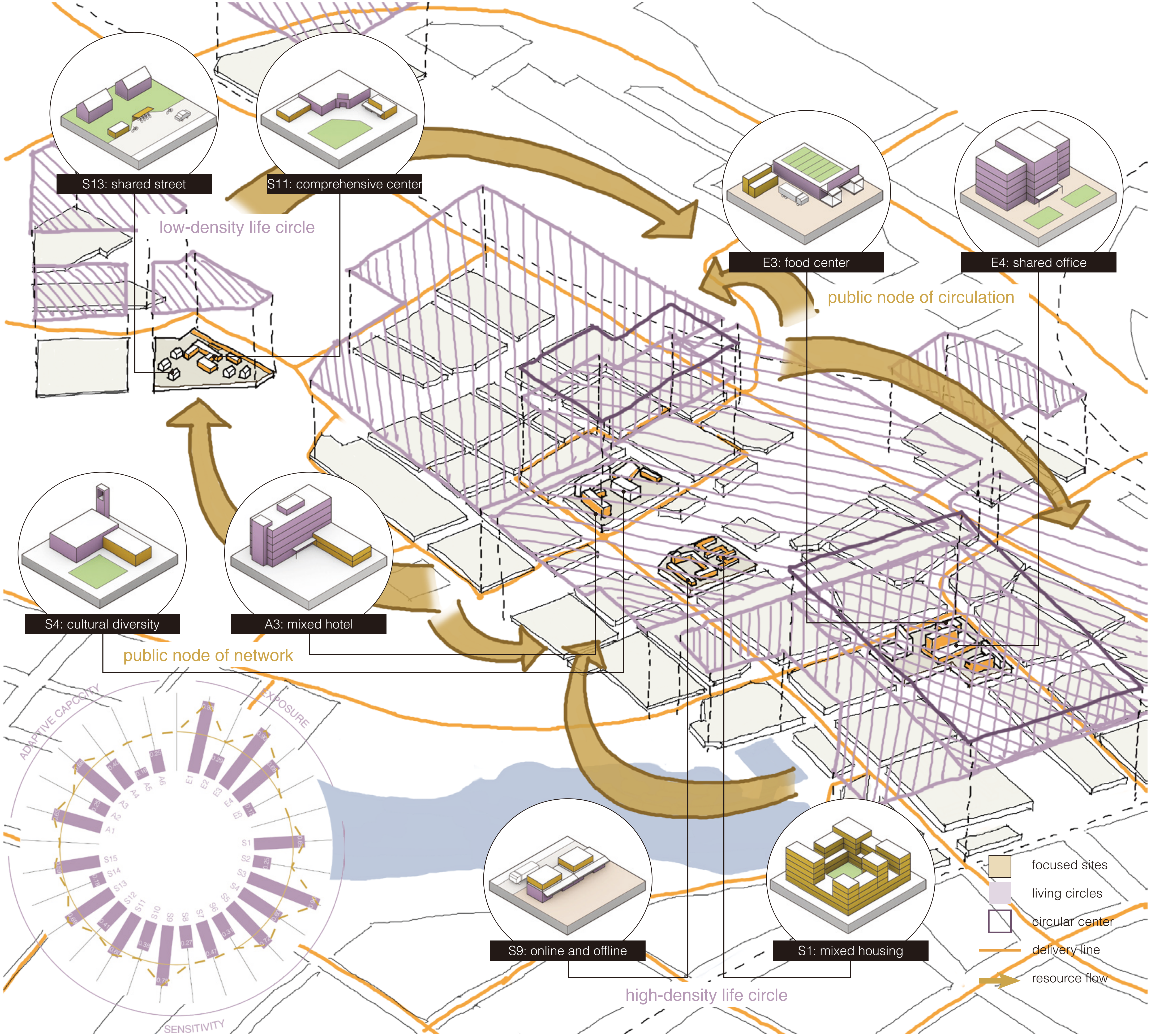


Fig. 6.6.5 The life circles and urban flow of transformability in Geuzenveld-Slotermeer. Made by author.
Fig. 6.6.6 The evaluated indicators of transformability in Geuzenveld-Slotermeer. Made by author.

6.4 TIME DIMENSION

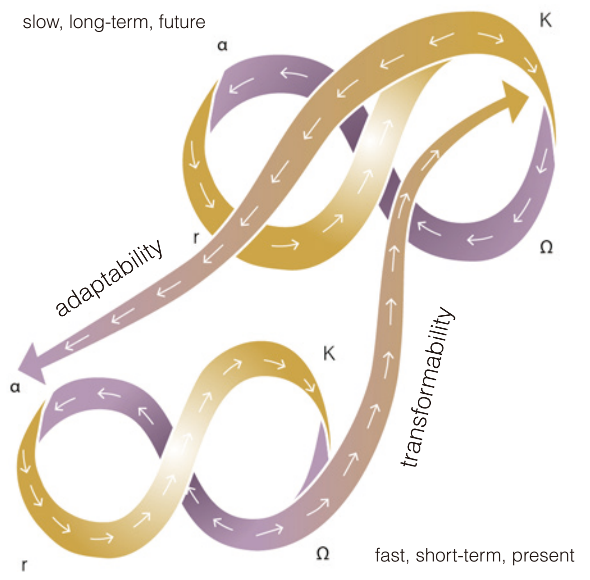


Fig. 6.6.8 Time dimension of dynamic planning. Made by author, adapted from Holling and Gunderson (2002, pp. 34–41).

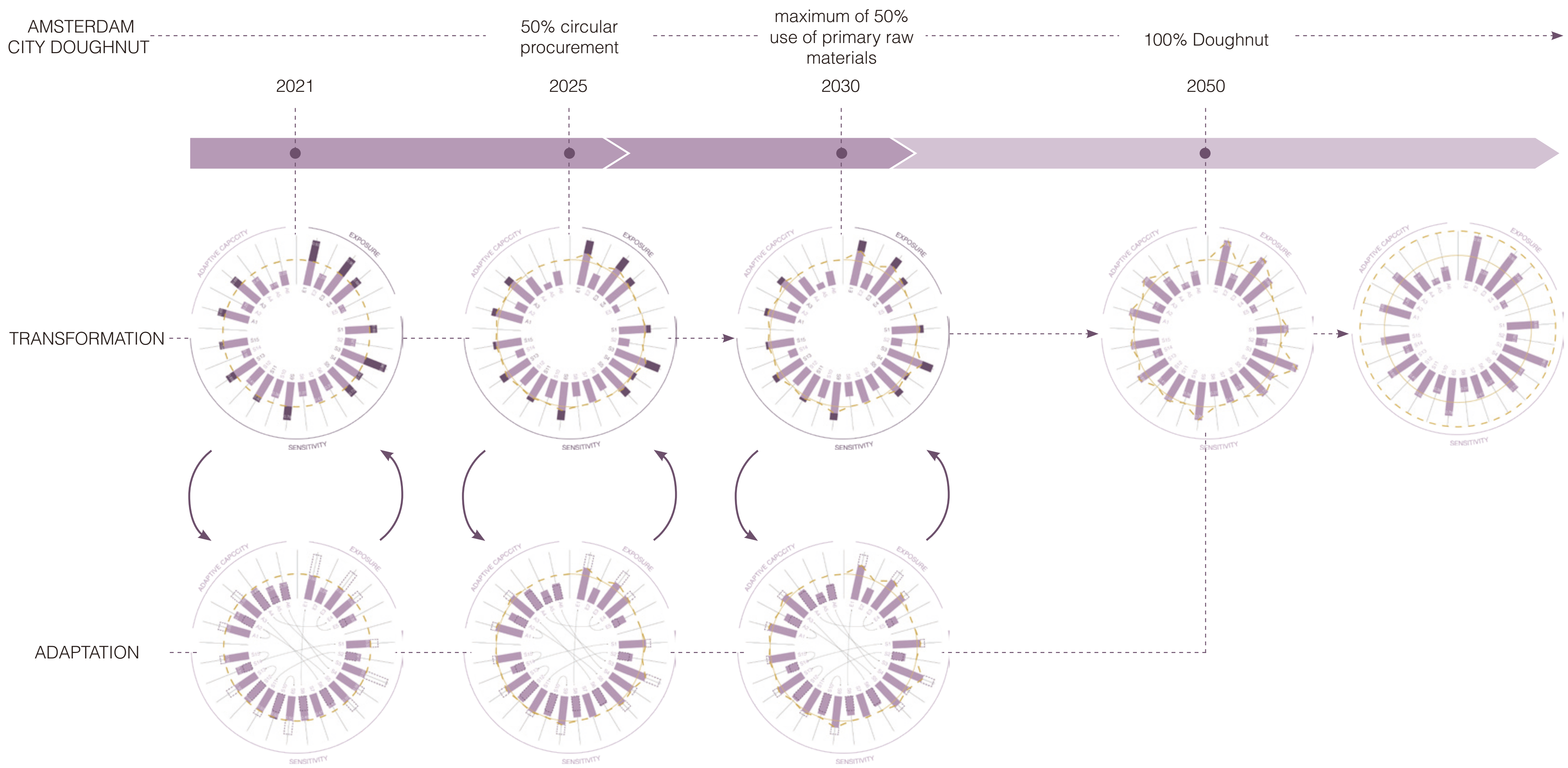


Fig. 6.6.7 Time dimension of development phases compared with Amsterdam Doughnut Economy. Made by author.

Finally, the design switches between the two adaptive cycles through transformability and adaptability in dynamic planning. Figure 6.6.7 reflects the change of vulnerability in Geuzenveld-Slotermeer by 2050, in relation to the Amsterdam City Doughnut. According to the previous planning for the community, there are two sets of strategies to reduce vulnerability: decreasing indicators and increasing thresholds, which corresponds to adaptability and transformability. These strategies enable the switch of adaptive circles between the two states (Fig. 6.6.8).

Planning for transformability emphasizes increasing the general resilience of the city through long-term community renewal. It will increase flexibility and resourcefulness. It will be generally implemented in usual periods when the city has not been affected by any direct or indirect effects of the epidemic. It will slowly change the threshold based on balanced social, ecological, and economic development. Similar to the doughnut economy, the threshold will be raised by half in 2030 and completely reach the target in 2050, making communities fully resilient to crises like COVID-19.

The strategy of adaptability focuses on a series of temporary spatial changes. It aims to respond quickly in the event of an outbreak and achieve the purpose of mitigating the pandemic and the spread of the virus. It means that during and shortly after an outbreak, vulnerability indicators can quickly drop below the threshold when a city needs to resist the virus or recover from a crisis. However, these emergency strategies may have negative indirect effects on other indicators of low vulnerability. Following the development of the city and implementing transformability, the threshold will accumulate. Therefore, the range of index reduction for adaptation will gradually decrease, and the consequent indirect impact will also be reduced. Eventually, by 2050, the target will be well below the threshold, so that cities can be both generally and specifically resilient.

Fig. 6.6.8 Perspective vision of a community public node in Geuzenveld-Slotermeer during the development. Made by author.

Fig. 6.6.9 Perspective vision of a community semi-public node in Geuzenveld-Slotermeer during the development. Made by author.

Fig. 6.6.10 Perspective vision of a living neighborhood in Geuzenveld-Slotermeer during the development. Made by author.

7 REGIONAL PLANNING

7.1 REGIONAL IMPACTS OF ADAPTATION

Fig. 6.7.1 Space and time of current population flow in multiple scales in MRA. Made by author.

7.1.1 Current flow

The approaches and concepts can also be applied on a larger regional scale. Population and resource flow from Geuzenveld-Slotermeer can be organized through dynamic planning. The current flow is shown in Fig. 6.7.1.

People living in high-density and low-density neighborhoods have different modes of transportation organization. Residents in low-density life circles rely more on motor vehicles for daily travel. However, their low traffic accessibility results in longer commutes and times. Residents partially use public transport only for long-distance trips to Amsterdam city center or other cities.

Residents in high-density life circles mostly walk and cycle in the community, who choose public transportation for longer-distance commuting and traveling. There are better transportation conditions than low-density life circles. However, the residents here are often limited by the educational, economic, and cultural levels, which makes it difficult to get adequate resources.

In short, taking the residents of Geuzenveld-Slotermeer as an example, the current model of population mobility is to concentrate in the city center, where most of the living resources are located, including work, commerce, and entertainment (Fig. 6.7.2). Thus, MRA is vulnerable to the pandemic because the concentration and long-distance mobility of citizens facilitate the spread of the virus. In addition, the lack of resources in the community also makes it impossible for residents, especially those at the bottom, to ensure their quality of life during the epidemic.

Fig. 6.7.2 Process of metropolitan region. Made by author.

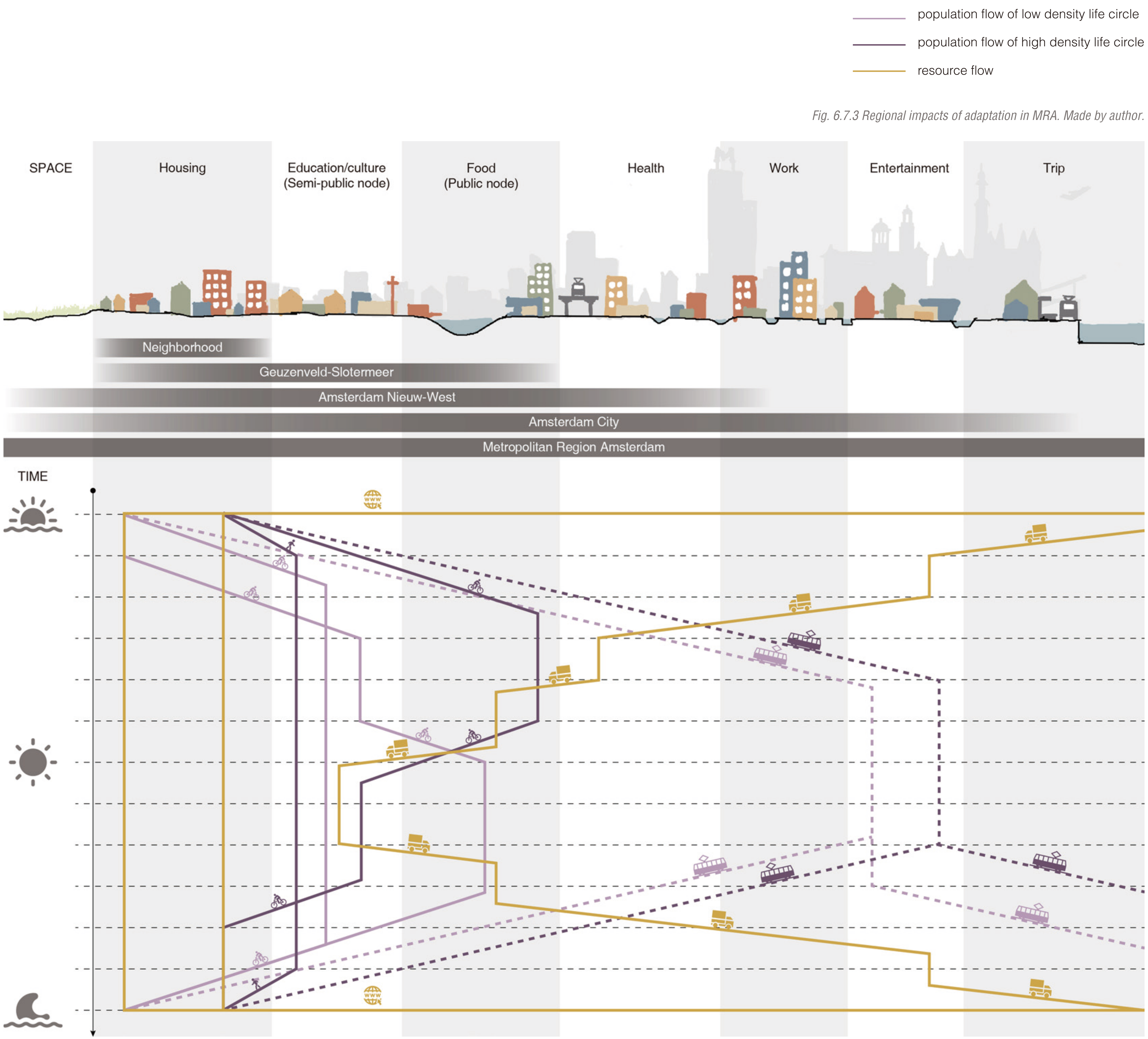


Fig. 6.7.3 Regional impacts of adaptation in MRA. Made by author.

7.1.2 Adaptation

Impacts of adaptation is to replace a part of remote population flow with resource flow from the city center (Fig. 6.7.3). Firstly, regional resources will be delivered to the community. Distribution logistics organized by a third party will undertake the responsibility of providing services outside the life circle for residents. Unified material mobility will replace population mobility, which offers residents resources more efficiently. It could also significantly reduce long-distance traffic in the region, reducing congestion and air pollution. Physical logistics will also collaborate with virtual information flows, such as remote work, education, and online entertainment.

In addition, the commuting distance will be reduced, and residents can travel within the community. The original food center and cultural center in Geuzenveld-Slotermeer will become public nodes and semi-public nodes, as the destination of delivery lines. Since most resources can be available within the community, motor vehicles will be reduced in both high-density and low-density life circles. Most jobs, shopping, and entertainment can be enjoyed at home or in public nodes by walking and cycling. In this way, the volume of long-distance travel will be greatly reduced, which will reduce public transport congestion and provide a safer infrastructure for a pandemic.

Eventually, there will be less long-distance communication between populations cross communities and cities, which can mitigate the spread of the virus (Fig. 6.7.4). However, such an outcome can only be resilient in a small scale temporarily during the pandemic. Regional resilience in a long term also should consider cultural and social impacts.

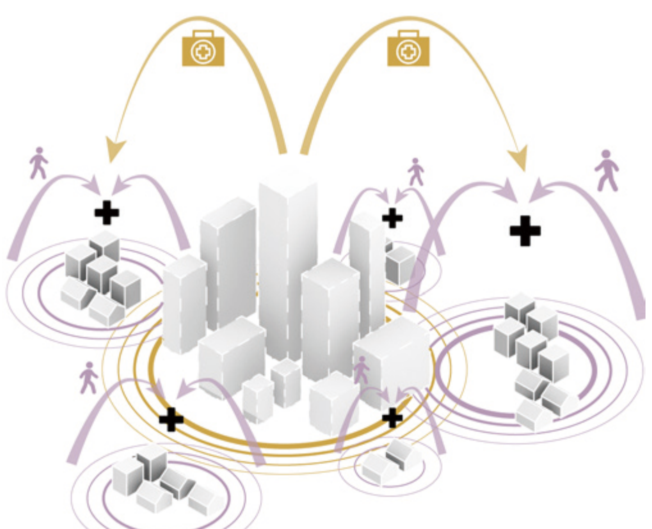


Fig. 6.7.4 Process of small cities. Made by author.

7.2 REGIONAL SOLUTIONS FOR TRANSFORMATION

7.2.1 Power of proximity

Returning to the regional scale, we cannot deny that metropolitan areas are one of the most important social and economic drivers of the world. Most of the economic and innovative activities take place in large cities and metropolitan areas, where prosperity is the most. The main reason is the power of proximity (Fulton, 2020). Dense centers support social interaction, where people randomly meet each other and exchange ideas. However, there are some drawbacks of concentration, the most prominent of which is that it increases environmental damage and accelerates the spread of viruses. Therefore, for the short-term adaptability in this project, the region can replace the population flow through material flow, limit the concentration of people and mitigate the impact of the pandemic. In the long-term transformability, it needs to promote the safe and efficient connection of the whole region while enjoying a high level of self-sufficiency internally (Fig. 6.7.5). Therefore, for the long-term transformation of the region, three additional strategies are proposed to facilitate the efficient connection of the subregions. These strategies were not integrated in the previous indicators, but are important in the regional-scale transformability. They are proposed in terms of origin, destination and connection respectively, corresponding to limited urban sprawl (Fig. 6.7.6), communication space (Fig. 6.7.7) and efficient public transport (Fig. 6.7.8).

Fig. 6.7.5 Outcome of dynamic network. Made by author.

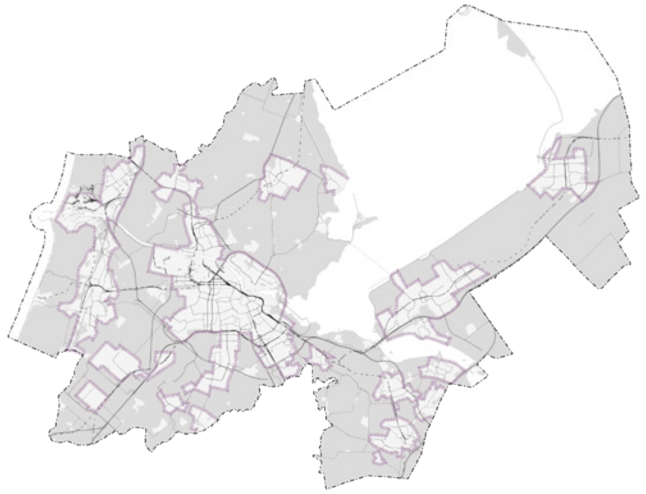


Fig. 6.7.6 Protected urban edge. Made by author.

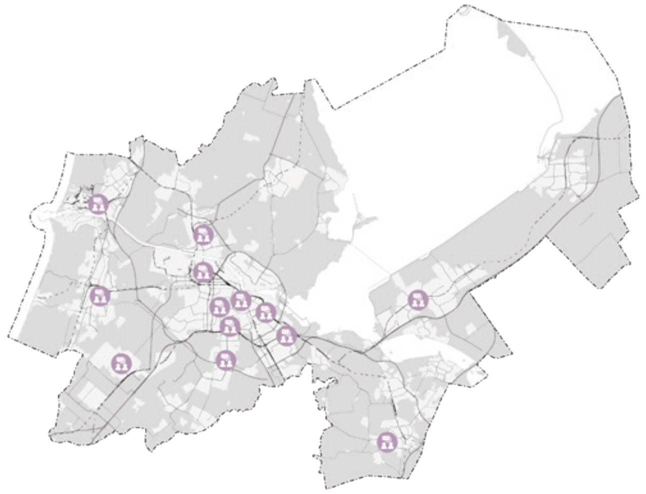


Fig. 6.7.7 Renovated urban center. Made by author.

Fig. 6.7.8 Public traffic transfer. Made by author.

7.2.2 Origin: limited sprawl

The first strategy is limited urban sprawl for origin. It is to increase density of resilience in the region. It has been broadly realized that the unlimited urban expansion has negative impacts on land occupation and increasing transport. The growing area will increase the distance and decrease the efficiency of population flow. Therefore, this strategy aims to combine prevention of urban sprawl with the densification of existing urban areas. They can be located along highways or waterways as peripheries between urban and nature (Fig. 6.7.9). Firstly, underused, vacant or abandoned land should be reused in existing settlements. Compact construction can not only meet the demand for housing, but also improve the quality of life and the efficiency of public infrastructure. Secondly, urban boundaries should be clearly defined and morphologically protected by isolating green belts or water systems. Majority of urban edges in MRA are defined by highway or waterway, which can be the political boundaries to limit construction outside and encourage regeneration inside. Finally, the ecological remediation around the edges is necessary to form a transition from the urban system to the ecosystem. Urban boundaries need not only to prevent the expansion of urban construction, but also to mitigate the impact of urban pollution on the ecological environment. Therefore, ecological recovery can be facilitated with development of natural inclusive tourism and recreation for citizens.

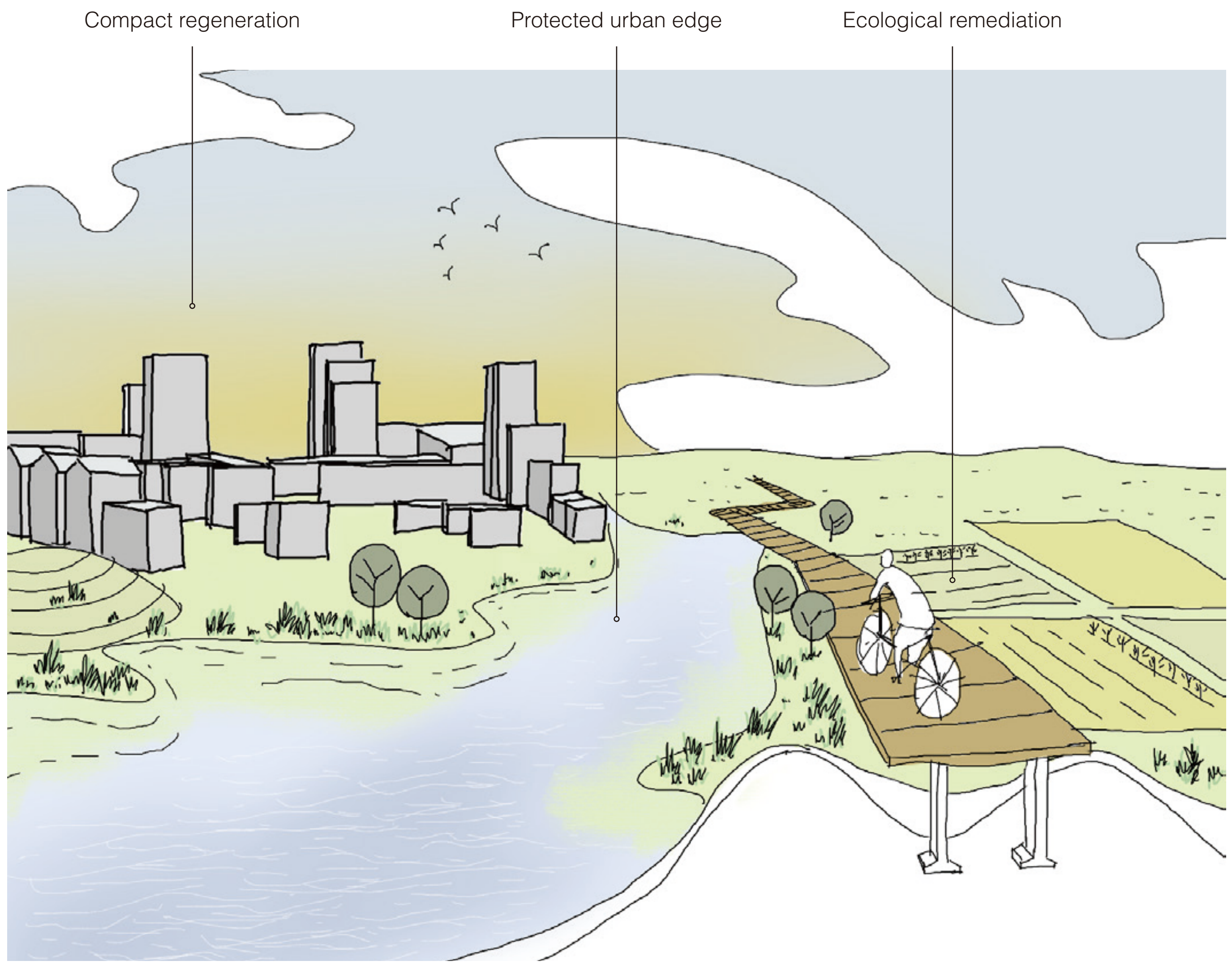


Fig. 6.7.9 Impression of limited urban sprawl in MRA in 2050. Made by author.

7.2.3 Destination: space for communication

Everywhere in the region can be an origin and destinatioon. According to the micro-design strategies for indicators, the purpose of population flow is going to be changed from working or necessities to social interactions. COVID-19 accelerates the decline of retail stores and shopping malls, reflecting a shift in the demands of urban living (Statista, 2020). Besides, crowded city centers have become hotspots to spread virus during the pandemic. Therefore, there should be enough space for communication to minimize negative impacts while improving the social activities in destination (Fig. 6.7.10). It is to increase diversity of resilience in the region. The development of street life is also integrated in vision of Amsterdam 2050 (Gemeente Amsterdam, 2019). Firstly, there should be mixed public services in the centers, which can reduce the transportation for different activities and improve the interaction between different groups of people. An idea is to combine it with the abundant street life in the city centers, which is related to the number of pedestrians. Active ground floor use, frequent building entrances, display windows and sidewalk trees can all contribute to the pedestrian experience. Besides, interwoven canals in MRA also provide a variety of spaces for the streets. Finally, various open space can contribute to the transformation of public activities to become pandemic resilient. Plazas, pocket parks, and green space with different scales and functions will be basis for different groups, who can also communicate in a social distance during the pandemic.

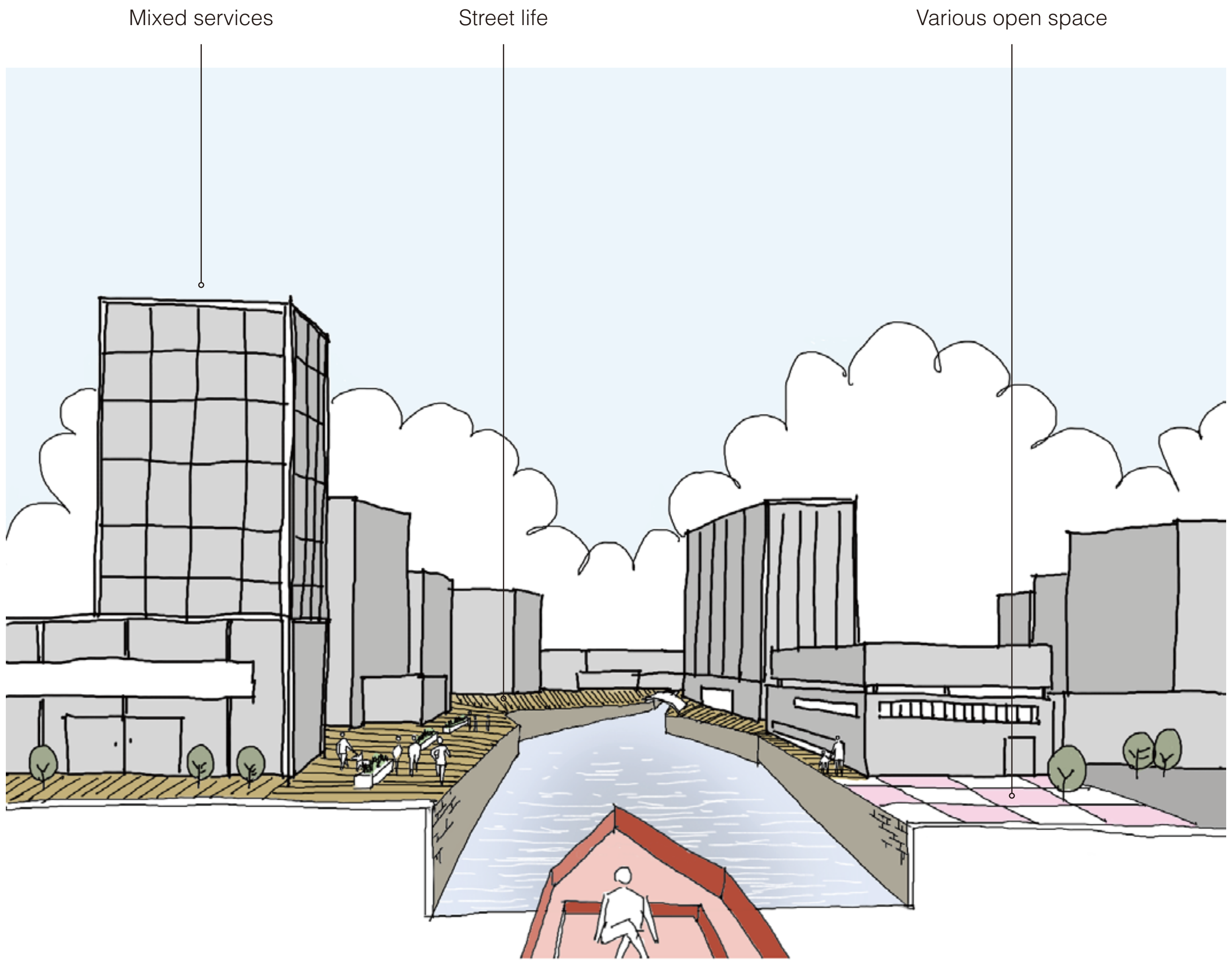


Fig. 6.7.10 Impression of space for communication in MRA in 2050. Made by author.

7.2.4 Connection: efficient public transportation

The third strategy is the implementation of TOD development around stations with large ridership in combination with convenient transfer among mixed transport modes (Fig. 6.7.11). It is to increase redundency of resilience in the region. It is necessary to make sure cities cannot recover from lockdown to gridlock. Due to the COVID-19, some cities have been reported a significant change from public transportation to private mobility (ITDP, 2020). Therefore, the public transport needs to transform to accommodate more passengers while keeping them safe. Firstly, some priority lanes for dedicated buses can be installed, accompanied by increased additional buses on busy routes and time to improve efficiency. Prior plans and investment for public transport expansion can decrease the use of private cars for long-distance travelling through improved efficiency, frequency, and reliability. The pandemic is also an opportunity for cities to reallocate streets with minimal disruption. Secondly, comprehensive transfer among different modes of public transport, as well as walking and cycling, will play a big role to connect the city center with subregions and urban peripheries. Thirdly, transit-oriented development (TOD) policies are important to support a reduction from private cars and transit ridership in the regional scale. Stations will become not only public transport hubs, but clusters of jobs, services, and housing. It is also a way to increase availability and convenience in the city for residents.

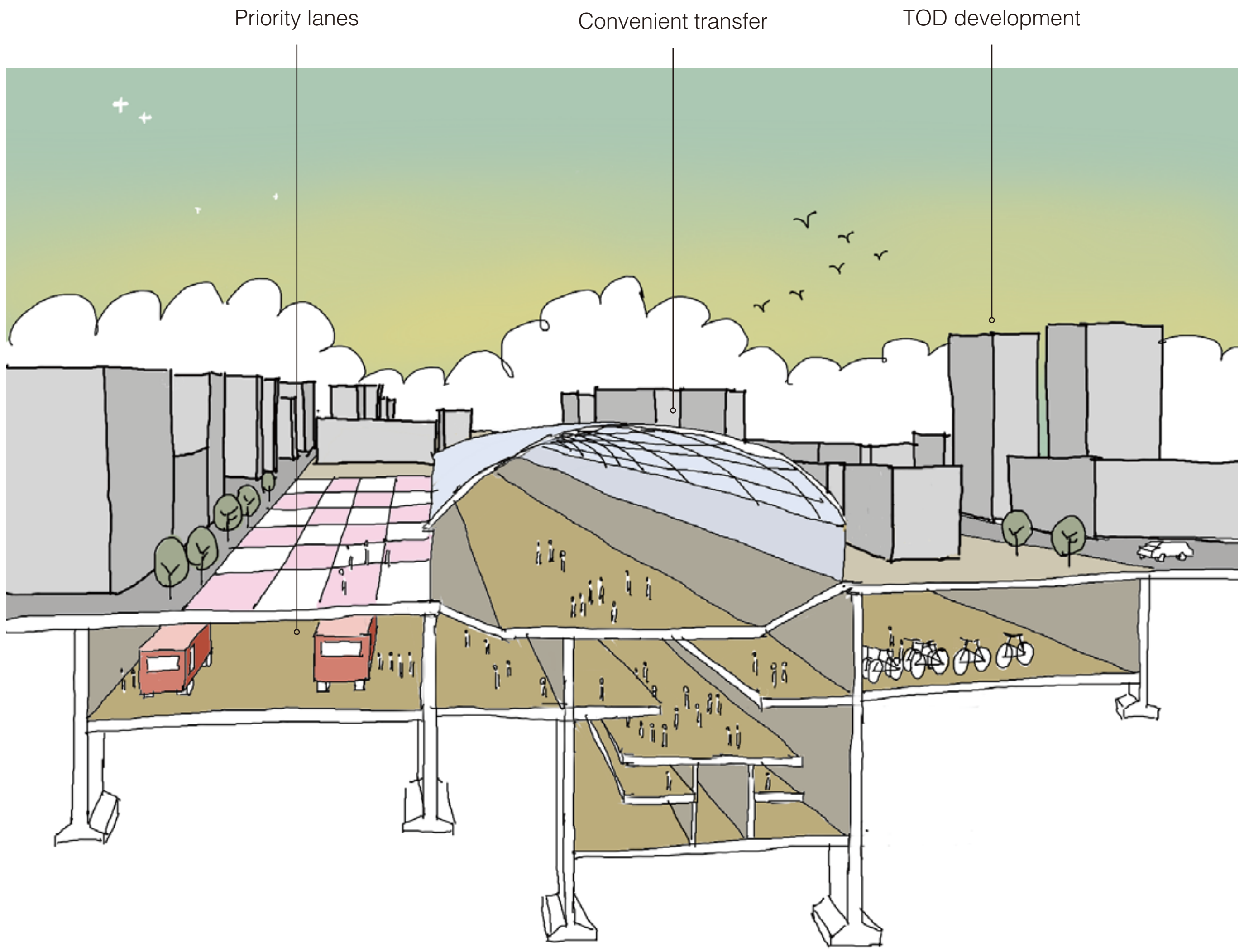


Fig. 6.7.11 Impression of efficient public transportation in MRA in 2050. Made by author.

The vision map shows the population and resource flow in MRA taking Geuzenveld-Slotermeer as an example (Fig. 6.7.12). Public services will be dispersed to different cities, rather than being concentrated in the Amsterdam capital. Therefore, the population of Geuzenveld-Slotermeer will travel to surrounding cities through efficient public transportation. The main ports will be transferred from Westpoort to IJmuiden, Lelystad, and Schiphol on the periphery of the region, reducing traffic and pollution in Amsterdam. Aalsmeer and Westpoort will become nodes for a circular economy, providing the region with healthy food and waste disposal. Moreover, resources will not be fixed in these centers but shared throughout the region in a flexible way. Products in Zaandijk and entertainment activities in Almere can be delivered to Geuzenveld-Slotermeer through online or offline approaches. Ultimately, community residents can enjoy the services without long-distance travel.

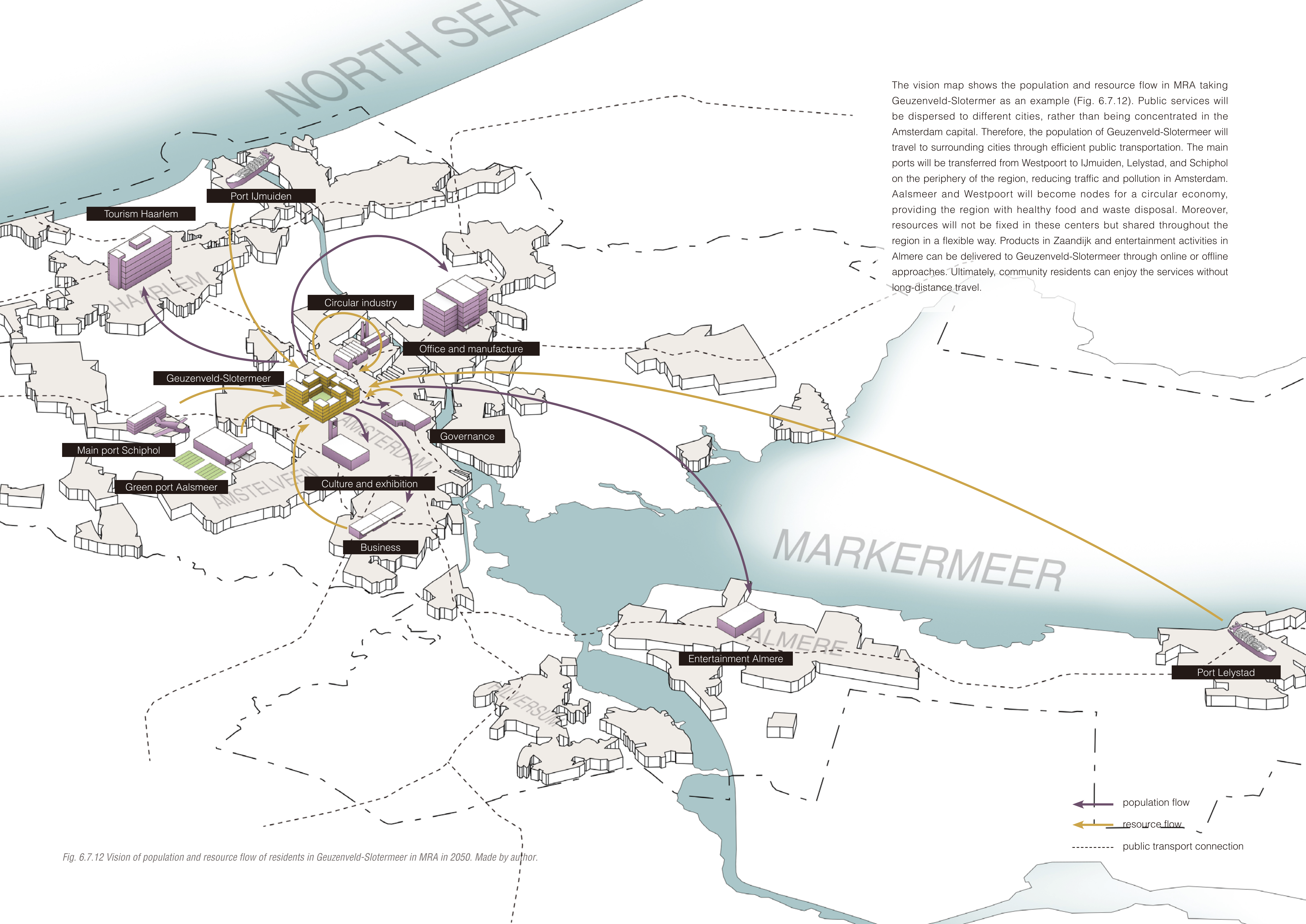


Fig. 6.7.12 Vision of population and resource flow of residents in Geuzenveld-Slotermeer in MRA in 2050. Made by author.

7.3 POLITICAL AGREEMENTS

7.3.1 Decentralisation of public services

Four political agreements will be proposed to ensure the multi-scale implementation of strategies. The first change should be decentralization of core services, benefit to localization, and self-sufficiency. According to the strategies, each resident's accessibility to public services will be prioritized in the planning of adaptation and transformation. There will be trouble resisting the pandemic if they lack access to necessities like housing, hospital, and food. Decentralization in this project means transferring responsibility for the management and allocate resources from centers to corporations and local government (Fig. 6.7.13). "It's not like each place has to be an island, but that there's some kind of sense of balance and sustainability that you can see within your own settlement." (Constable, 2020)

Decentralization focuses on the cooperation between the central government, the government, and Civil Society Organizations (CSOs) (Rondinelli, 1981). The relationship between the central government and the local government is devolution, which aims to improve the efficiency of allocative. Local governments can make the decision with respect to their own rules through the power of autonomous initiative. In the process of decentralization from public services to agencies, third-party logistics (3PL) will play a role in delivery and relocation. CSOs will work as partners of the government through transferring responsibilities for the delivery of services. It emphasizes more on the needs of people at a lower level, which is often neglected in the work of governments. Therefore, CSOs can play a significant role in offering enough resources to local residents like healthcare, education, and religion.

7.3.2 Circular system

The global economy has been moving in a linear pattern, leading to resource shortages, climate change, and global pandemics. The recovery of COVID-19 could be an opportunity to rethink this linear system. We need to use existing resources more efficiently to reduce crises. A circular system can not only promote economic recovery but also promote a thriving and green city.

A circular system can increase urban resilience by reducing imports and exports. In this globalized world, resources from any corner can be gathered in the city center in a matter of days, with viruses. It can build resilience in the supply chain by increasing the purchase and recycling of local materials. In addition, it can also provide more opportunities and jobs for local businesses (Florant, Noel, Stewart, & Wright, 2020)

This agreement is based on the Amsterdam Circular Strategy to propose a more beneficial circular system for improving the resilience of the pandemic, including food and living facilities management and materials management. Food and living facilities recycling is planned to reduce the amount of waste that residents produce in their daily lives. The purpose of material recycling is to reduce pollution caused by urban construction. Each part of the two value chains has a corresponding circular approach. For example, the value of residents' second-hand products can be maximized through community sharing, while some building materials waste can be recycled through professional factories.

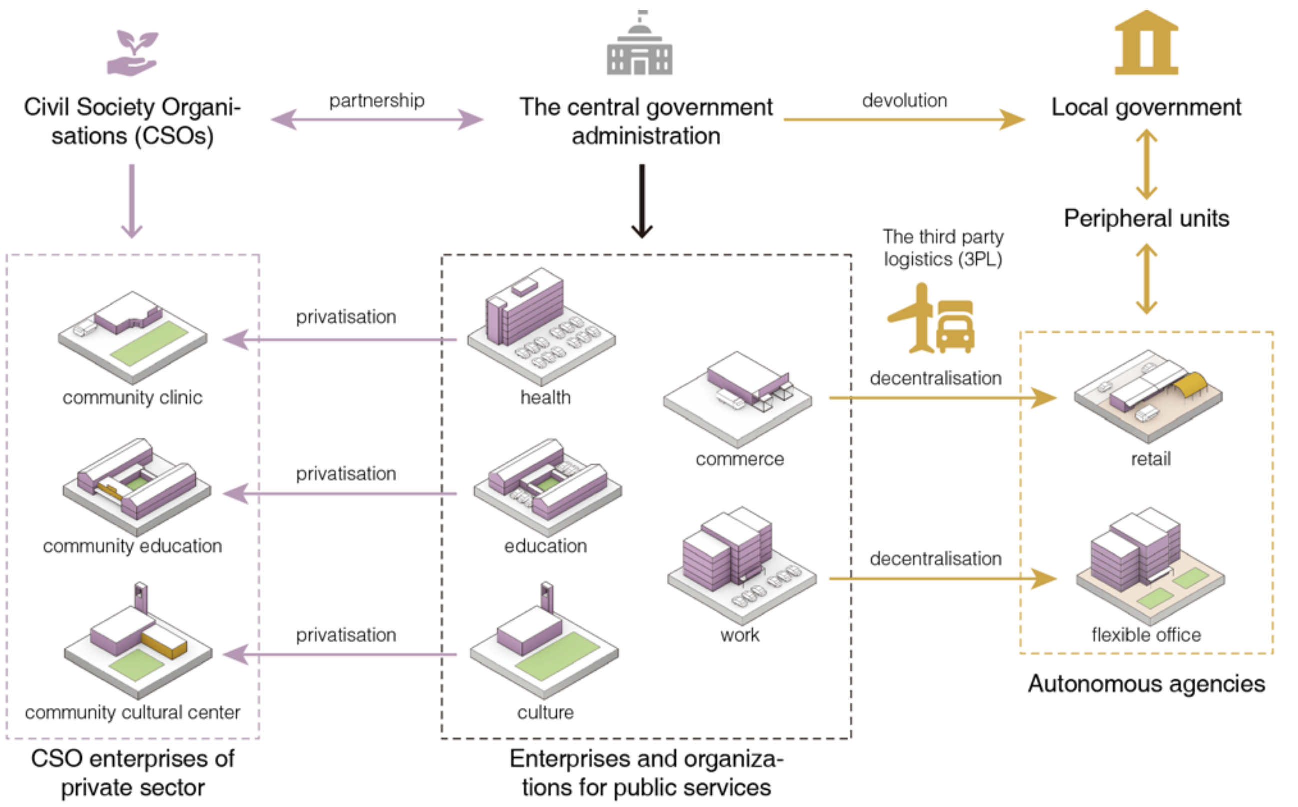


Fig. 6.7.13 Vision of decentralisation of public services in MRA in 2050. Made by author, based on Smith, 2001.

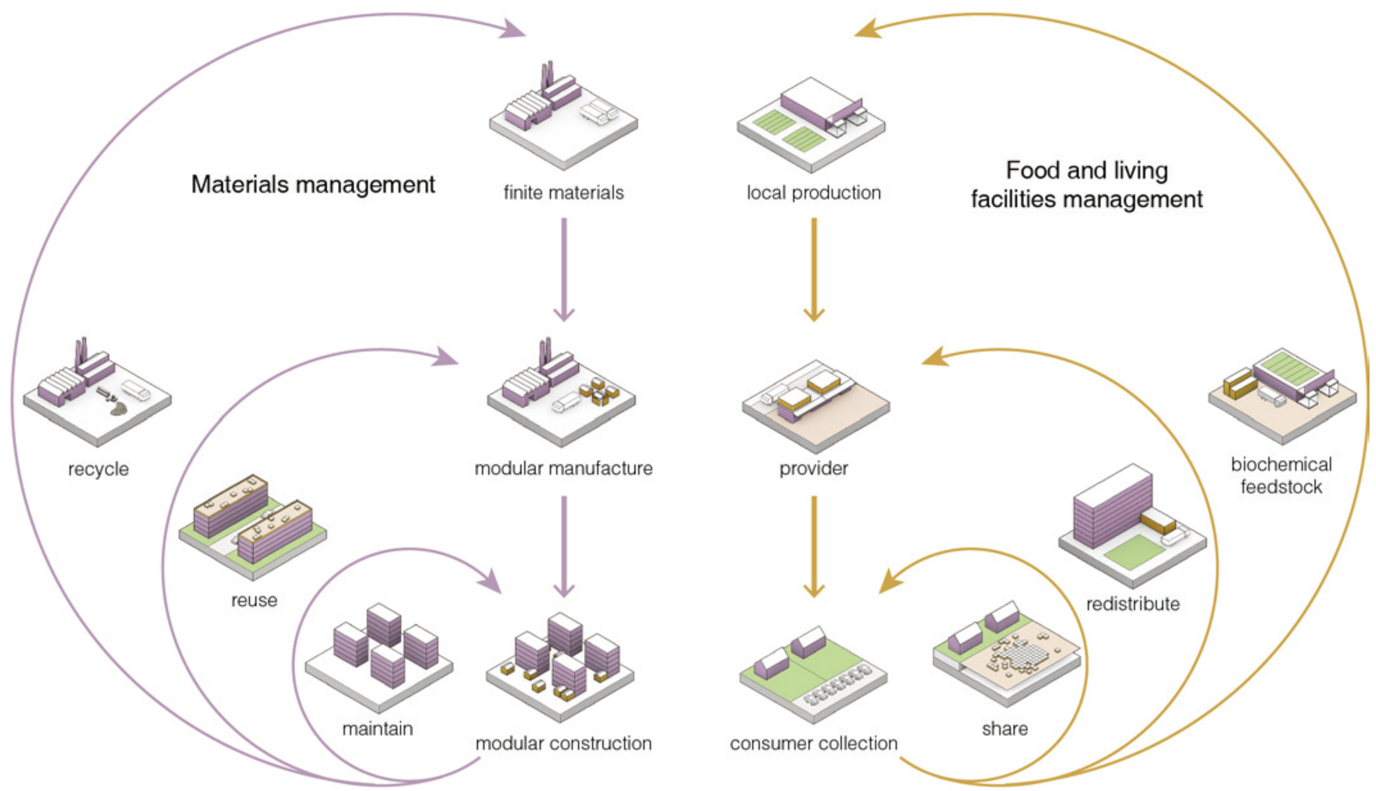


Fig. 6.7.14 Vision of circular urban system in MRA in 2050. Made by author, based on Ellen Macarthur Foundation, 2019.

7.3.3 Transport management

Localization is not only in food and goods but also in daily transportation. It is essential to support the construction of small life circles to provide safe, affordable, and sustainable transportation. First of all, in the short term after COVID-19, people will still avoid using public transportation and rely more on private transportation to maintain social distance (Lee & Carvalho, 2020). Therefore, there should be some measures to reduce the use of private cars to reduce greenhouse gas emissions. For example, cities need to be more prepared for cycling and walking and provide more safe lanes and services to reduce motor vehicle use. In the governance aspect, we need to tighten standards and increase the use of renewable energy to reduce harmful emissions.

The second aspect is the use of public traffic, which, while not ideal in a pandemic scenario, will remain an environmentally friendly transportation solution for a long time. To reduce the risk of the virus and recover trust in public transportation, cities need some measures to make it safer for workers and individuals who use public transportation. For example, it can reduce congestion by reducing the capacity of individual services and increasing the frequency. It will help reduce density by combining scheduled travel times with flexible working hours.

Finally, all of these strategies will support the more flexible use of streets and modes of transportation through smart coordination. For example, as suggested in the previous design, the driveway can be narrowed during off-peak hours for neighborhood activities.

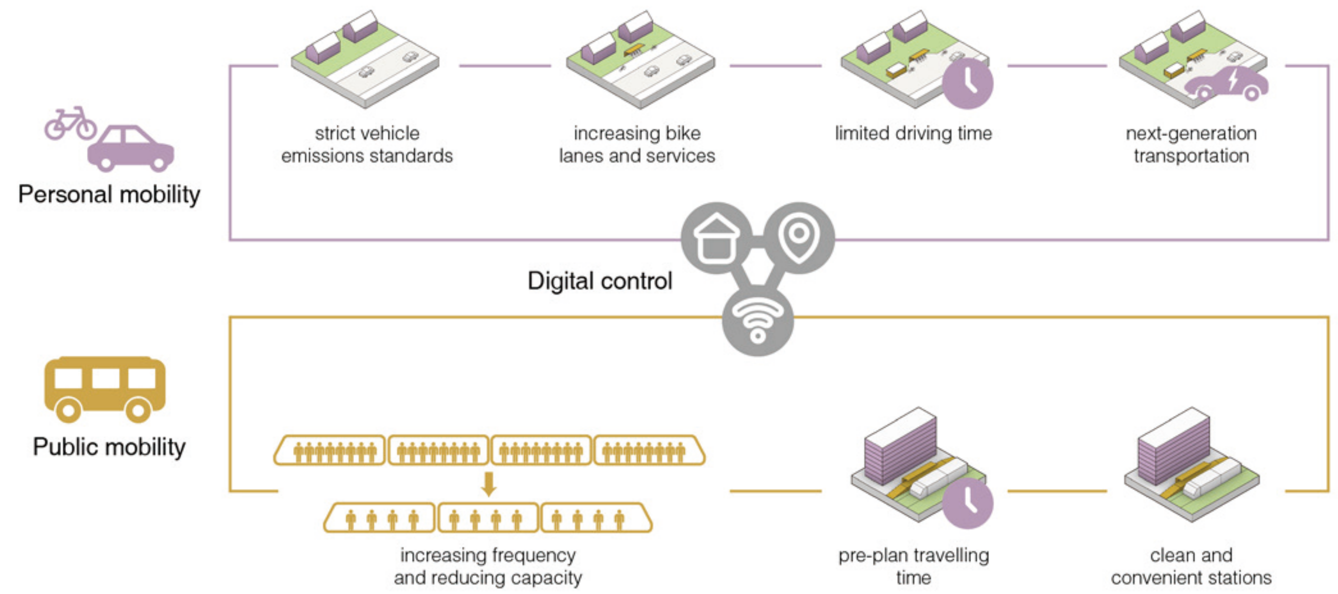


Fig. 6.7.15 Political agreements of transportation in MRA in 2050. Made by author.

7.3.4 Smart city and digitalization

COVID-19 has showed the importance of digitalization in responding to the pandemic. Providing data within a city digitally can help government institutions respond more quickly. We should not consider different aspects of digitization in isolation. Unified, real-time, and secure information will be used by decision-makers across all industries in a cooperative and interconnected way. As this trend matures, we need to catch the opportunities in urban construction to resist the rapidly changing conditions for future urban crises like the pandemic.

Firstly, collaborative innovation between the government and the private sector can bring individual smart technologies to affordable cities. It requires not only government investment and policy support, but also bottom-up contributions from business companies and citizens. Secondly, it can support low-carbon development by collecting large amounts of data digitally to guide the construction of infrastructure. Thirdly, the building of smart cities needs to focus on the needs of all residents. It means systematically providing urban services to all citizens, opening data to those most vulnerable to the pandemic.

Finally, smart cities and digitization do not necessarily mean livable cities, and how to further transform the two is another challenge for the government. The key is the adaptability and transformability emphasized in this project. They can enhance the digital investment capacity of smart cities, facilitate budget reallocation, and increase new revenue.

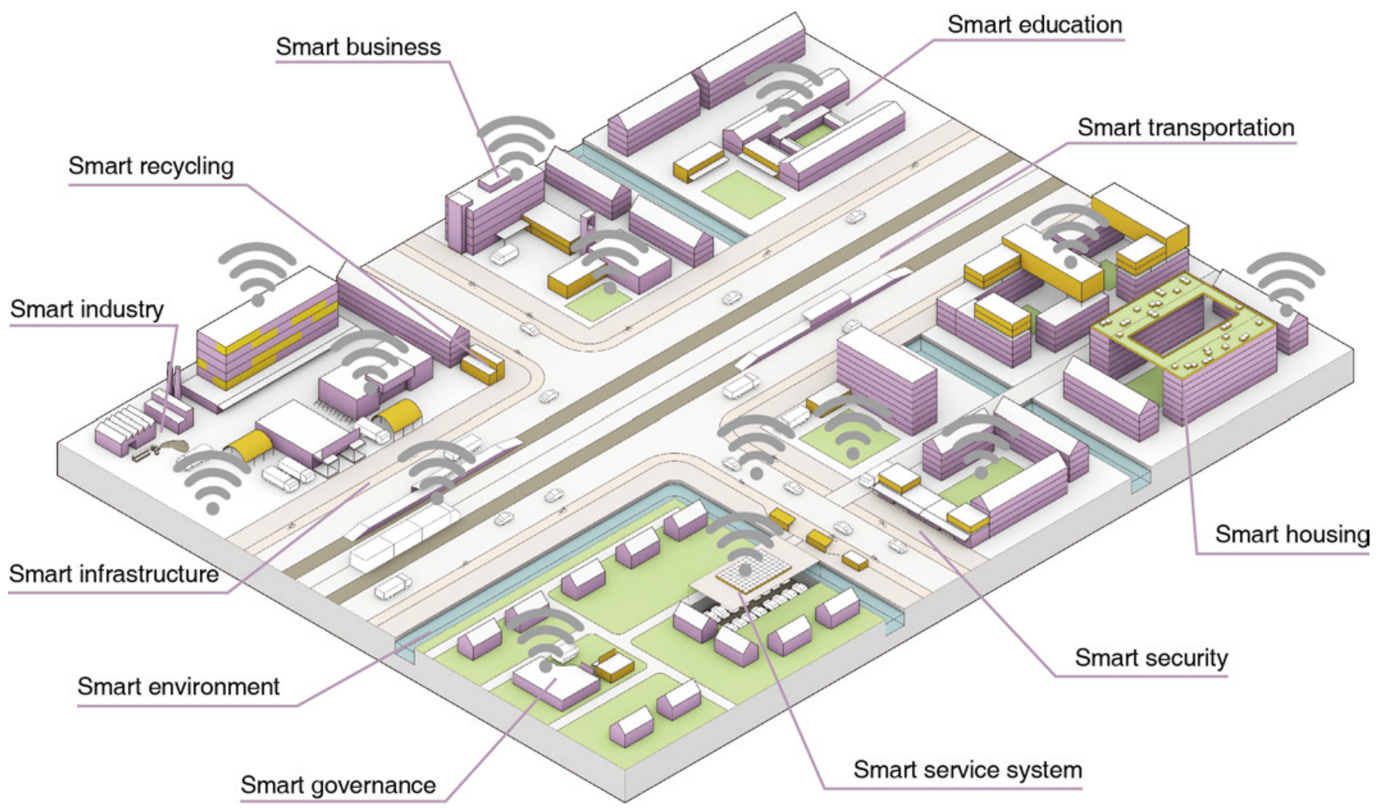


Fig. 6.7.16 Vision of smart city in MRA in 2050. Made by author.

Fig. 6.8.1. The street art in Slotermeer, Amsterdam, 2020. Photographed by author.

8. CONCLUSION

This chapter answers the sub-research questions. What are the spatial strategic interventions to foster the improvement of urban resilience to pandemics? What are the planning actions to contribute to the general urban resilience in MRA? These questions play significant roles in the aim: 'to proposing spatial and political strategies spatial strategies through the balance among economy, society and ecology to improve metropolitan resilience facing the pandemic in MRA after COVID-19'.

Based on the theory of urban vulnerability and socio-ecological resilience, this chapter is the implementation of 'dynamic planning' in Geuzenveld-Slotermeer firstly. It is one of the most seriously affected areas in MRA due to its high exposure and high sensitivity. Therefore, main strategies are proposed to decrease exposure and decrease sensitivity related to the assessment of indicators in the community. The strategy for decreasing exposure is to make full use of local resources by building a circular economy. It aims to achieve self-sufficiency, reduce the damage to the external environment, and the possibility of being affected by risks. And the main strategy to reduce the sensitivity is to improve the quality of life for residents through community renovation.

According to the framework of dynamic planning of resilience, the detailed design principles are proposed respectively from adaptability and transformability. Adaptability emphasizes the ability to adapt and persist, so the pandemic resilience is mainly manifested as the urban space, function, and structure which can be reversibly converted for an outbreak. Transformability considers the potential and opportunity into new systems, so strategies of transformability are mainly long term, slow, and future-oriented for general urban resilience. Then, four local areas are selected as different contexts for these micro principles: public node, semi-public node, high-density life cycle, and low-density life cycle.

Then, based on four types of local design, this project proposes planning strategies of the urban system and the evaluation of the Geuzenveld-Slotermeer at the urban scale. The planning of adaptability is to rapidly reduce the transportation distance of residents for relatively independent life cycles in their living neighborhoods during an outbreak. And the planning for transformability is to undertake various socio-economic activities in the community through more flexible-used and shared space, so the material flow can replace population flow.

Finally, these strategies are applied on a larger regional scale, which is resilient for short-term adaptability, but unsuitable for long-term transformability. Therefore, three additional strategies are proposed to improve the safe and efficient population flow for transformation in pandemic resilience from origin, destination, and connection. Accordingly, four political agreements are proposed to ensure the multi-scale implementation of strategies.

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7 EVALUATION

In this chapter, dynamic planning in Geuzenveld-Slotermmer is evaluated through the framework of pandemic vulnerability and compared with the scenarios of businesses as usual and doughnut economy to judge impacts from the proposed strategies.

CONTENT

1 INTRODUCTION

The project will be evaluated to discuss the feasibility of planning strategies by pandemic vulnerability analysis for three scenarios in Geuzenveld-Slotermeer: business as usual, doughnut economic planning, and dynamic planning. Following the framework of pandemic vulnerability, the evaluation framework consists of exposure, sensitivity, and adaptive capacity (Fig.7.1.1). The data of all indicators are distributed from 0 to 1, and the level of vulnerability is determined through the threshold. The scenarios of businesses as usual and doughnut economy follow traditional planning strategies, to reduce the vulnerability by directly reducing the value of factors. Their evaluation will only result in a change of indicators. Since dynamic planning includes adaptability and transformability, which affect indicators and thresholds respectively, the change will include both indicators and thresholds.

The scenario of business as usual assumes an economic-oriented development along with the existing community land use and structure (Fig. 7.1.2). It is thus presumed that areas in the east, closer to Amsterdam city will develop more rapidly to a business center. As the infrastructure remains, residential areas in the west will be under development. The scenario of the doughnut economy is based on the Amsterdam Planning in 2050 (Gemeent Amsterdam, 2019, see Fig. 7.1.3). This scenario places more emphasis on sustainable and circular energy and resource. Solar areas will be built in the north and west of the community. More mixed-use land will be extended along the main road. Besides, the main public transport will be changed from two parallel tram lines from the city center to the community, to one connecting the railway station to the south. The scenario of dynamic planning has been introduced in the previous chapter (Fig. 7.1.4). It will include life circles and delivery lines, where the infrastructure takes the form of more mixed land along the road. The overlapping areas of those life circles will become two public nodes.

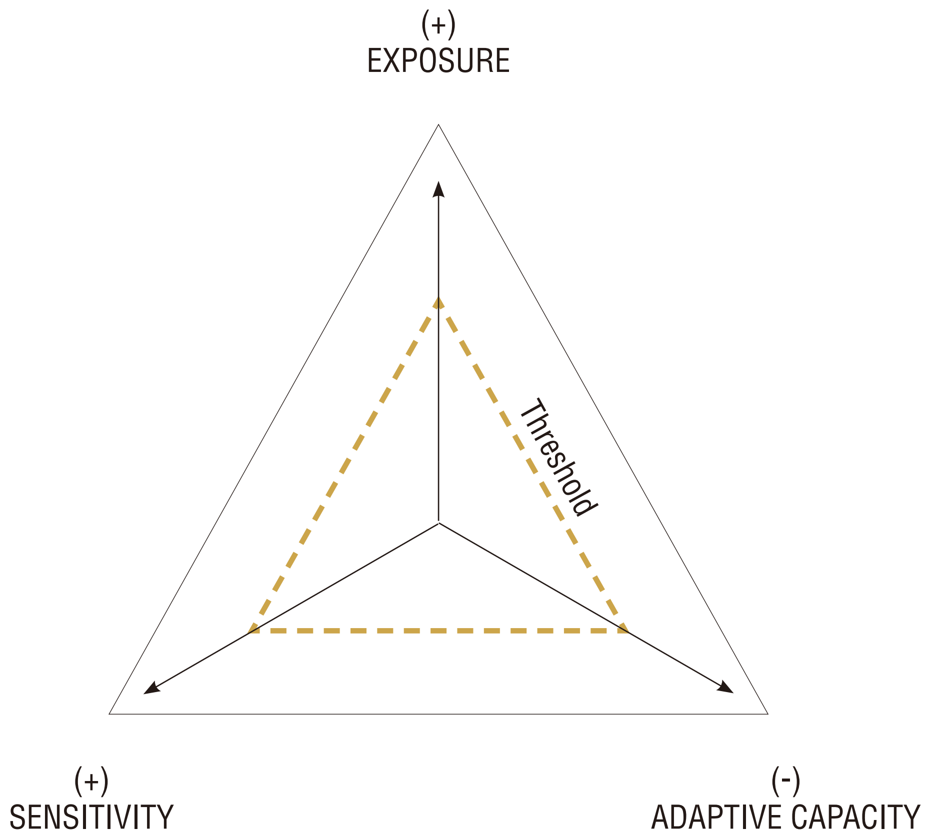


Fig. 7.1.1. Evaluation framework of urban vulnerability to the pandemic. Made by author.

housing areas
mixed areas
business center
water space
green space
main public transport
main urban streets
railway station

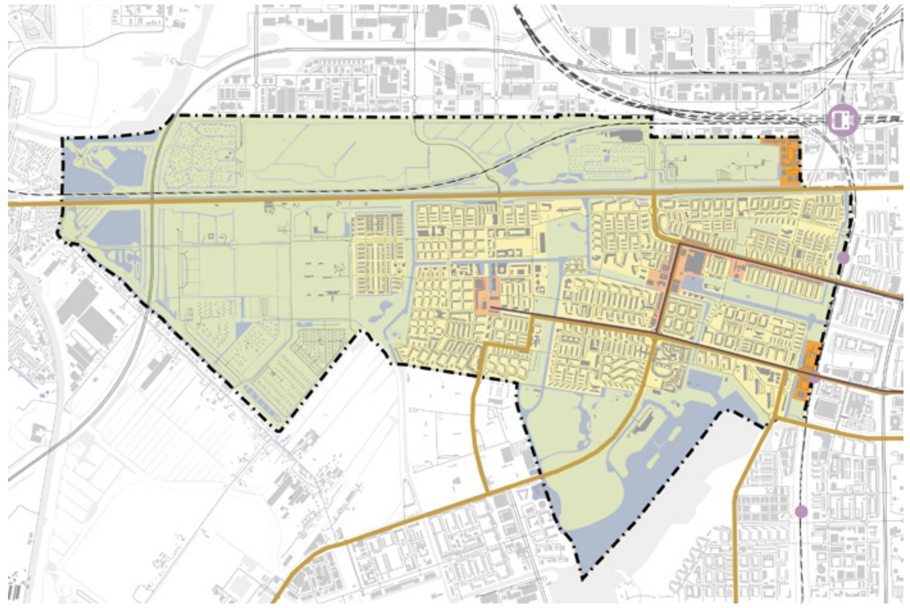


Fig. 7.1.2 Scenario 1: businesses as usual in Geuzenveld-Slotermeer in 2050. Made by author.

area for solar energy
green-blue hotspot

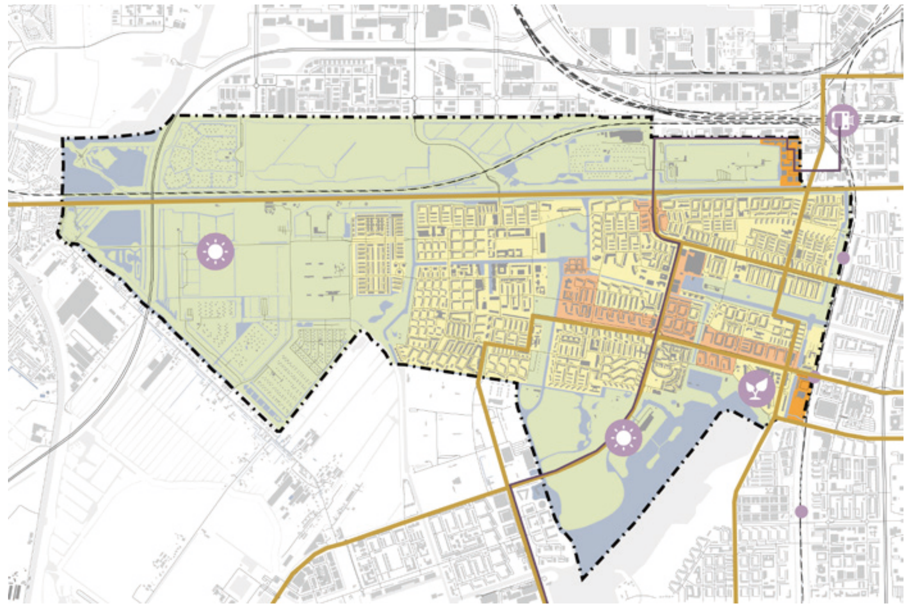


Fig. 7.1.3 Scenario 2: doughnut economy in Geuzenveld-Slotermeer in 2050. Made by author, based on source from https://amsterdam2050.nl/.

public node
semi-public node

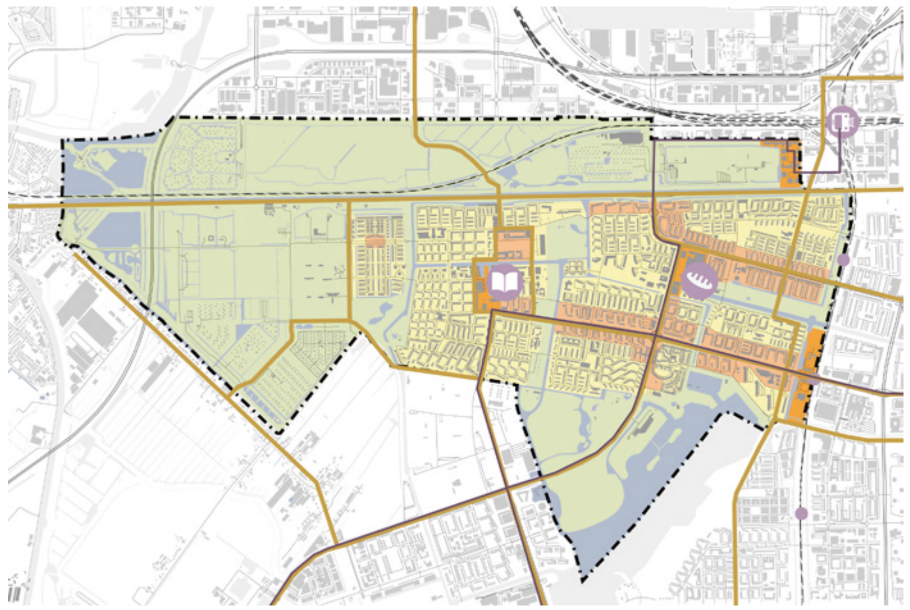


Fig. 7.1.4 Scenario 3: dynamic plannig in Geuzenveld-Slotermeer in 2050. Made by author.

2 EXPOSURE

The pandemic vulnerability of three scenarios can be assessed based on their vision and the relationship with each other. Data of Scenario 1 is predicted following the trend of current development, and the majority of data of Scenario 2 can be collected in the report (Gemeent Amsterdam, 2019). However, indicators of Scenario 3 are planning goals rather than predicted results, which frame for possible strategies as triggers of intervention. Therefore, the change is reflected by the quantity of "+" and "-", which show the relative relationship among these scenarios.

Table 7.2.1 shows the exposure in the three scenarios. There are three indicators of high vulnerability in the original site. All indicators in Scenario 1 are increasing, which will be above the threshold by 2050. Most of the indicators in Scenario 2 are being lowered, where most of the indicators, excluding daily passengers, will be under 0.5 by 2050. However, the goal of Doughnut will not be fully achieved in 2030. The original three high-vulnerability indicators will be still above the threshold. The outcome of dynamic planning in 2050 is similar to that of the doughnut economy, but the development process is different. For example, the decreasing of air pollution can be faster than doughnut economic planning, because strategies in this project focus not only on transformability of circular material use but the adaptability of modular construction in a short term. Besides, indicators with low exposure are more stable than in Scenario 2. Flexible offices and collaborative models can reduce the exposure of international corporations to the pandemic.

Indicator	Current index over threshold	Business as usual		Doughnut economy		Dynamic planning	
		2030	2050	2030	2050	2030	2050
EXPOSURE							
air pollution	0.43	+ +	+ + +	-	- - -	- -	- - -
air humidity	-0.21	+	+ +	-	- -	-	-
import/export	0.40	+	+ + +	-	- -	- -	- - -
daily passengers	0.18	+ +	+ + +	-	-	- -	- -
international corporations	-0.38	+	+ +	+	+ +	+	+

Vulnerable indicator
+ Increasing 0.1
- Decreasing 0.1

Table 7.2.1 Changing indicators of exposure in scenarios of business as usual, doughnut economy, and dynamic planning. Made by author.

3 ADAPTIVE CAPACITY

Adaptive capacity is beneficial for reducing vulnerability, so table 7.3.1 shows its negative number. It means the higher the number of indicators above the threshold, the lower capacity and the higher vulnerability. Indicators of education and hospital beds are above the threshold currently in Geuzenveld-Slotermeer. However, in the scenario of businesses as usual, the government trust will decrease rapidly in the short term due to the impact of COVID-19. Until 2050, the original problem can be exacerbated by the growth of the population. At the same time, population health will become a new indicator of high vulnerability due to marginalization. Thus, in Scenario 1, Geuzenveld-Slotermeer may regress to a site with low adaptive capacity in 2050. The change in Scenario 2 is similar to that of exposure, whose all indicators are decreasing slowly. Education and hospital beds will not be completely below the threshold until 2050.

In Scenario 3, strategies of adaptation in the short term will also indirectly lead to the increase of some low-vulnerability indicators. It means that while education and hospital beds decrease in 2030, other indicators can be more vulnerable to some extent. For example, in dynamic planning, the education level of both students and residents can be improved in the short term through distance education cooperated with community education. They will decrease the indicator and raise the threshold faster than planning for the doughnut. However, there needs to be a higher ability to use technology, which will reduce adaptive capacity within the threshold in 2030 and improve it through shared educational resources until 2050. Similarly, using hotels for temporary quarantine during an outbreak can provide more hospital beds quickly than in Scenario 2. Meanwhile, the resulting reduction in government trust can be recovered in the long term by improving transformability. Therefore, dynamic planning can finally improve the adaptive capacity of the site in both the short and long term.

Indicator	Current index over threshold	Business as usual		Doughnut economy		Dynamic planning	
		2030	2050	2030	2050	2030	2050
ADAPTIVE CAPACITY (-)							
education	0.15	+	+ +	-	- -	- -	- -
government trust	-0.15	+ +	+ + +	-	-	+	-
hospital beds	0.13	+ +	+ + +	-	- -	- -	- -
health	-0.10	+	+ +	-	- -	+	- -
ability to use technology	-0.34	-	-	- -	- - -	+	- -
government efficency	-0.25	-	-	-	- -	+	-

Table 7.3.1 Changing indicators of adaptive capacity in scenarios of business as usual, doughnut economy, and dynamic planning. Made by author.

4 SENSITIVITY

There are eight indicators over 0.5 in the current situation in Geuzenveld-Slotermeer, making it a highly sensitive area. As with the first two components, most of the indicators for Scenario 1 will continue to increase (Table 7.4.1). The evaluation shows that in 2030, without any economic transformation, tourism and transport dependency will develop into additional indicators of high vulnerability. Up to 2050, more indicators will increase beyond the threshold, making Geuzenveld-Slotermeer a more sensitive community. Most of the indicators in Scenario 2 will decrease at a slow rate, especially over a short period of time. The development of the high-level infrastructure of the Schiphol Airport is bound to drive the development of tourism within the community. It will become a new vulnerable indicator through implementing the Doughnut Economy (Gemeent Amsterdam, 2019). Therefore, although most indicators will gradually decrease, Geuzenveld-Slotermeer will remain highly sensitive, which means vulnerable to the pandemic.

In the scenario of dynamic planning, similar to exposure and adaptive capacity, it is more resilient than others due to its quick response. For example, residential density will decrease to the threshold faster than Doughnut because of its temporary housing strategy through modular construction. Child distribution can be reduced by providing more flexibly shared space for activities rather than slowly changing the population structure. However, there will be some indirect negative impacts on other indicators. Green space is mainly affected. According to the previous design, it will be affected by the strategies for open space and residential density. Fortunately, there are abundant green space resources in Geuzenveld-Slotermeer, so the temporary reduction will not seriously affect the spatial quality of the community. By 2050, with the implementation of transformation, it will be recovered with the increased thresholds, and the site will completely become a low-sensitivity area.

Indicator	Current index over threshold	Business as usual		Doughnut economy		Dynamic planning	
		2030	2050	2030	2050	2030	2050
SENSITIVITY							
residential density	0.15	+ +	+ + +	-	- -	- -	- - -
age (65+) diistribution	-0.25	+	+ + +	+	+ +	+	
age (18-) diistribution	0.46	-	-	-	- -	- - -	- - -
immigrants	0.10	+	+ +		-	-	- -
household income	0.12	+	+	-	- - -	- -	- - -
migrant workers	-0.19	+ +	+ + +	+	+	+	- -
tourism	-0.03	+	+ +	+	+ +		-
manufacture	-0.13	+	+ +	-	- -	+	-
small businesses	0.28	+ +	+ + +	-	- -	- -	- -
traffic density	-0.12	+ +	+ + +	-	- - -	+	-
hospital accessibility	0.10	+	+	-	- -	-	- -
amenity accessibility	-0.09	-	+	- -	- - -	+	- -
motorized transport	0.19	+	+ +	-	- - -	- -	- - -
green space	-0.32	+	+ + +	-	- -	+ +	-
open space	0.09	+ +	+ + +	-	- -	- -	- - -

Vulnerable indicator
\+ Increasing 0.1
\- Decreasing 0.1

Table 7.4.1 Changing indicators of sensitivity in scenarios of business as usual, doughnut economy, and dynamic planning. Made by author.

5 PANDEMIC VULNERABILITY

5.1 SHORT-TERM VULNERABILITY (2030)

Finally, the vulnerability of the three scenarios can be evaluated separately based on estimation of indicators and thresholds and spatial characteristics in vision maps. Most of the areas in the current site belong to type 2, namely high exposure and high sensitivity. Except for the southeast neighborhood, it is close to the railway station and public infrastructure with a better quality of life (Fig. 7.5.1).

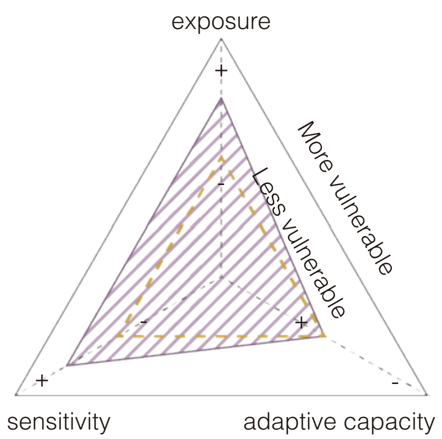
In Scenario 1, the evaluation diagram expands in three directions. It means that all three components in Geuzenveld-Slotermeer are becoming more vulnerable to a pandemic if it follows businesses as usual (Fig. 7.5.2). In addition, due to the low economic and educational level of residents, the adaptive capacity of the neighbors in the west will decrease rapidly. Finally it will become type 1 in a short term: the most vulnerable areas with the most problems.

In Scenario 2, the doughnut economic planning, two angles of the diagram, exposure, and sensitivity, are slowly shrinking but still above the threshold (Fig. 7.5.3). The former southeast high-exposure neighborhood will gradually develop into type 8. Besides, the sensitivity of areas around mixed land with public facilities will be reduced. However, the west neighborhood will remain vulnerable to the pandemic.

In Scenario 3 of dynamic planning, the decreasing speed of the triangle is similar to that of Scenario 2. However, three components can all become low vulnerable due to the change of the threshold through transformation (Fig. 7.5.4). Both high- and low-density life circles can meet their living conditions through delivery lines to reduce exposure and sensitivity. Therefore, in a short term, most of the neighborhoods can become type 8 with low exposure, low sensitivity, and high adaptive capacity.

Typology

1. E(+), S(+), AC(-)
2. E(+), S(+), AC(+)
3. E(+), S(-), AC(-)
4. E(+), S(-), AC(+)
5. E(-), S(+), AC(-)
6. E(-), S(+), AC(+)
7. E(-), S(-), AC(-)
8. E(-), S(-), AC(+)



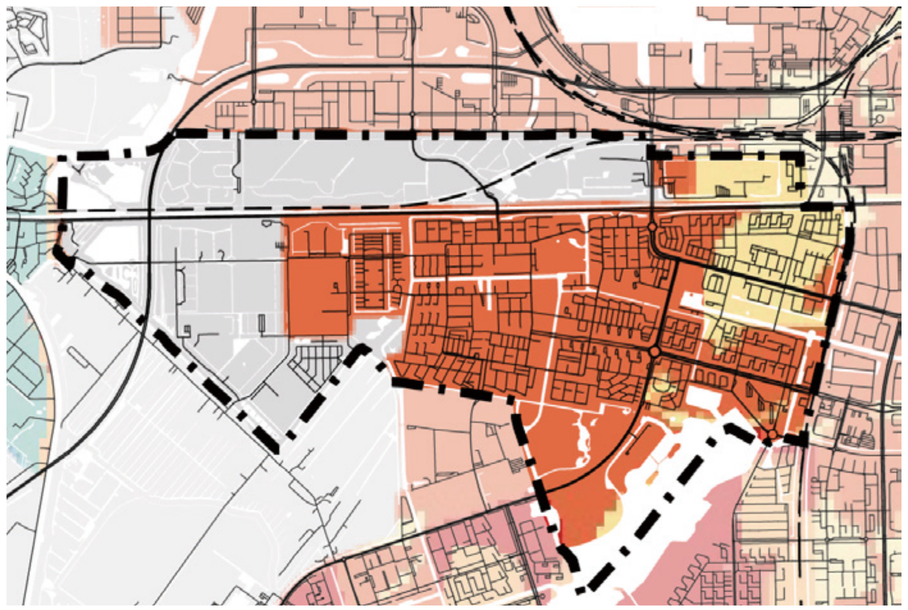
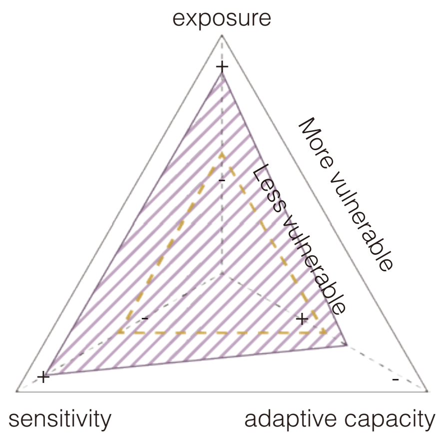


Fig. 7.5.1 Vulnerability of current situation in Geuzenveld-Slotermeer. Made by author.



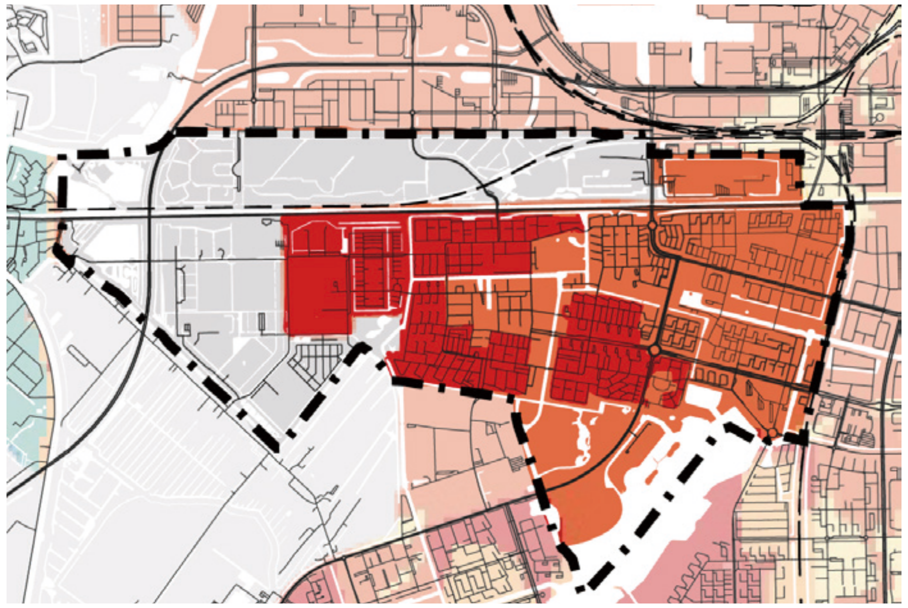
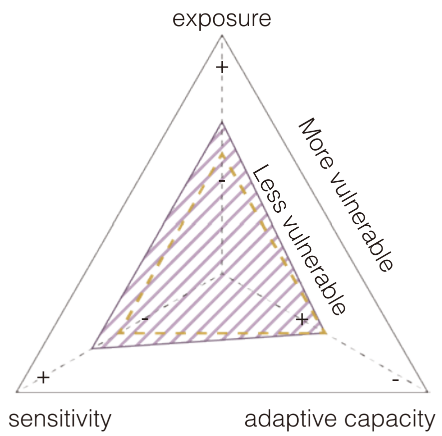


Fig. 7.5.2 Vulnerability of business as usual in Geuzenveld-Slotermeer in a short term. Made by author.



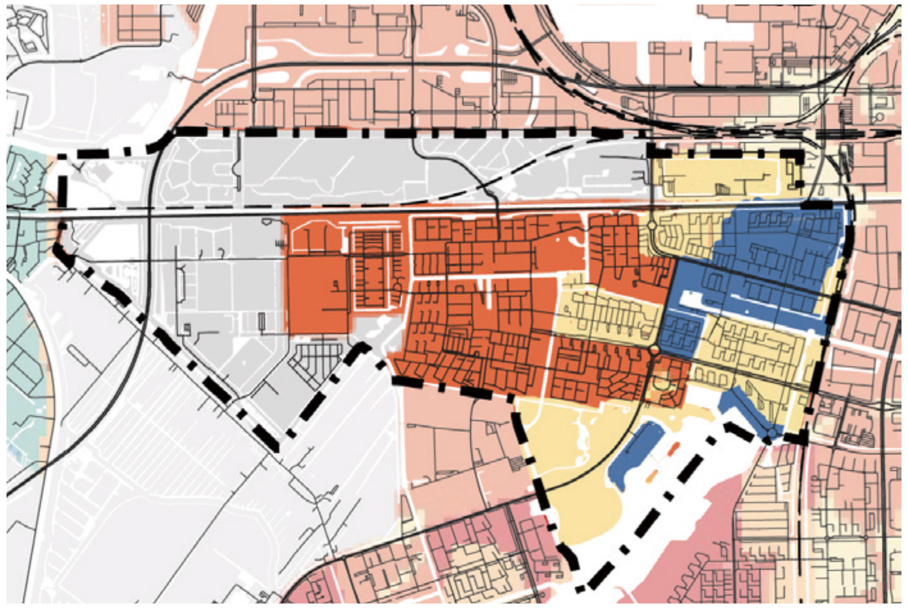
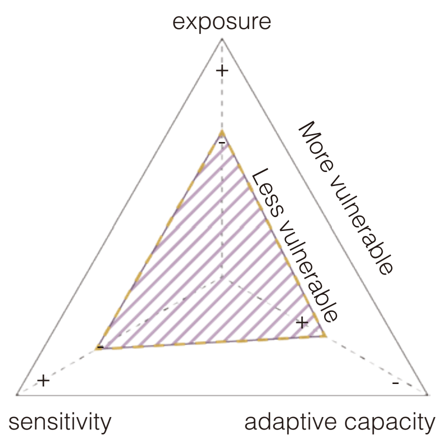


Fig. 7.5.3 Vulnerability of Doughnut economic planning in Geuzenveld-Slotermeer in a short term. Made by author.



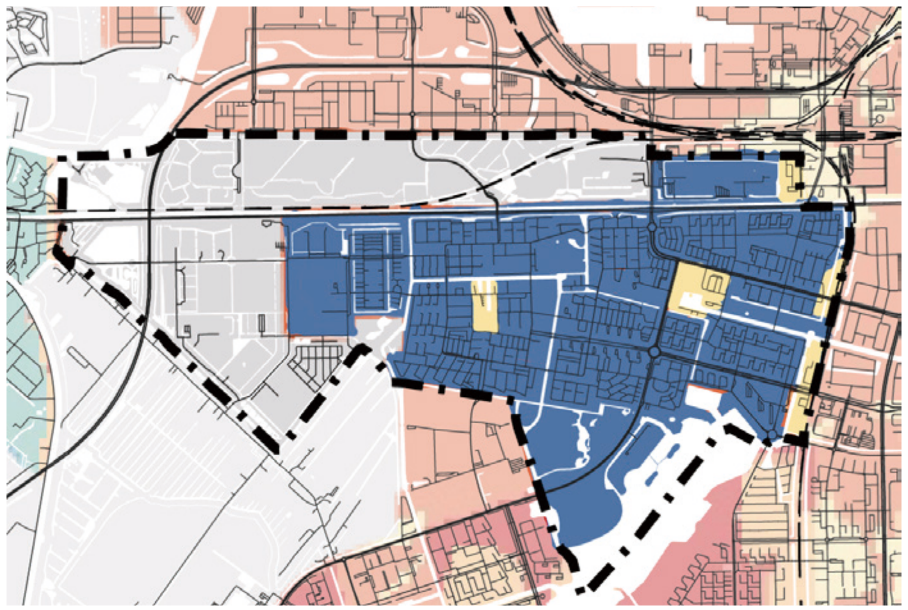


Fig. 7.5.4 Vulnerability of Dynamic planning in Geuzenveld-Slotermeer in a short term. Made by author.

5.2 LONG-TERM VULNERABILITY (2050)

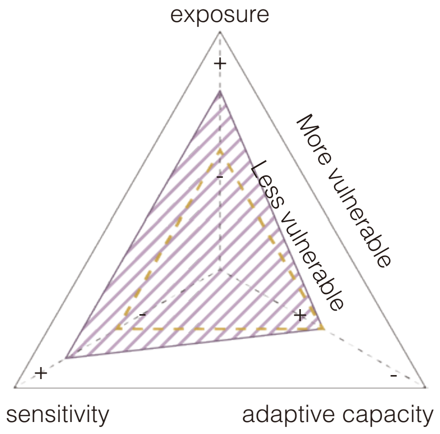
The triangle in Scenario 1 will be further expanded into Type 1 by 2050, with high exposure, high sensitivity, and low adaptive capacity (Fig. 7.5.5). Most areas will become more vulnerable to the pandemic because of population growth, lack of public facilities, and degradation of living conditions. Only the neighborhood in the southeast is likely to keep high adaptive capacity with a higher quality of life, which will also decline as society develops further.

Scenario 2 will ultimately achieve the goal of doughnut economics: social justice and ecologically friendly. The in-dough system means that indicators in the vulnerability framework can also be below the threshold (Fig. 7.5.6). The spatial assessment map indicates that most communities will become Type 8 by 2050, completely become low vulnerable to the pandemic. However, there are some exceptions. Firstly, areas along with public transport and the blue and green hotspot next to the Sloterplas lake will become new gathering points for residents and therefore have high exposure risks. In addition, the problem of low accessibility in low-density communities in the west is maintained, where residents will remain sensitive to the pandemic.

In Scenario 3, due to the combination of adaptability and transformability, the threshold will be further raised with higher resilience in 2050 (Fig. 7.5.7). The combination of life circles in different densities and delivery lines enables the neighbors in any location to obtain sufficient social resources. At the same time, flexible and shared space utilization can mitigate the population concentration in public nodes and community centers, and reduce the pollution caused by motor vehicle traffic congestion.

Typology

- 1. E(+), S(+), AC(-)
- 2. E(+), S(+), AC(+)
- 3. E(+), S(-), AC(-)
- 4. E(+), S(-), AC(+)
- 5. E(-), S(+), AC(-)
- 6. E(-), S(+), AC(+)
- 7. E(-), S(-), AC(-)
- 8. E(-), S(-), AC(+)



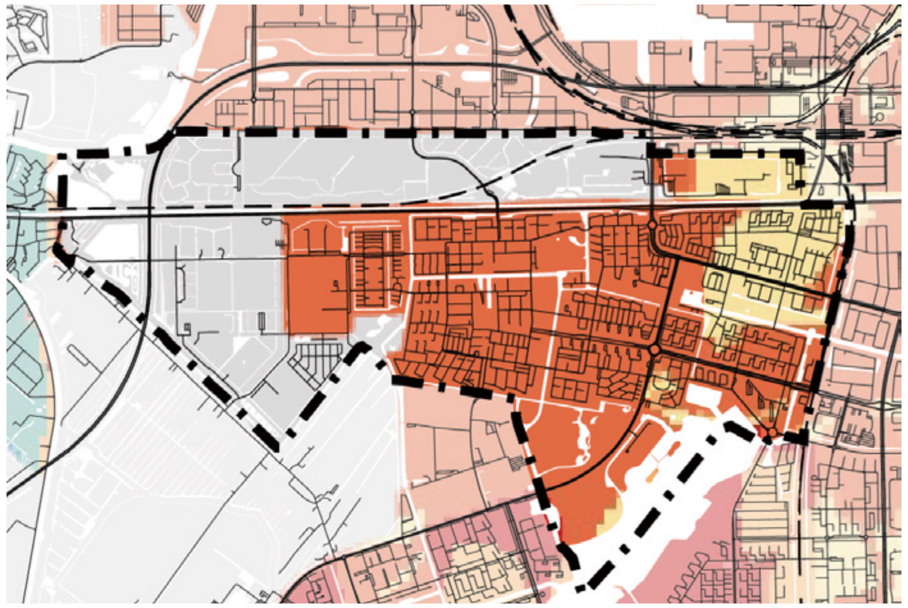
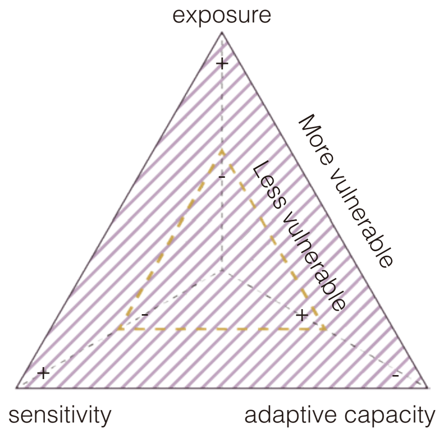


Fig. 7.5.1 Vulnerability of current situation in Geuzenveld-Slotermeer. Made by author.



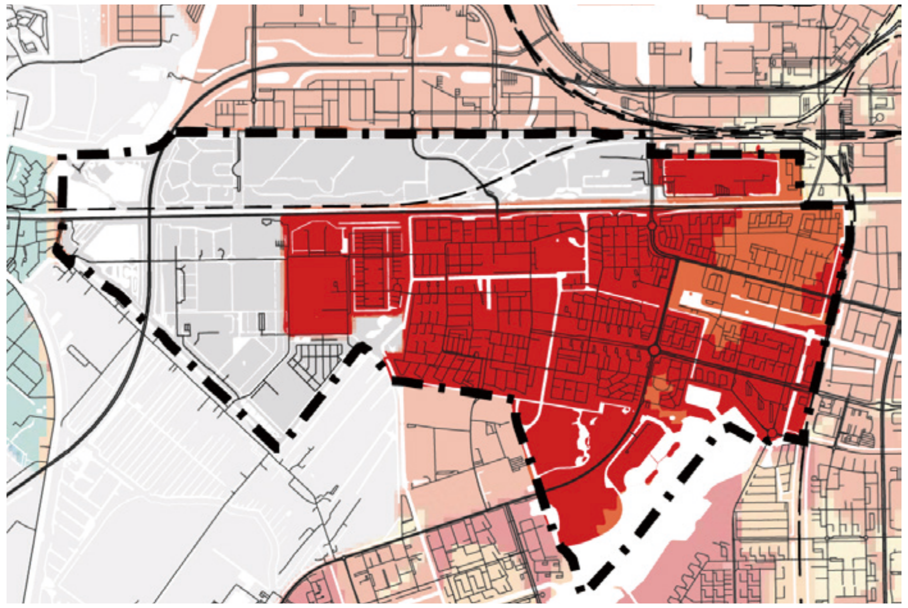
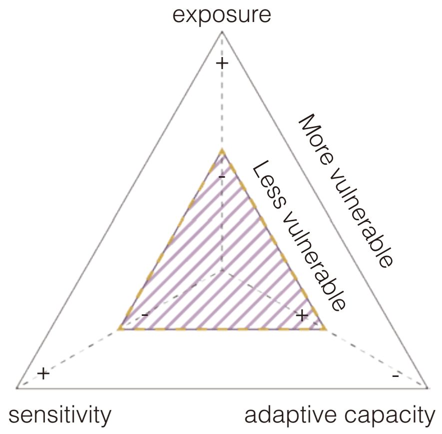


Fig. 7.5.5 Vulnerability of business as usual in Geuzenveld-Slotermeer in a long term. Made by author.



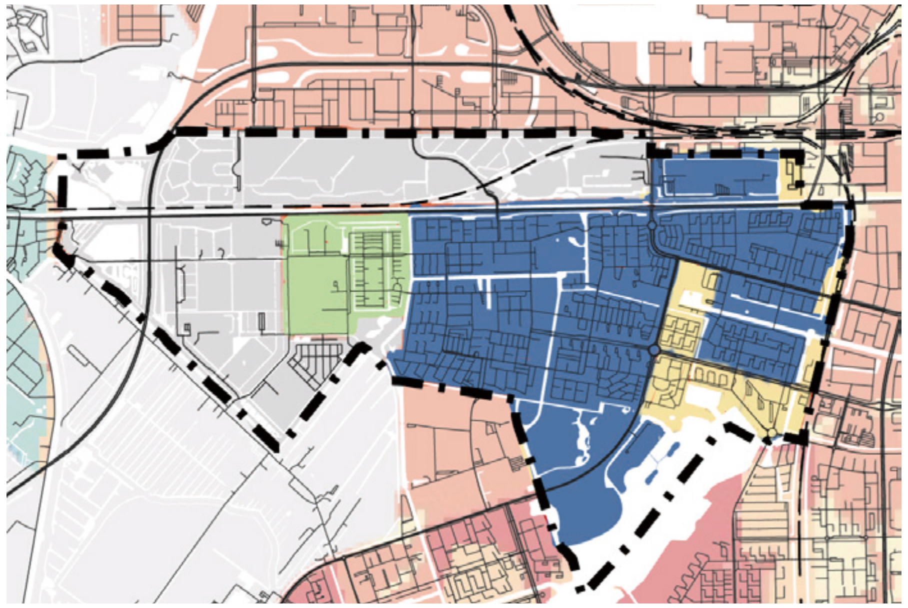
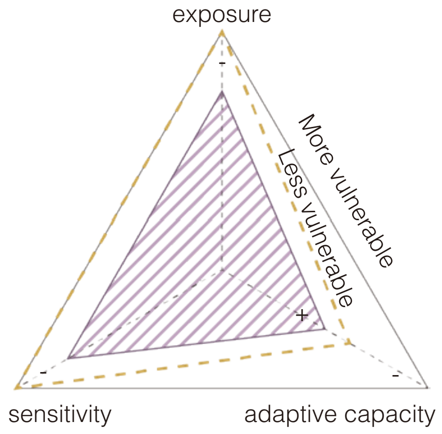


Fig. 7.5.6 Vulnerability of Doughnut economic planning in Geuzenveld-Slotermeer in a long term. Made by author.



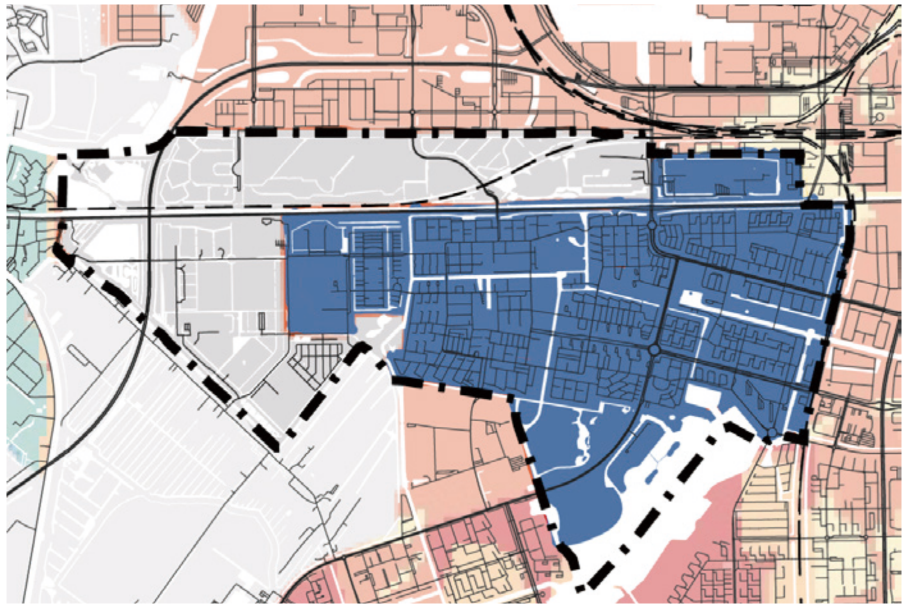


Fig. 7.5.7 Vulnerability of Dynamic planning in Geuzenveld-Slotermeer in a long term. Made by author.

Fig. 7.6.1. A dog walker in Slotermeer, Amsterdam, 2020. Photographed by author.

6. CONCLUSION

This chapter is intended to predict and evaluate the urban vulnerability to the pandemic in three scenarios concerning the development of the project compared with business as usual and doughnut economy.

It shows that the pandemic resilience of business as usual is gradually decreasing. Firstly, the community development will continue with the current structure, centered on areas close to Amsterdam and the public stations. These infrastructure hotspots will become destinations for the population. Residents will become more dependent on motorized transportation, leading to more air pollution and traffic congestion. Secondly, there will be more social hierarchy and segregation, through the increase of educational, economic, and health problems of immigrants. Finally, population growth brings higher demand for housing and lower quality of life.

The scenario of the doughnut economy is characterized by a slow increase in resilience. Circular resources and a sustainable economy can make Geuzenveld-Slotermeer a resilient community by 2050. However, in a short time, the problem cannot be solved perfectly. Firstly, the most serious problems within the community, such as air pollution, over-reliance on imports and exports, and lack of hospital beds, cannot be fully addressed in 2030 to reach the threshold. Secondly, the urban periphery, such as the low-density neighborhoods in the west, will be forgotten, where residents have limited benefits from the planning. Finally, doughnut planning still follows the traditional planning method. It means resources will be concentrated in a few areas permanently, which cannot solve the problem of concentration.

The dynamic planning in this project has proven to be both a quick response to outbreaks in the short term and a resilient community in the long term. The combination of adaptability and transformability will change both the indicators and thresholds of vulnerability. Therefore, Geuzenveld-Slotermeer can also become a low-vulnerability area in 2030. In addition, flexible spatial use, flowing and shared resources will eliminate the problem of virus transmission due to the movement of people with enough necessities in all neighborhoods.

8 CONCLUSIONS

This chapter is the overall conclusion of the whole project to evaluate its effectiveness, advantages and limitaions. It also includes the chapter of reflection of this project, and the future research to be developed.

CONTENT

1 ANSWERING RESEARCH QUESTIONS

RQ: How can a multi-scale planning strategy in MRA reduce the vulnerability of the region to global pandemics to improve the regional resilience of various areas, groups, and institutions to COVID-19?

The conflict between the emergency policies proposed by countries to combat COVID-19 and the declining quality of life of citizens due to the economic paralysis during this period forms the problem and main research question of my project (Fig. 8.1.1). As a result of the outbreak, urban institutions, especially policymakers in metropolitan areas, have had to legislate some temporary restrictions of population movement to mitigate the spread of the virus. However, on the one hand, their quality of life has been greatly reduced and social stability has been damaged. On the other hand, it has been followed by the all-around suspension of urban activities, and it is difficult to recover to the pre-epidemic level soon (Rutynskyi and Kushniruk, 2020)

Notwithstanding the foregoing, while understanding the purpose and shortcomings of these policies in mitigating COVID-19, there has not been enough time to fully test the benefits and disadvantages of existing strategies in the context of current urban development. In this regard, the rationale in this study remains abstract and incomplete and will need to be refined, modified, and tested over the next few years. However, in this project, I have at least been able to confirm that planning to increase the resilience of metropolitan areas to the pandemic is related to both short-term and long-term strategies for specific and general risks. It is necessary to control the population mobility while maintaining the living needs of residents independently during the outbreak (Fig. 8.1.2).

SBQ1 How to define the urban vulnerability to pandemic from the perspective of urbanism and globalization?

SBQ2 What is a conceptual framework for qualitative and quantitative measurement of pandemic vulnerability?

SBQ3 What are the spatial strategic interventions to foster the improvement of urban resilience to pandemics?

SBQ4 What are the planning actions to contribute to the general urban resilience in MRA?

The first finding of this project is the definition and assessment framework of the urban vulnerability model, which answers sub-question 1 and 2. Based on the concept of climate vulnerability and social vulnerability, pandemic vulnerability is defined through three components: exposure, sensitivity, and adaptive capacity (Gong et al., 2020). Then, combined with the policy analysis of Metropolitan Region Amsterdam (MRA) and quantitative calculation of indicators, this study found that since the existing policy emphasis on the rapid improvement of adaptive capacity in the short term, the areas with higher exposure and sensitivity in the region are more vulnerable.

Sub-question 3 and 4 emphasize that the planning of urban resilience for socio-ecological systems should fully consider social factors, such as scale, time, and actors (Weichselgartner & Kelman, 2015). Regarding this, resilient planning processes for pandemic require multidimensional tradeoffs in addition to the resilience of ecosystems. In the same ideological line, governance and planning measures have been divided into short-term, pandemic-specific strategies based on existing conditions, and long-term, future-oriented, more generalized strategies.

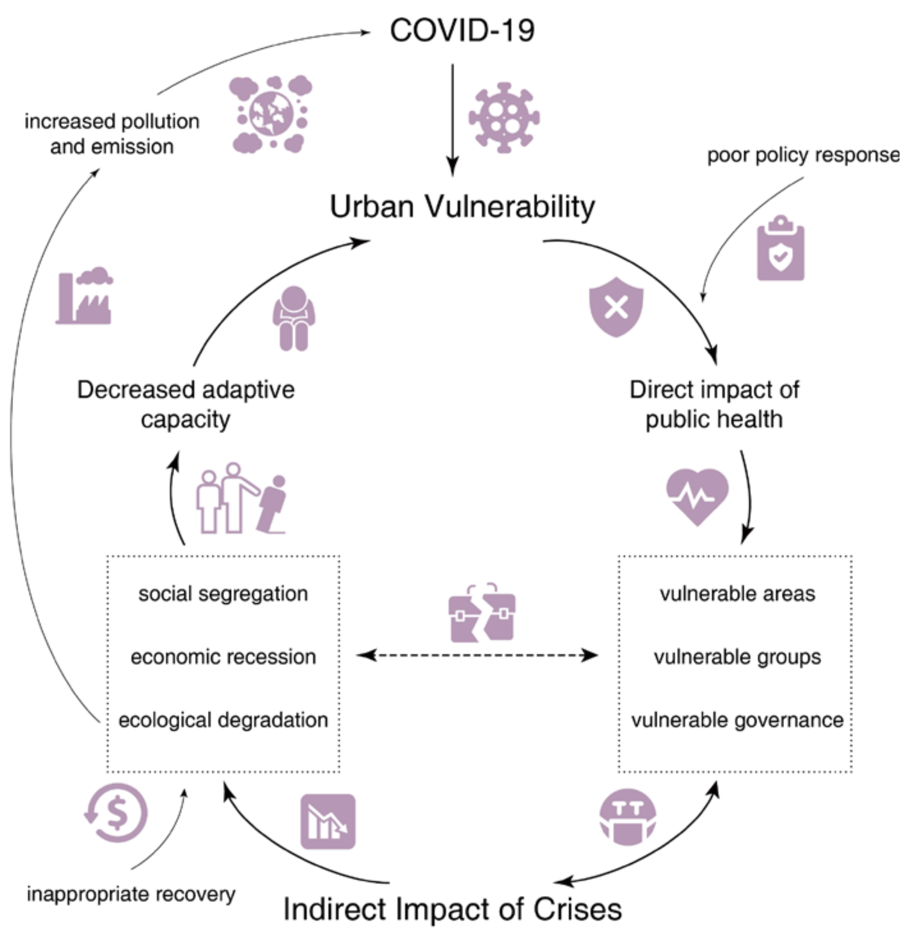


Fig. 8.1.1. Research problem: A vicious cycle of urban pandemic vulnerability. Made by author.

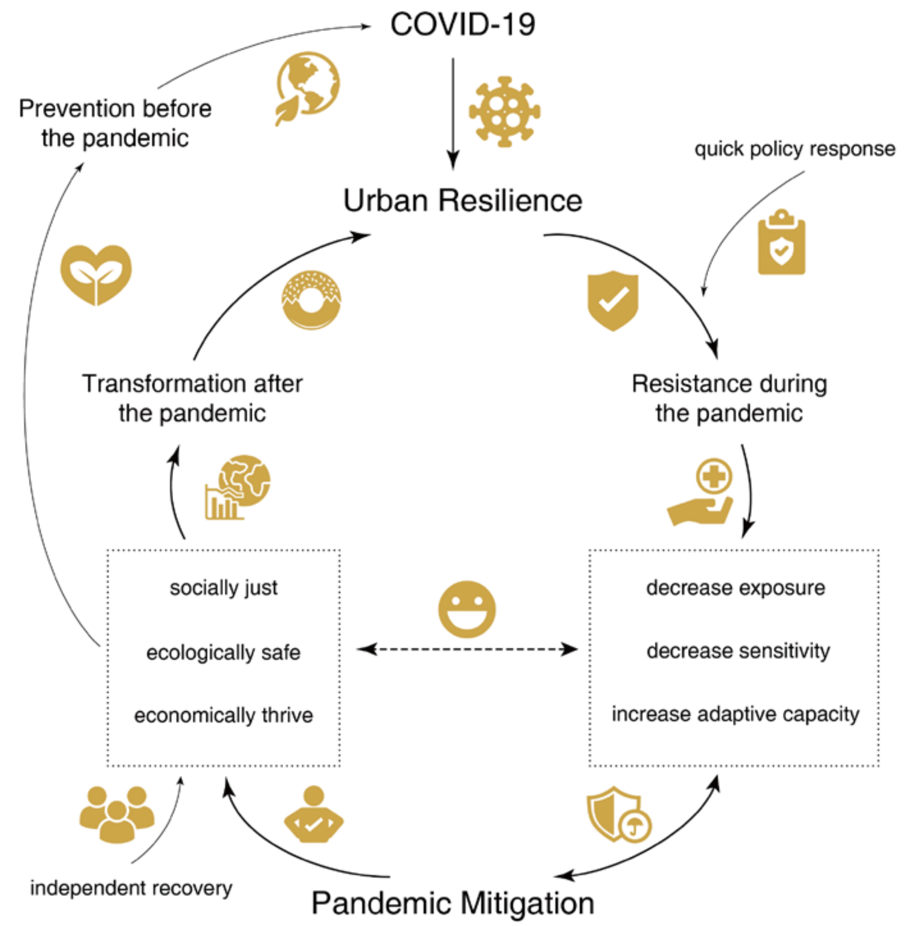


Fig. 8.1.2. Research outcome: A virtuous cycle of urban pandemic resilience. Made by author.

2 METHODOLOGY

2.1 METHODS AND APPROACH

In this project, various methods and approaches were applied (Fig. 8.2.3). Multi-scale research and design run through the whole process, which is important to fully understand the urban environment, actors, and problems at different scales. Thus, a status-based typological analysis supported by qualitative and quantitative tools (GIS), together with a planning exploration developed from the theory of resilience, serves to determine the problems and potential of MRA.

Regarding the conceptual model of urban vulnerability, the triangle assessment diagram was developed from the framework proposed by the EEA based on the IPCC definition combined with the socio-economic characteristics of the pandemic (Fig. 8.2.1). It analyzes the characteristics of the MRA through exposure, sensitivity, and adaptive capacity and classifies the vulnerability of regions to the pandemic into eight types based on indicators of them. This approach is useful to identify focused areas and study their comprehensive characteristics, including levels of residents, community environment, and infrastructure.

The concept of resilient MRA is established from the theory of evolutionary resilience (Davoudi, 2012) and adaptive cycles (Gunderson & Holling, 2002.). It can strategically and visually structure a new approach to resilient urban planning for pandemic risks: dynamic planning (Fig. 8.2.2). This approach can start from the selected areas, propose flexible strategies for spatial use and activities, and provide the possibility for dynamic governance in the MRA from the bottom up.

2.2 TRANSFERABILITY

Research and design approaches in this project are suitable for transferability to the majority of metropolitan regions vulnerable to the pandemic in the current situation. The proposed methods and tools of resilient planning, such as "Dynamic Planning", are interesting to develop further for application in various contexts. However, the quantitative indexes and evaluation for planning can only be regarded as a trend of development due to the lack of related studies on COVID-19 and urbanism. A technical evaluation should be done in the process of planning and on the results of implementation in order to adjust the planning results and goals.

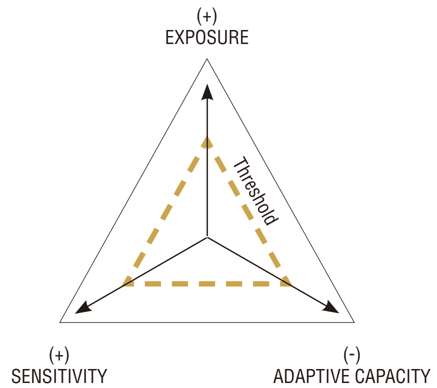


Fig. 8.2.1. Framework of urban vulnerability to the pandemic. Made by author.

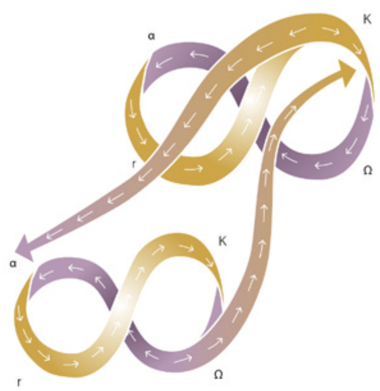


Fig. 8.2.2 Dynamic planning. Made by author, adapted from Holling and Gunderson (2002, pp. 34–41).

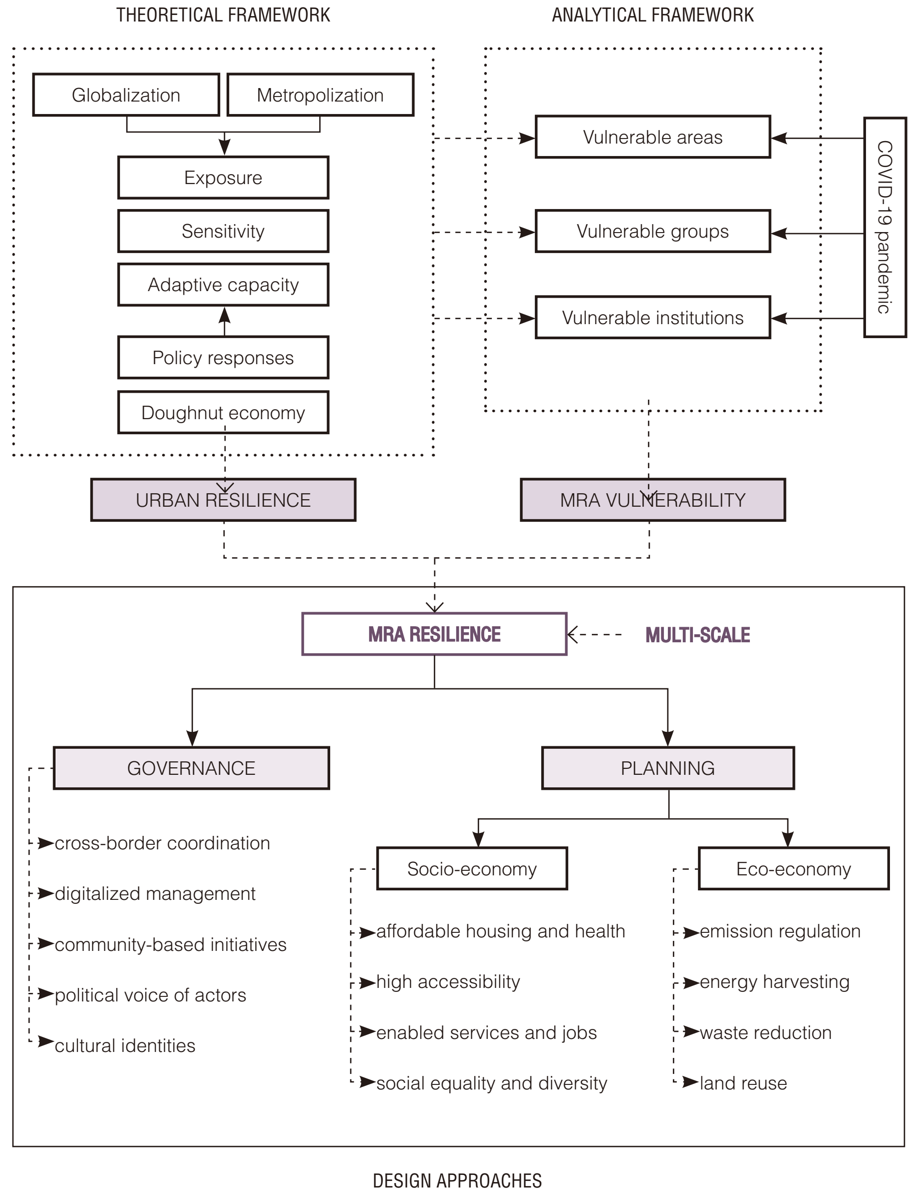


Fig. 8.2.3. Conceptual framework. Made by author.

3 REFLECTION

3.1 RESEARCH AND DESIGN

The design and research of this graduation project are interwoven with each other. This is not only reflected in the research questions in the early stage but also reflected in the "research by design" later. Firstly, the study on the definition and framework of the urban vulnerability identified the community Geuzenveld-Slotermeer that were most vulnerable to the pandemic in the MRA. It then became the main research site for the design. Secondly, the theoretical research of urban resilience and adaptive design has guided the main design method, namely “dynamic planning”. Finally, after the planning of the community, the project evaluated the design through the previous evaluation framework. The feasibility of the abstract theory in the project was tested by comparing it to the current situation and the planning of the Doughnut economy. Overall, a comprehensive study on urban vulnerability and urban resilience finally becomes the background for the design strategy. At the same time, the design also has an action-reflection character, to constantly test the theoretical basis of research.

3.2 RESEARCH ADVANTAGES AND LIMITATIONS

This research deals with the analysis of the vulnerability and resilience of characteristics within MRA. A variety of methods and tools are used in the design and research. Firstly, the multi-scale research method runs through the whole process. It is necessary to understand the characteristics, problems, tradeoffs, and solutions of urban vulnerability and resilience at different scales. Secondly, the framework of urban pandemic vulnerability based on European Environment Agency (EEA) indicators plays a significant role in regional spatial quantitative analysis (Swart, 2012). Since COVID-19 is not completely over yet, it is difficult to fully understand the factors of impacts. This method, which applies general indicators to specific sites, can predict the ongoing crisis with relative accuracy. Finally, the methodology of dynamic planning based on the adaptive cycle (Gunderson & Holling, 2002) and adaptive planning (Folke et al. 2005) becomes the main concept supporting the design of this project. Based on ecosystem planning, this method takes full account of social actors, power, and equity to improve the resilience of the socio-ecological system.

However, these focused areas are home to a very large number of diverse populations in terms of religion, culture, knowledge, generation, occupation from other parts of the country and even the world. Each of these groups has very distinct factors that lead to their vulnerability to the pandemic. Thus, the observation and study of group behavior are subdivided to the neighborhood scale, where the levels and habits of residents are similar. Besides, COVID-19 is a timely topic with limited research from a spatial and urban perspective. The theoretical framework and related analysis should be proposed based on the existing conclusion from the literature review. And since the Netherlands is still in the second wave of COVID-19, it is an advanced concept to predict and evaluate the vulnerability of different groups, areas, and institutions. Therefore, the focused problem and design approaches will be extrapolated based on the characteristics that the region now exhibits.

3.3 SOCIETAL RELEVANCE

In metropolitan regions like MRA, focusing on continuous economic development and the rapid pace of globalization has led to the decreasing of living quality. There is a lack of clean and inclusive public space in some communities with high density, which is home to most of the bottom groups like low-income workers and immigrants. And as a result, they are more vulnerable and deeply influenced by the pandemic than the rich. This research aims to reflect on two impacts on society: physical and mental.

Common social risks like health issues, unemployment, and poverty can be experienced as an outcome of physical impacts. They are usually perceived in people on the front line of the pandemic, which is the main social problem that the government is requested accountably to support and address. This research is extremely relevant to the vulnerable groups with the increasing demand for social assistance in the COVID-19. They are living in a crowded neighborhood without a second house in the suburbs to avoid the virus. And they are working mostly in service that is not allowed to work remotely, and have to face unemployment. Therefore, this research targets the vulnerable society with its contribution to the proposed strategy and governance model.

Besides, psychologically, the challenge is to manage social segregation and mental health during the measures of physical distancing and lockdown. Especially old people, who have always been spatially, generationally, and emotionally segregated, are also recognized as one of the most susceptible groups during the COVID-19. Considering this, the lasting lockdown of the whole society chould lead to additional pressure due to the limited communication and further cause increasing panic and loneliness among residents. This research aims to propose new approaches to mitigate the negative impacts through planning and design. Further, it focuses on the methodology to improve the wellbeing of vulnerable groups and their integration into society.

3.4 SCIENTIFIC RELEVANCE

The research highlights two major gaps in the discourse: the definition and interrelations. The topic of urban vulnerability and urban resilience is inherently considered being a part of environmental protection to the extreme climate. However, it has had a close relationship with global pandemics for decades. The morphological and functional linkage worldwide has led to and has exponentially increased the exposure of cities. It has become a subject of growing interest especially owing to the outbreak of COVID-19. And metropolitan regions are mostly influenced, where people are subjected to more serious health, economic, and social issues. The condition of this pandemic vulnerability is similar to that of economic and social crises and requires considerable scientific research.

The second gap is between scientific fields of planning methodology and urban resilience to the pandemic. The Doughnut Economics proposed by Kate Raworth is a workable framework for evaluation and measurement, but it is such a long-term vision relying on high technology development and investment. A pandemic is a social event that is difficult to expect or predict how and when a new challenge is emerging. Besides, traditional planning for ecological resilience differs from the socio-ecological resilience to the pandemic. Therefore, this project proposes a ‘dynamic planning’ concept, based on the concept of adaptive planning to adapt processes transforming to a resilient metropolitan region.

3.5 ETHICAL CONSIDERATION

Considering scenarios of a wealthy but vulnerable urban environment, there are two aspects of ethical relevance that are crucial to address the issue of the pandemic. This research firstly focuses on the ethical standpoint of exposed areas on accessing and accepting globalization and underlying global crises. There is an increasing ethical dilemma of governments ushered by COVID-19 which is fueling protectionism and playing into nationalist narratives. Free economic and population flows are under a significant threat as governments scramble to reduce their vulnerability to the virus by limiting global trade and politicized travel and migration. However, a global network is inevitable, and it is unethical to close borders in an attempt to prevent the virus from spreading. It is also necessary for the population to ensure their living quality while protecting from the pandemic. Therefore, the project explores how to improve urban resilience to the pandemic in the context of tight connections. Secondly, the research also highlights the responsibility of metropolitan areas to the global environment. As the heart of urbanization and globalization, metropolitan areas are both the departure and destination of an international and national exchange. On the contrary, the agglomeration of such economic activities backfired as the reason for multiple risks like pandemics. There are several ethical questions as the key for a resilient global environment: how to manage the internal resources scarcity while ensuring the essential global operation during the crisis, how to respect the wellbeing of people from other countries, and what influence the region will have on global ecology and economy through different recovering measures.

3.6 THE STUDIO AND MASTER TRACK

Planning Complex Cities graduation studio is a highly integrated academic platform whose starting points are conflicts arising from the distribution of resources (TU Delft, n.d.). Critical research on urbanization and globalization has been carried out in this studio. Research in the studio is based on expertise in spatial development, planning, land management, and participation (TU Delft, n.d.). COVID-19, which has been a major cause of globalization turbulence and impacts on urban development in the last two years, is necessary for mentors and international students to work on understanding these urban issues from academic and practical perspectives. The graduate project focuses on the particular vulnerability in a metropolitan area, pandemic vulnerability. Another aspect of this studio is that it investigates planning approaches in regions and cities, and how they affect the transformation of spatial structures to achieve more sustainable spatial outcomes (Tu Delft, n.d.). This is also one of the research aims of this project, which is explored in the study of the MRA's resilient planning to the pandemic. This aspect can also be thought of as a major element of the track of Urbanism. The dynamic interaction between cities and regions is one of the highlights of the urbanism profession.

4 FUTURE RESEARCH

Until the end of this project, COVID-19 still cannot be considered a thing of the past, whose potential impact on the world will last decades. Since this is an exploratory topic, the research on the vulnerability and resilience of cities to pandemics is based on existing literature reviews and observations. Therefore, it is necessary to explore in the future.

Firstly, the framework of urban vulnerability needs to be adjusted due to the latest academic research, especially the changes in indicators. As the research on COVID-19 becomes more in-depth, scholars will learn more about the influence of different factors on urban vulnerability. For example, a paper published in February 2021 suggested that climate change may have a direct effect on the spread of coronavirus (Beyer, et al., 2021). Factors related to climate or temperature were not considered in this project, so further exploration may be needed to modify this assessment framework.

Secondly, due to time and project constraints, this graduation project only took Geuzenveld-Slotermeer as an example to propose strategies based on the theory of resilience. It belongs to vulnerability type 2, with high exposure, high sensitivity, and high adaptability, which represents one of the most vulnerable areas in the MRA at present to the pandemic. However, it is still significant to continue other types of research in the future. Different design strategies should be proposed for areas with different vulnerability. Only in this way can the planning of the whole region be guided. Future research on regional resilience is likely to further improve the theoretical concept of “dynamic planning”.

Fig. 8.5.1 Prospective vision of the pandemic resilient MRA in 2050. Made by author.

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APPENDIX

1 THEORY PAPER

URBAN VULNERABILITY IN THE CONTEXT OF COVID-19

A new definition and framework for pandemic vulnerability through an indicator-based approach

Abstract - Since the outbreak of COVID-19, academics have explored its spread and impact in cities, and urban vulnerability is a crucial concept to understand the issue. However, conceptual frameworks of vulnerability have been mostly defined in response to challenges like climate change and social poverty. It lacks an accurate construction adapted to infectious disease. During the COVID-19 pandemic, large metropolitan areas have become epicenters, as they are nodes of population concentration and mobility in the global network. In addition, European cities are more tightly linked due to geographical proximity and political integration, which may intensify the spread of virus. Therefore, this paper attempts to build a new conceptual framework of urban vulnerability to define and assess urban pandemic impacts. Through a literature review of the impact of COVID-19, the research identifies some influencing factors on urban vulnerability related to the pandemic. It aims to propose a framework of indicators suited to a 'pandemic vulnerability analysis' based on current qualitative and quantitative data available in cities. Pandemic vulnerability defines the severity to which an urban system is susceptible to pandemic shocks in terms of how spaces, social groups, and institutions are negatively affected by this challenge to human health and its following crises. In conclusion, the paper argues that the pandemic vulnerability of large metropolitan areas depends on three main components: exposure, sensitivity, and adaptive capacity, with increasing political actionability. Overall, this research suggests that a pandemic is a tough test on urban areas in various aspects. However, it can also be considered an opportunity for alternative actions to become more resilient and sustainable globally.

Keywords - Globalization, Metropolitan areas, COVID-19, Pandemic vulnerability, Urban indicator

1. Introduction

Most of the world's population lives in cities, which are centers of wealth, knowledge, and jobs combined with threats from hazards, disasters and recently, pandemics, producing a myriad of direct and indirect effects. As cornerstones of the global business networks and supply chains, these crowded, rich and cosmopolitan centers have become initial vulnerable areas to the pandemic of COVID-19. When a cluster of pneumonia cases appeared in 2019 from Wuhan, China, COVID-19 has mutated into an urban crisis that has ravaged many countries and cities through the vast worldwide network in a short time. As of 12 October 2020, there have been 37,640,243 confirmed cases in 188 countries, resulting in more than 1 million deaths (CSSE, 2020). The pandemic with physical health impact has alarming consequences for social and economic life through deeply affected functioning of people. The coronavirus disease raises several social, economic, and environmental issues and severely affects cities. They are facing an invisible enemy with devastating disruptions (Goniewicz et al., 2020). The rapid spread of the pandemic among big cities intensified the trend of globalization destruction. The physical and functional global connected network is fragile, leading to frightening uncertainty such as the protectionism and nationalist narratives (Budds, 2020).

The pandemic has resulted in visible damage as a crisis being responsible for more deaths and hindered development. Furthermore, COVID-19 is not the first fulminating infectious disease in urban areas. During the 21st century, the 2003 SARS in China, the 2009 H1N1 in North America, and the 2015 Zika virus in Brazil, have killed thousands of residents with short-term and long-term impacts. With the arrival of these crises, the urbanists and experts have realized that metropolitan areas have not been as stable as they believe. Therefore, increasing research has been published on their consequences over the past few decades to learn lessons from pandemics (Matthew and McDonald, 2006). However, the previous research mainly focuses on inequalities of impact distribution in the developing or undeveloped areas to the pandemic (Wade, 2020). Preliminary research is conducted to understand the vulnerability in big cities, which have been brought to the fore for decades. Vulnerability is generally defined as the "exposure to contingencies and stress, and difficulties coping with them (Chambers, 1989)." It has been developed as an analytical framework for marginality and socio-economic problems. Nonetheless, little attention has been paid to understanding the reason for increasing urban epidemic events from urban vulnerability to adapt to the pandemic. Various negative drivers like population growth, climate change, and ecological pollution may increase the frequency and severity of further pandemics, while cities in metropolitan regions are tightly connected as a whole morphologically and functionally. It is necessary to better explore the underlying factors and dynamics of pandemic vulnerability in the context of globalization and urbanization to undermine cities' capacity to react through adaptation measures (Connolly et al., 2020). Therefore, the COVID-19 can be regarded as an unprecedented opportunity to investigate and improve the pandemic vulnerability of metropolitan areas to understand what elements are crucial to influencing the urban vulnerability to adapt to the pandemic and the crisis. This study aims to propose a concept and definition better suitable to pandemic vulnerability by integrating qualitative and quantitative data from a literature review for urban areas. Forecasting and summarizing directions and the mechanism of impact of COVID-19 at the current stage is complicated due to incomplete research and possible scenarios of the progress. However, it is urgent to diagnose the impact of the pandemic in urban planning and management to clarify the challenges that policymakers are facing.

This study begins with an overview of the literature in two related fields: the emerging field of literature published on the impact of COVID-19 in cities and the definition of urban vulnerability from other aspects of the climate and social crisis to pandemic vulnerability. This paper then examines cities affected by the pandemic and highlights their different elements, which are crucial for shaping the possibility of these events, hence conceptualizing those elements as determined indicators of the proposed framework of pandemic vulnerability. Subsequently, this study finalizes with a conclusion in which I point out some lessons learned from the pandemic and the future potential to improve for policy.

2. Definition of pandemic vulnerability

1) COVID-19 and other pandemics in history

Several experts researching 'vulnerability' have emphasized its necessity regarding a specific situation. Brooks (2003) takes the opinion that "one can only talk meaningfully about the vulnerability of a specified system to a specified hazard or range of hazards," and need to differentiate the current and future vulnerability. Therefore, the pandemic vulnerability in this study is proposed in response to the threat of contagious diseases to short-term and long-term impacts like public health, social, and economic crisis

Pandemic	Year	Epicenters	Direct impact	Indirect impact	
			Public health	Economy	Society
SARS (Keogn-Brown & Smith, 2008)	2003	Hong Kong, Singapore, Toronto	It has killed at least 774 people worldwide from 29 countries and territories.	Tourism and agriculture impacts were estimated to be substantial at US$ 1.3 in Hong Kong.	Distress among frontline healthcare workers and public members, many of whom were anxious, fearful, and depressed.
H1N1 (McKibbin, 2009)	2009	Mexico, Hong Kong, Osaka	It was estimated to have about 284,00 deaths.	It cost the global economy decrease about $360 billion within a year.	It lowered the return on education and increased family burden on healthcare.
ZIKV (Ulansky, 2016)	2015	Recife, Miami, Orlando, New York	It reached more than 1.5 million people infected in Brazil.	The short-term economic impact in the Latin American and the Caribbean region is a total of US$3.5 billion or 0.06% of GDP.	The effect is disproportionately higher in low socio-economic groups.
COVID-19 (CBS, 2020)	2019	Wuhan, London, Milan, Amsterdam	There have been 37,640,243 confirmed cases in 188 countries, resulting in more than 1 million deaths.	GDP in Amsterdam declined more than half in Q2 2020 with fewer investments and trade.	A soaring unemployment rate of 53% in March in Amsterdam, which is far above the national average.

Table 2.1 The comparison of SARS, H1N1, Zika virus, and COVID-19 on territory and impacts (Source: Keogn-Brown & Smith, 2008, McKibbin, 2009, Ulansky, 2016, CBS, 2020)

in urban areas, focusing on COVID-19. Comparing with the last three pandemics before in world history, SARS in 2003, H1N1 in 2009, ZIKV in 2015, the latest pandemics similarly begun and attacked mostly in urban areas (Table 2.1). Moreover, these pandemics have led to both direct health issues and indirect adverse effects. It has shed light on existing urbanization problems, showing a heightened sensitivity of these areas in the global network to the pandemic.

Cities are the fastest-growing type of human settlement with the largest population, while they have become the fertile ground for pandemics as they are serving as intermediaries between international networks, municipalities, and people. When a cluster of corona cases appeared in 2019 from Wuhan, China, it has mutated into a pandemic that has ravaged many countries and cities through the vast worldwide network in a short time. The direct person-to-person transmission of COVID-19 is the main route of spread related to the population concentration in cities (WHO, 2020). During the spread, urban areas have become the epicenter of the pandemic, where 90% of reported cases are located (UN,2020). For example, the initial focus of the new coronavirus, Wuhan, is a metropolis of about 11 million, where more than 4,000 people have died.

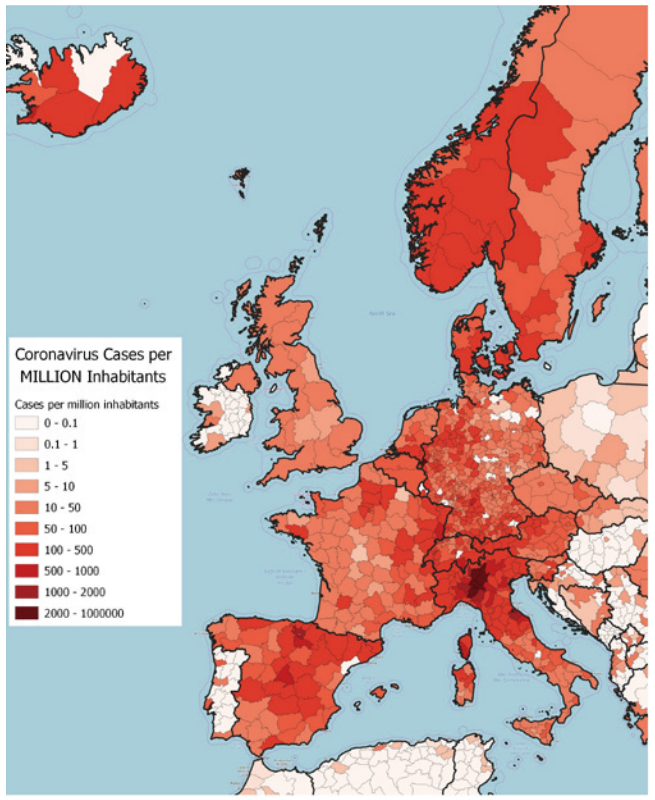

Fig.2.1 The coronavirus cases per million inhabitants in Europe updated 16.03.2020 16:00 GMT (Source: https://twitter.com/risklayer/status/1239585330413568001)

Furthermore, most corona cases also spread and concentrated in highly urbanized cities in Europe (Fig. 2.1). Milan and the region of Lombardy, as the capital and one of Italy's richest areas, were the first epicenter of COVID-19 in Europe. London was the UK's first concentration of corona cases. The COVID-19 spread rapidly in the vulnerable Greater London due to its international links, public transport network, and worst air quality (Rode, 2020). And the Netherlands, one of the current pandemic hotspots, has reached more than 457,000, a large number of whom are people living or working in the capital city Amsterdam (CSSE, 2020). And beyond people's physical-health direct impact, it has a set of associated impacts on social functioning and the urban economy. COVID-19 is having an impact on metropolises, which has focused the attention on the role and vulnerability of interconnected cities in the current increasingly globalized world.

2) Interpretation of the definition

What makes urban areas vulnerable? On the one hand, a straightforward answer exists about poverty and underdevelopment (Allen, 2003). On the other hand, it is positively related to the crisis interplay between inter-territory and inner-territory processes where the coping ability of marginalized groups has diminished (Moser, 1998). And for developed countries and wealthy cities, it is necessary to grapple with the nature and linkage of the main determinants involved in urban vulnerability. The research on urban vulnerability is increasingly abundant throughout recent years with broad definitions and scopes in different disciplines. However, there has been little research explicitly exploring the definition and concept of urban pandemic vulnerability. It is urgent for innovative responses because cities are epicenters of pandemics besides the risk of climate and poverty. A systematic review of the existing definition of urban vulnerability is thus needed to conceptualize this field.

There are many different definitions of urban vulnerability. In summary, urban vulnerability relates to its adaptability to be attacked by the threat (Adger et al., 2004). The majority of current definitions on urban vulnerability focus on two aspects: social vulnerability, including poverty, powerlessness, resource depletion, and environmental vulnerability like heat, floods, and forest fires. For urban vulnerability of social crises, it represents people's ability to deal with hazards in socio-economic aspects (Allen, 2003). It means 'the insecurity or wellbeing of individuals or communities in the face of changing environments in the form of sudden shocks, long term trends or seasonal cycles' (Moser, 1998). Numerous studies focused on the issue of social vulnerability, and all of them highlight that cities are the most vulnerable areas with the worst impact due to the concentration of population, economy, specialization, and innovation (Piñeira Mantiñán and Trillo-Santamaría, 2011). In their research, the consequences of social vulnerability include unemployment, poverty, social inequality, and decreasing purchasing power. Whereafter social segregation exists with a limited ability to protect residents from certain risks and their negative consequences. Based on this definition, the framework consists of three determining factors: economic vulnerability, social vulnerability, and residential vulnerability (Fig. 2.2).

For urban climate vulnerability, it is an urban property referring to the possibility of climate events and the likelihood that the system can be negatively affected by hazards or disasters (Nicholls et al.,1999). Even though there are different definitions with many ways of qualifying (Füssel, 2007; O'Brien et al., 2007), the climate vulnerability is mostly represented as an interaction of both internal properties and external drivers including overall three key elements: exposure, sensitivity, and adaptive capacity (Fig. 2.3). The exposure represents the exacerbated climate conditions of a system through economic and social

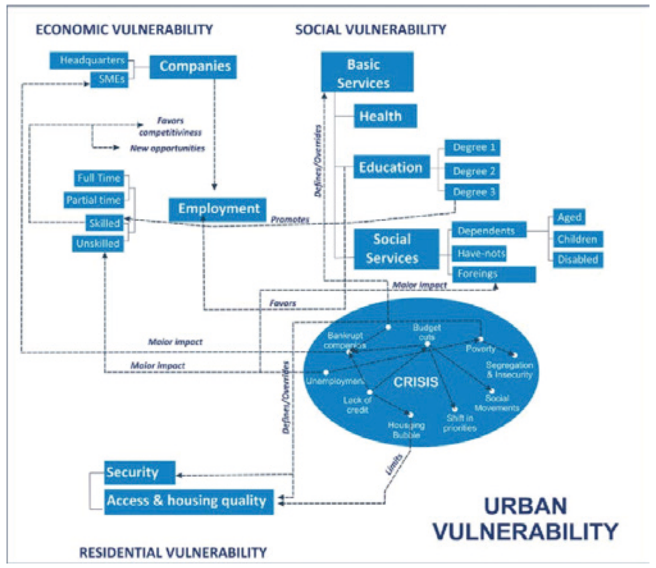

Fig.2.2 A conceptual framework of urban vulnerability to poverty and social segregation (Source: Piñeira Mantiñán and Trillo-Santamaría, 2011).

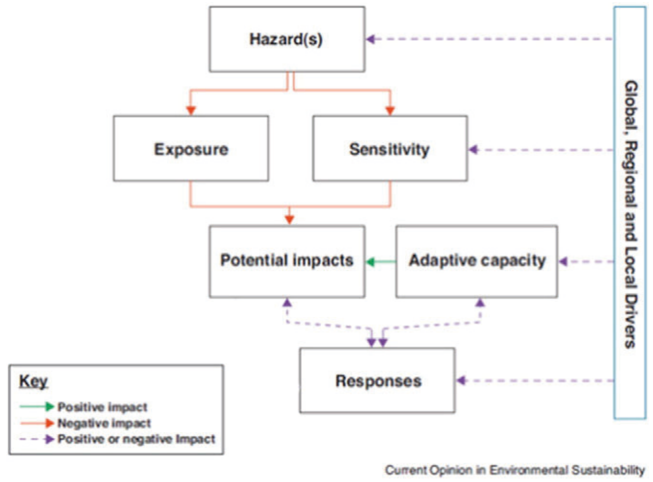

Fig.2.3 A conceptual framework of urban vulnerability to global climate change (Source: Romero-Lankao & Qin, 2011).

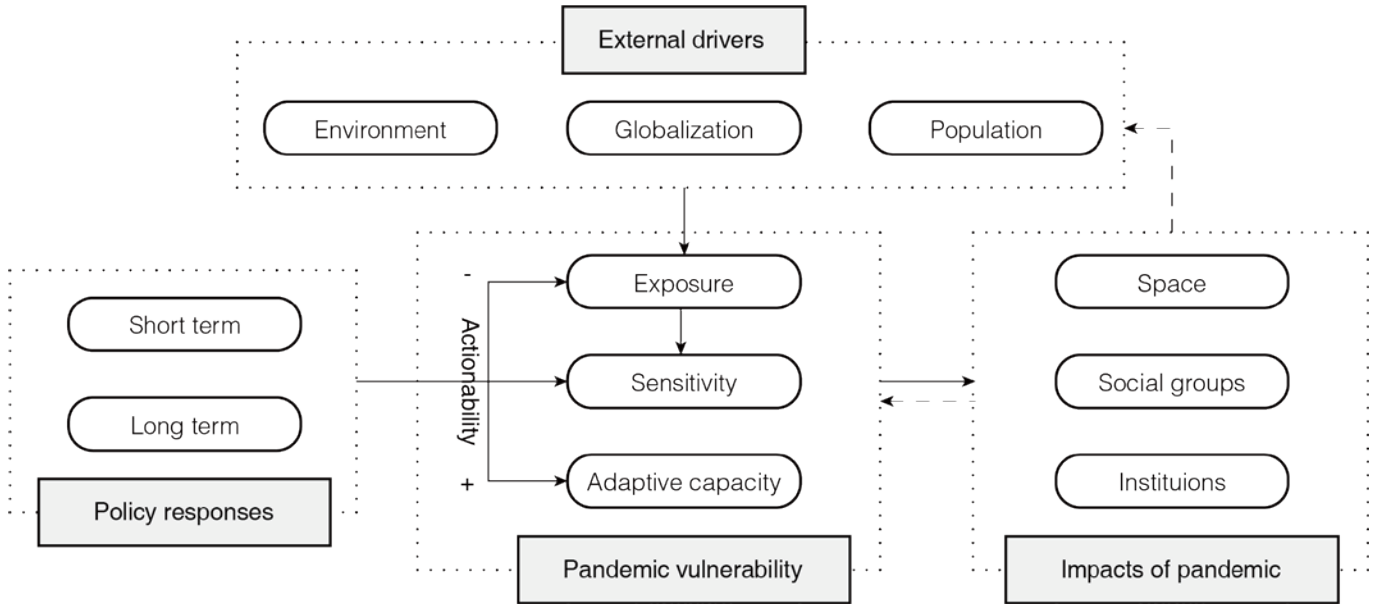

Fig.2.4 The conceptual framework of urban vulnerability to pandemic.

activities such as transportation and materials storage. Sensitivity means the extent to which a system is affected by impacts. And the adaptive capacity means the potential and the degree of a system that can absorb or mitigate impacts from the hazard (Romero-Lankao & Qin, 2011).

Based on these references, a logical outline of the understanding of urban pandemic vulnerability has been defined. The pandemic impacts are mainly represented in three consequences: urban spaces, social groups, and institutions. Therefore, the pandemic vulnerability is the combination of these two aspects, and the proposed definition adopts from the former in the context of pandemic and its impact on the urban scale (Fig. 2.4):

The pandemic vulnerability of a city means the severity to which a system is susceptible to the pandemic, when the urban spaces, social groups, and institutions are negatively affected in the challenge of human health and its following crises.

Similar to the framework of generalized vulnerability, this study defines pandemic vulnerability through three components: exposure, sensitivity, and adaptive capacity. These components also parallel to the definition of regional economic resilience to pandemic by Gong et al. (2020): local aggregation of infected people, urban current factors (e.g. population density, trade dependency), and governmental effectiveness. Accordingly, exposure means the pandemic context the system is subject to, which can be influenced by external drivers, such as environment, globalization, and population. Sensitivity is the extent to which the city is influenced by risks that the population cannot absorb, both directly and indirectly. And adaptive capacity is the potential and ability of a system that can adjust to a pandemic crisis and cope with its consequences. Therefore, the policy response for urban vulnerability can be divided into three ways: decreasing exposure, decreasing sensitivity, and increasing adaptive capacity, and the actionability of these three approaches is increasing due to their various indicators.

3. Indicators of pandemic vulnerability

According to the framework, each of the three components should consist of different indicators to assess pandemic vulnerability. They will be meaningful to identify the vulnerable areas, groups, and institutions at local levels. There are several possible applications of indicators, including identification of mitigation targets, vulnerable people, regions, and sectors, raising awareness, policy guidance, and scientific research (Hinkel, 2011). Besides, the analysis of vulnerability is more useful when their spatial characteristics are taken into account. Füssel (2007) argues that identifying a vulnerable situation often relates to spatial reference and specific attributes to a specific hazard. Therefore, indicators of pandemic vulnerability in this study are a set of place-specific analytical elements from a spatial perspective in the context of COVID-19.

This study follows the structure of European Environment Agency (EEA) indicators based on the definitions from Intergovernmental Panel on Climate Change (IPCC) about urban ecological vulnerability with relevant climate-related risks, types of determining factors and responses (Swart, 2012). I firstly review relevant literature published recently in response to threats of COVID-19. Papers were searched for scholarly literature in SCOPUS and the Web of Science using the keywords of "covid*/coronavirus," "urban/city/cities," and "planning/design." Following the initial search, many articles are not related to the influencing factors of urban vulnerability as indicators. Besides those from the pathological and psychosocial lens, there is a large portion of papers about the urban impact of COVID-19, like improving air quality and decreasing transportation. Therefore, after filtering and rechecking their abstracts, the categorization is refined following the three components according to its framework. Table 3.1 provides an overview of the proposed factors in three aspects, which are divided into short and long term related to different political stages of the COVID-19.

1) Exposure

The exposure indicators cover two main factors: environmental factors focusing on air quality and flowing factors about population and economic flow. Firstly, it is evident that the health problems of COVID-19 are related to air quality. According to the study in Italy, there is a strong relationship between deaths and air pollution. There is a higher spread rate in northern Italy, where higher air pollution levels are located (Cartenì et al., 2020). Besides, some studies have found out that drier air facilitates the transmission of the coronavirus. From the perspective of virus propagation, it is more likely to drop down in a humid air environment (Zoran et al., 2020). As coronavirus is an airborne virus, other environmental parameters such as soil and water pollution are limited. Secondly, connectivity is another variable for exposure indicators. Lin et al. (2020) identified the population exchange, especially in Wuhan, China, as a majority influencing factor of the spread. It indicates that the government needs to implement more protection responses in areas with frequent passenger flow like commercial centers, airports, and railway stations. And during the long-term impact of economic shutdowns, the supply chains have been broadly discussed. For instance, the transport restriction induced by border closure in COVID-19 has affected the food supply chains in cities (Pulighe and Lupia, 2020). Napierala et al. (2020) pointed out that the recovery of more internationalized companies in Poland is more complicated, positively related to global conditions. It shows that the more international clients they host, the more impacts they suffer in the outbreak. Overall, the combination of existing low air quality and national/international connectivity nodes contributes to the different degrees of exposure to pandemic vulnerability. These indicators are represented by either quantitative environmental data or relative distribution in grided and point formats.

Aspect	Exposure		Sensitivity				Adaptive capacity	
	Environment	Flow	Social	Economic	Infrastructural	Biophysical	Awareness	Ability
Space	air pollution	import/ export nodes	residential density		traffic density	open space		hospital beds
	air dryness	delivery system			hospital accessibility	green space		
					amenity accessibility			
Social groups		daily passengers	age distribution	household income	motorized dependency		risk perception	insurance
			immigrants	migrant workers			education level	healthy
			discriminated foreigners					ability to use technology
Institutions				tourism/ mining/ manufacture			government trust	government integration
		international corporations		small-sized businesses				government efficiency

Table 3.1 System of pandemic vulnerability factors in different stages; indication in stages: Short term Long term

2) Sensitivity

Sensitivity indicators cover four categories: social sensitivity, economic sensitivity, infrastructural sensitivity, and biophysical sensitivity. While some indicators are relevant in both short-term and long-term impacts (e.g., people with low household income have limited medical opportunities in the short term and are more sensitive to financial troubles in the long term), most indicators are specific to a certain period.

Social sensitivity is represented by some old social problems exposed in a new light, discussed in developing and developed countries. The focus is mainly on the long-standing issues of social inequalities. There is a growing recognition of the older people as a high-risk population to COVID-19 because of the hypo-immunity, disability of emergency, limited financial resources, and social isolation. As they are the group who is reliant on others for health care and daily living, the 'homestay' measures present a significant challenge to ensure their basic needs. It is also influenced by ethnicity and culture, particularly immigrants, who suffer more from the exposure to the pandemic, limited accessibility to health care, and risk of unemployment. For instance, the death rate of the Black and Latino in New York is double of the White (Wade, 2020). Besides, the poor living in slums with over-high density, lower incomes, and precarious livelihoods are always difficult to contain impacts. In many cities in Global South, the living conditions for the poorest dwellers are even worse than prisoners, making it difficult to mitigate the spread through social distancing (Biswas, 2020). And the poor living conditions further exacerbate the long-term impact of the lack of access to essential services. Last but not least, due to the origin and cross-border spread of the virus, there is increasing discrimination and stigmatization of foreigners, and it increased the sensitivity of the society in social stability and integration (Wade, 2020).

Economic sensitivity indicators are the most salient determinants to the long-term impact, particularly to the threat of economic recession. Migrant workers are the initial vulnerable group affected by a predicted period of recession. Cre an and Light (2020) figured out that in European countries with rising unemployment rates, international employment opportunities decrease accordingly in Western Europe. This recession increases the unemployment of migrant workers. And for different economic structures, it can be expected that the specialized economy is vulnerable. The pattern in Poland shows that cities that rely on tourism, mining, and manufacture are mostly affected by the outbreak (Krzysztofik et al., 2020). Accordingly, they predict that the recovery of these industries is much more challenging. Furthermore, small- and medium-sized businesses are more sensitive to absorb the consequences of pro-longed restrictions and probably end up in bankruptcy.

The transport infrastructure and service accessibility have been considered as critical factors of the spread of the virus. It is proved by the relationship between the population mobility and the pandemic spread in Italy that the density of trips is strongly related to the infectious cases 21 days later (Cartenì et al., 2020). Similar findings are confirmed from another perspective that there is a significant decrease in the reported corona cases following the travel restrictions. Furthermore, many papers focuse on the resilience of various transport modes. There is a substantial relationship between flights and railway services from Wuhan and infected cases in the destination (Zhang et al., 2020). For other transport modes, Teixeira and Lopes (2020) found that the cycling and walking network showed a relatively lower decrease than the subway system, with an increasing shift from subway users to bike-sharers. Therefore, the motorized transportation modes are more vulnerable to the pandemic. The accessibility to health and daily services is a critical issue that requires ethical equity while the pandemic is occurring. The areas with low accessibility are always living places for the poor and marginalized groups, explained in social sensitivity.

There is a lack of quantitative evaluation on the green and open spaces for the spread of COVID-19, but some arguments exist that cities need to increase public spaces for physical distancing and mental health. Providing ample open space can accommodate residents' recreation demands to meet outdoors (Honey-Rosés et al., 2020). And the reconfiguration of green space can also increase the urban greenery that may contribute to urban resilience through an improved environment against other viruses.

3) Adaptive capacity

There are many ways to structure the indicators of adaptive capacity (Swart et al., 2020). However, the relationship between some indicators and the available information in a metropolitan and urban scale is weak (e.g., investments made only for specific groups or governance can only play a limited role in the interconnected urban system) or unstable (e.g., testing rates in different municipalities are changing continuously). Therefore, this framework is developed for generic capacity indicators, which are necessary and valid for most populations, areas, and institutions for a long time. Risk awareness is predominantly related to the development of society, regarding the ability to understand, access, and communicate information of the pandemic. For instance, people with low-risk perception and low level of trust in government have been identified by Thoi (2020) as a high-risk population, which makes it challenging to achieve the objectives. Another vulnerable group is people with low educational levels who suffer disproportionately from the disease and the financial troubles related to COVID-19 (Qian and Fan, 2020). Moreover, the response-ability to the pandemic is the other factor of adaptive capacity. Several literature pieces indicate that adequate investment in primary healthcare systems benefits the effective response to the pandemic, including hospital beds, insurance, and social health conditions (Thoi, 2020). Besides, using smart technology is evidenced as a new ability to adapt to major social and economic issues through teleworking, online commerce and education, and telemedicine (Kunzmann, 2020). In contrast, they have also raised another concern about their accessibility and affordability, which requires more attention to the digital divide. Finally, for urban governance, the conflicts between different actors and different levels of governance have been exposed by COVID-19. Fragmented governance and inefficient use of limited resources are blamed for the poor management of the spread in some states in the US (Connolly et al., 2020).

4) Indicators for measurement

Periodic outbreaks characterize infectious pandemics, and urban areas are regularly exposed to crises. Therefore, prediction of pandemic vulnerability is necessary to highlight the spatial distribution of major vulnerable sectors and propose strategies for improvement accordingly. This paper provides an introduction to the suggested indicators for qualitative and quantitative evaluation. According to the above literature review of influencing factors, Table 3.2 explains indicators to measure pandemic vulnerability in a particular context.

Since the indicators affect different aspects, their data collection and measurement methods should be adjusted accordingly. Indicators in space are factors related to the spatial characteristics and traffic accessibility, whose measurement method of vulnerability is determined according to the distance. Indicators in social groups represent the vulnerable people, so their spatial distribution in urban areas should be focused through the density of concentration. Indicators in institutions are based on various administrative regions instead of specific sites, which should be calculated in municipalities to discuss the vulnerability in different levels.

ASPECT	FACTOR/INDICATOR	MORE VULNERABLE	LESS VULNERABLE
		MORE EXPOSURE	LESS EXPOSURE
SPACE	air pollution (NO2/PM2.5)	high concentration of air pollutants	low concentration of air pollutants
	air dryness	low air humidity	high air humidity
	import/ export nodes	close to port, airport, etc.	far from port, airport, etc.
SOCIAL GROUP	daily passengers	more frequent commutes	less frequent commutes
INSTITUTIONS	delivery system	congested and dense	streamlined and organized
	international corporations	many global firms depending on trade	few global firms
		MORE SENSITIVITY	LESS SENSITIVITY
SPACE	residential density	high residential density	low residential density
	traffic density	high traffic density	low traffic density
	hospital accessibility	close to hospital, clinic, etc.	far from hospital, clinic, etc.
	amenity accessibility	close to market, activity center, etc.	far from market, activity center, etc.
	open space	close to park, playground, etc.	far from park, playground, etc.
	green space	close to garden, nature, etc.	far from garden, nature, etc.
SOCIAL GROUP	age distribution	older than 60/65	younger than 60/65
	immigrants	unstable short-term migration	stable long-term migration
	discriminated foreigners	Asian, non-EU people, etc.	EU people, Dutch, etc.
	household income	low average household income	high average household income
	migrant workers	daily national/international commuting	close to working place
	motorized dependency	car drivers, public traffic travelers, etc.	bicycle users, walkers, etc.
INSTITUTIONS	tourism/mining/ manufacture	congested and dense	streamlined and organized
	small-sized businesses	many global firms depending on trade	few global firms
		LESS ADAPTIVE CAPACITY	MORE ADAPTIVE CAPACITY
SPACE	hospital beds	residential areas with fewer beds	residential areas with more beds
SOCIAL GROUP	risk perception	low pandemic perception	high pandemic perception
	education	low education level	high education level
	insurance	uncovered by insurance	covered by insurance
	healthy	bad health condition	good health condition
	ability to use technology	new to using technology	skilled use of technology
INSTITUTIONS	government trust	low trusted, conflict tradition	high trusted, consensus tradition
	government integration	fragmented political structure	integrated political structure
	government efficiency	low working/reacting efficiency	high working/reacting efficiency

Table 3.2 Measurement of pandemic vulnerability indicators.

4. Interaction of indicators

Indicators related to different elements have been presented independently, but some of them are relevant simultaneously. A prominent issue is that certain exposure, sensitivity, and adaptive capacity indicators interact and appear recurrently in different stages of the pandemic (e.g., air-polluting mining and manufactural industries affect both the spread of the virus before and the economic sensitivity after the outbreak). The indicators with compounded effects should lead to emphasized domains, where the system is difficult to recover from the fundamental problems before the following disturbance occurs, resulting in multiplying vulnerability. Therefore, this chapter will further discuss the relationship and interaction among different indicators (Table 4.1).

Not surprisingly, institutions who rely on mining, manufactural industries, and international corporations are the most vulnerable ones. Their space exposes to the pandemic while specified economic structure facing the unprecedented challenges from 'close border' measures. Moreover, the most vulnerable space is the one with dense traffic and residential areas. The main traffic nodes and communities with the concentration of daily passengers speed the interpersonal spread. And migrant workers dependent on the commuting will be restricted by social distancing policies after the outbreak in the risk of unemployment. The over-density neighborhoods are always living places for the poor, where limited open and green spaces affect social-distancing prevention measures and indispensable community interaction. Finally, the most vulnerable groups, except those mentioned before, are immigrants and older people. Immigrants are unable to afford medical treatment due to the massive lack of social infrastructure, including insurance. And they have to face the risk of both unemployment and discrimination against native residents in the pandemic. Senior citizens are particularly vulnerable to coronavirus due to their low level of health. And because of a long time of social and technological segregation, it is difficult for them to mitigate the impact of the pandemic through smart technology.

Indicators			Impacts		
			Space	Social groups	Institutions
air polluted areas	mining/ manufacture		□		■
daily passengers	migrant workers	dense traffic	□	□■	
import/ export nodes	international corporations		□		■
immigrants	discriminated foreigners	lack of insurance		□■	
dense residential areas	the poor	little open space	□■	□	
the old	unhealthy	use smart technology		□■	

Table 4.1 Examples of indicators that interact and are relevant in different stages: □ Short term ■ Long term

5. Conclusion

Metropolitan areas are center to world's population and engines of global development, which are also on the frontline ravaged by pandemics in many countries. They always start as a health issue and quickly transfer into an economic and social crisis, highlighting the urban vulnerability to influenza diseases. While the academic community is currently dealing with the urban impact of COVID-19, there is a deficit of focus on its underlying dynamics. Research on the definition and framework of urban vulnerability to a pandemic is very much needed since infectious diseases have become a considerable threat in the strengthened interconnected global system. Therefore, this paper prioritizes the assessment of risks and pandemic vulnerability based on the available literature. This research attempts to understand the pandemic vulnerability associated with the definition and framework of both climate and social vulnerability. It consists of three components: exposure affected by external drivers, sensitivity, and adaptive capacity. Identify critical factors that are then considered as indicators for evaluation and preparation for future pandemics. This study explores a comprehensive set of indicators, which could qualitatively and quantitatively analyze the urban vulnerability from the aspect of their exposure, sensitivity, and adaptive capacity. The indicators in this study are general factors that should be further changed in terms of urban conditions, like their relevance for pandemic adaptation or quantification in various cities.

This review shows that most indicators in space appear in the short term, while those of institutions mostly indicate in the long term. It represents the necessity of a quick policy response in concentrated areas to limit the spread of the virus. The coordination of actors will gradually emerge over time as a key factor to affect the utility of measures. For different elements, the early evidence covers the three themes. The indicators related to the exposure are the fewest, while papers about this issue are dominant. This is supposed because COVID-19 is a globally infectious disease, and the data about the relationship between global connectivity and the spread of the virus on a national scale is more available than a regional scale. It also highlights the lack of research on urban sensitivity and adaptive capacity that needs more time to be further studied. The majority of the indicators expose several old development problems, such as socio-economic inequalities, environmental pollution, segregation, and marginalization. It is discussed how these issues could increase urban vulnerability by making it difficult to implement measures or absorb long-term harm. Besides, some indicators also emphasized the potential of smart technology. The COVID-19 pandemic has provided unprecedented momentum to develop smart solutions to increase urban resilience.

Indicators in this research are not complete in some aspects regarding the limitations. As the second wave of the pandemic continue, there may emerge several new researches with different findings. Therefore, further research should involve more reviews for supplement of currently under-studies framework. Furthermore, it should also develop several qualitative and quantitative analysis in various urban areas as case study to evaluate the pandemic vulnerability proposed in this study, when the COVID-19 is fully over with available and stable data.

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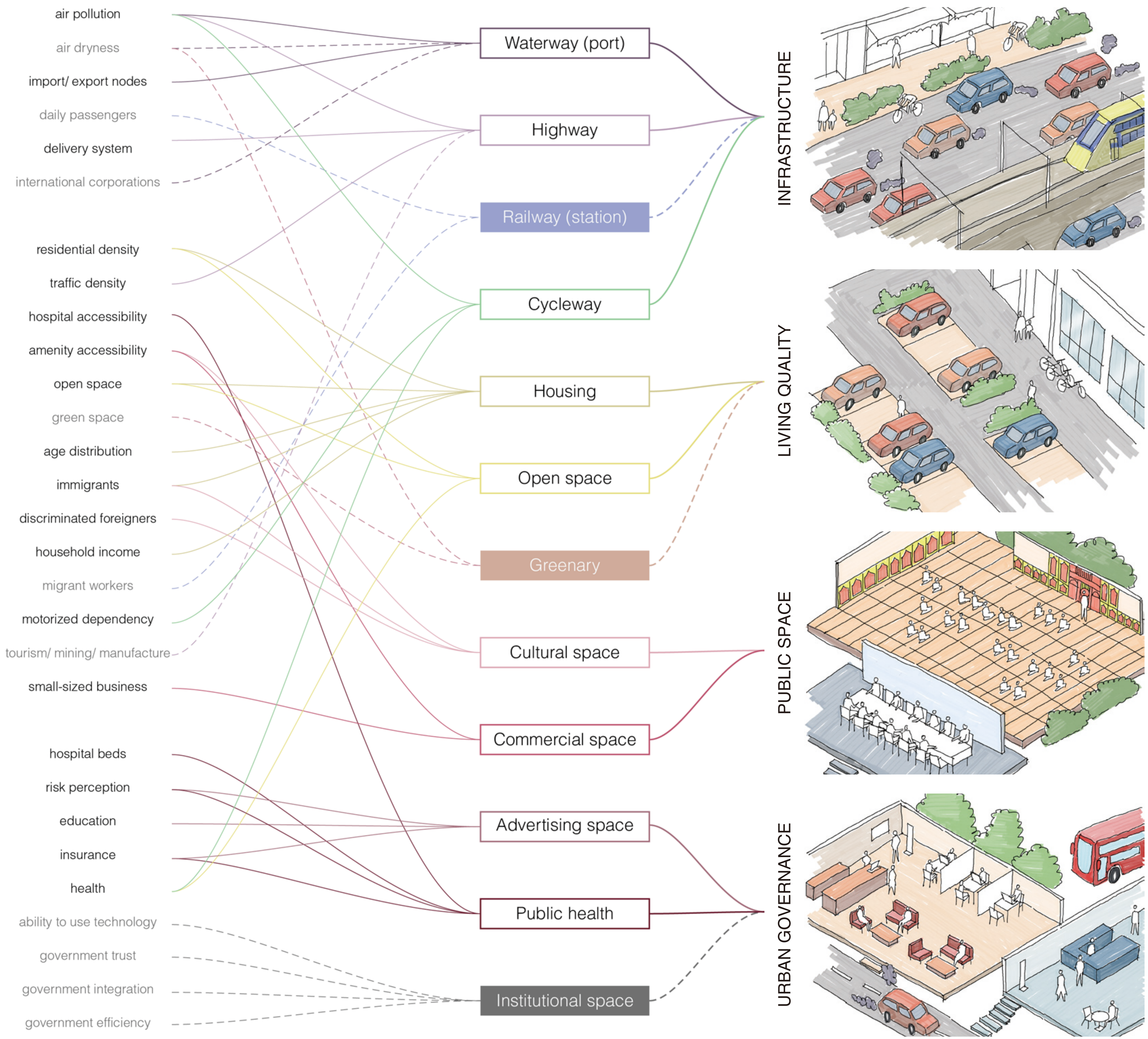
2 DESIGN PROCESS

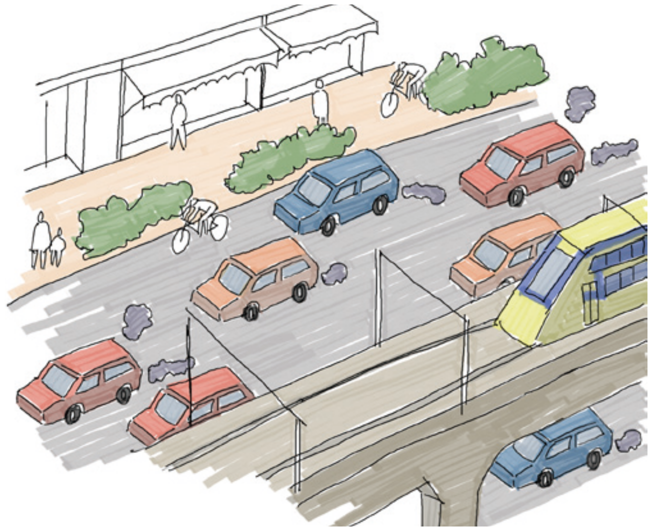
2.1 General design principles

This appendix shows the design principles proposed during the deisng process. The first example is to translate all indicators into general spatial dimensions in the context of Geuzenveld-Slotermeer. Therefore, 12 spatial forms are summarized. Finally, four spatial aspects are selected for further design: infrastructure, living quality, public space, and urban governance.



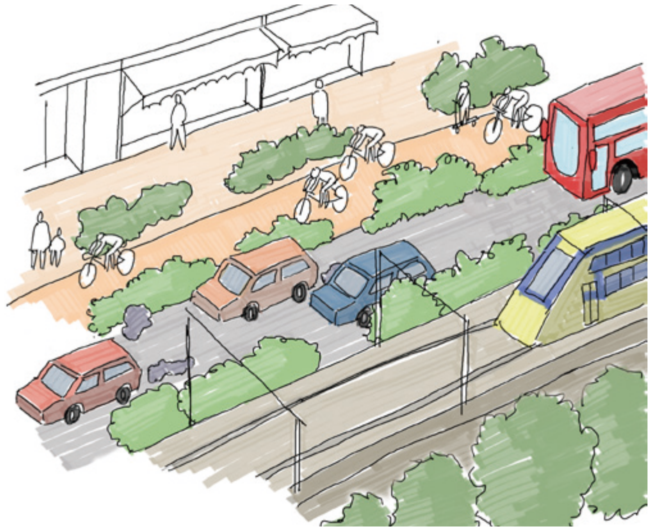
—— More vulnerable factor
– – Less vulnerable factor
☐ More vulnerable space
■ Less vulnerable space

Current situation

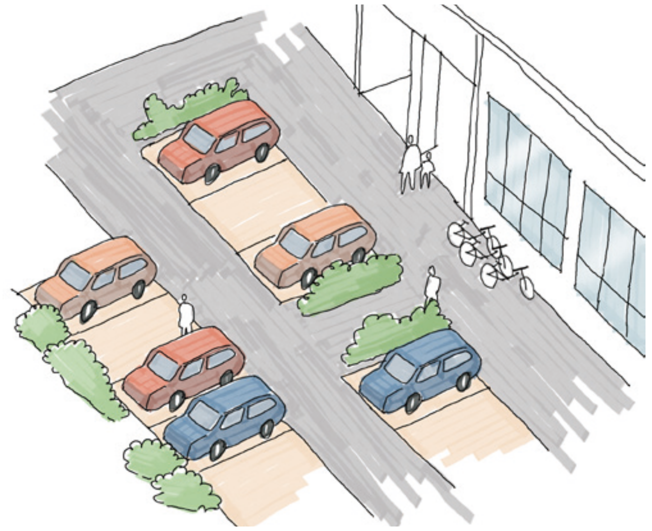


The transportation infrastructure in the community is now dominated by motorized transportation. Many of the roads within the site do not have separate cycleways, which affects bike usage and threatens pedestrian safety. However, it is close to the railway station and has the potential to be enhanced in terms of public transport.

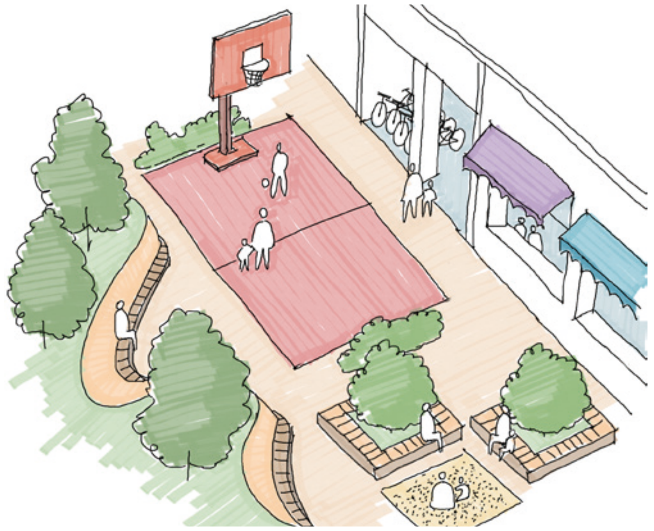
Planning vision



In order to increase the pandemic resilience of the community, motorized dependency should be reduced. First of all, the environment and safety conditions for non-motorized traffic such as walking and cycling should be improved. Secondly, a number of policies will be adopted to encourage more common use of public transport, while increasing the pandemic safety in buses and trains.

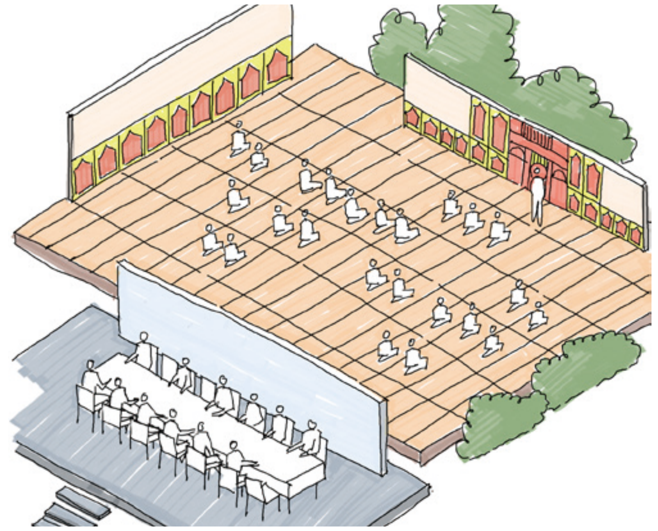


A large number of social housing, high living density, and scarce open space lead to poor living quality in the site. The public supporting facilities for residents, such as sports facilities, parking facilities, activity facilities are not sufficient. Therefore, most of the space is now occupied by parking, which is less mobile, unsafe, and has less space for children to play around.



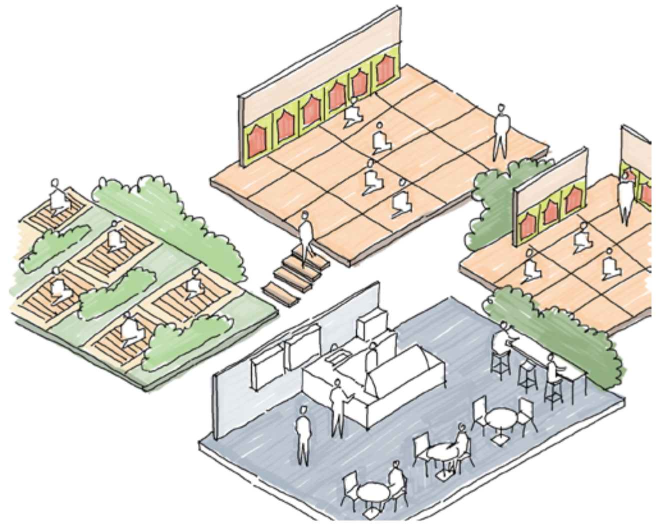
The living areas will be designed to take full advantage of the existing empty space with the housing facade. Firstly, increase the sight from the surroundings in the open space to improve safety. Secondly, parking lots should be changed into the underground, and the aboveground space will be used as sports space, rest space, and green space to provide communication opportunities for residents.

Current situation

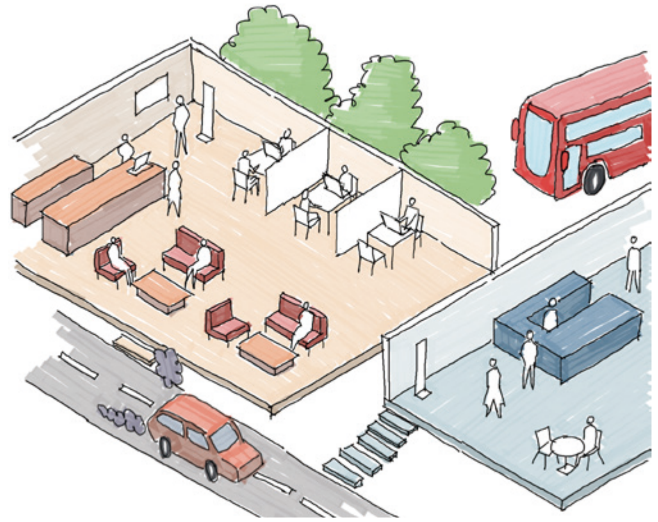


Since the special cultural needs of immigrants, it is difficult to maintain social distance in their activities. For example, in the mosques, crowded halls and restaurants become the concentration of the virus. For the residents here, the cultural space is not only a religious place, but their main public space to communicate, which has been lost after lockdown for COVID-19.

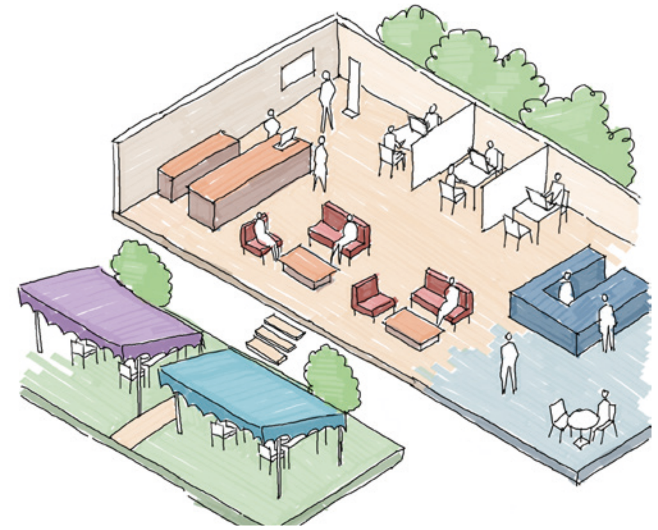
Planning vision



There should be more evenly distributed but smaller public space. Firstly, it can improve the quality of the interior space and reduce the population concentration. Secondly, public space in different neighborhoods can provide residents with more opportunities to communicate. Finally, some temporary activities can be organized outdoor to avoid serious impacts on social activities due to the pandemic.



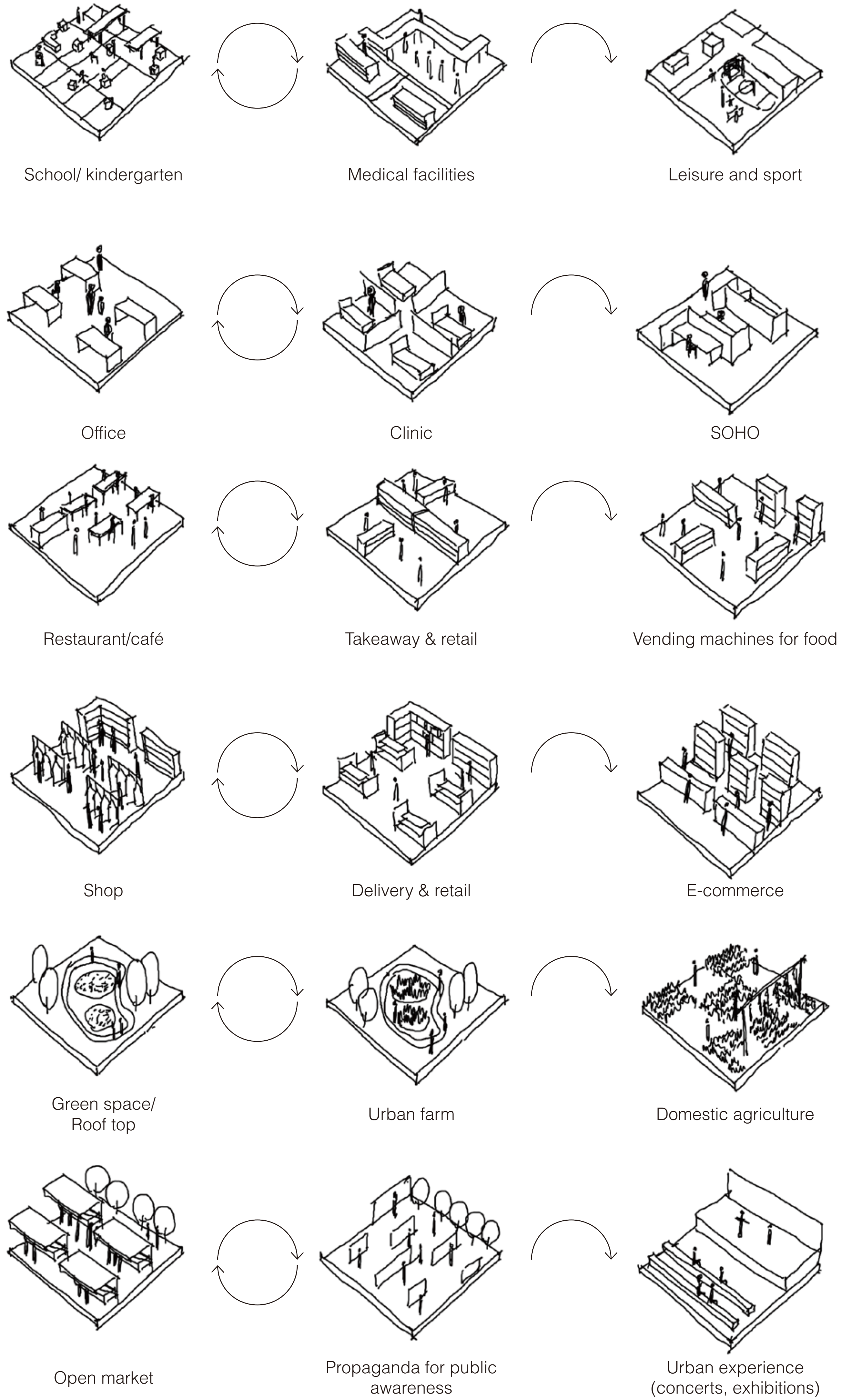
Existing government or unofficial services are fragmented, especially for immigrants, who have lower education levels or insurance coverage. And because of language and other factors, the population in these neighborhoods is less likely to actively follow policy developments, which makes them more vulnerable to marginalization.



Therefore, if the city wants to improve the level of governance on the site, assistance institutions need to be more integrated and convenient. Besides, staff should go to the community regularly to help residents keep abreast of the latest situation and actively follow up on the living problems of vulnerable groups such as the elderly and children.

2.2 Dynamic design principles

The second example focuses on dynamic amenities in different period of the pandemic. The aim is to increase accessibility of necessity for life and transfer some resources used to be other areas in the city. Therefore, the space in Geuzenveld-Slotermeer can be used for different functions before, during, and after the pandemic.



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Planning Complex Cities

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