ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

UNDERSTANDING SOCIAL DISPARITIES THROUGH THE PRACTICE OF PUBLIC TRANSPORTATION IN POST COVID-19 PERIOD, LESSONS FROM BRUSSELS, BELGIUM

M.Sc. THESIS

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

COVID-19 SONRASI SOSYAL EŞİTSİZLİKLERİ TOPLU TAŞIMA PRATİKLERİ ÜZERİNDEN ANLAMAK, BRÜKSEL, BELÇİKA'DAN DERSLER

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ŞUBAT 2022

Cihat Baluken, a M.Sc. student of İTU Graduate School student ID 502181855, successfully defended the thesis/dissertation entitled “UNDERSTANDING SOCIAL DISPARITIES THROUGH THE PRACTICE OF PUBLIC TRANSPORTATION IN POST COVID-19 PERIOD, LESSONS FROM BRUSSELS, BELGIUM”, which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission : 14 January 2022
Date of Defense : 08 February 2022

To my beloved family,

FOREWORD

The ongoing Covid-19 pandemic impacts everyday life and shows us how defenceless humankind is in a case of a global crisis that directly impact human health or human settlements. The academic discussions around Covid-19 and human settlements are not independent from the concerns on climate change. Many scientists have supported that the one of the biggest crises in history is happaned because of the distorted and disproportionate relation between the way of humankind live, produce, accommodate and the nature. The more the nature is damaged by humanity, the more threats it poses to humanity. For many years, we have acted selfishly, taking only our comfort and interests into account, stealing the values that nature loves, and now we are sending our loved ones to eternity towards nature as the price of this. Considering all that has happened over the past 3 years, we have painfully experienced how we can quickly lose our lives, our comfort, and our economic values. Naturally, a coherent mind would be expected to enumerate proposals for a strict order in ecology and human relations. However, if we look at the efforts to prevent ecological destruction today, unfortunately, there is a sign that these are only for show, and these efforts are far from convincing the people working on this issue. From the interviews that took place behind closed doors, the large organizations with thousands of people flight overseas and the ambition of private companies to make more sales, it is understood how insincere the environment is. Therefore, public, and private enterprises have not yet learned the necessary lessons from the crises we have experienced recent years. I firmly believe that the responsibility of this crisis falls on the profit-making companies that ruthlessly destroy nature and the world governments that allow them. In the aftermath of this crisis, poverty, hunger, and deprivation of inadequate health services have risen to a higher level than ever before. The people who were not primarily responsible for the crisis paid the price by becoming poorer, but the companies that were shown to be responsible for this crisis continued to get richer. The flow of capital from the poor to the rich gained more momentum. In my opinion, the most important reason for this is that the bond established with the environment is far from establishing a healthy relationship. This study reveals the fact that the urban poor are exposed to unequal treatment (in terms of social, economic infrastructure) by working harder and getting poorer even in times of crisis.

I would like to acknowledge amazing support and contributions of Eda BEYAZIT INCE, my dear supervisor, incredible efforts of Burak PAK, professor from Ghent/Brussels, people have even a single trace on my path to get this point in Istanbul and in Brussels and lifelong belief of my beloved family.

January 2022

Cihat BALUKEN
(Urban Planner)

TABLE OF CONTENTS

Page

ABBREVIATIONS

GIS **:** Geographical Information Systems
STIB **:** Brussels Intercommunal Transport Company
WfH **:** Working from Home

LIST OF TABLES

Page

LIST OF FIGURES

Page

UNDERSTANDING THE PRACTICE OF COMMUNITY MOBILITY IN POST COVID-19 PERIOD, LESSONS FROM BRUSSELS, BELGIUM

SUMMARY

The COVID-19 pandemic has seriously affected mobility in cities around the world. From the first moment, the effects of this change in various parts of the world have been investigated and analyzed. Since the rapid decline trend of mobility during the pandemic has had a significant impact on almost every person, institution and sector in cities, the studies carried out are far from reaching the saturation point and are very diverse. In this process, to make observations faster and act more effectively, global companies such as Apple and Google have made their mobility data available to the public. Many scientists generally consider these data trustworthy and have already been part of many studies. In addition to providing activity reports from Apple and Google, Google has launched Google Popular Times. Popular times is a system in which people using public transportation can transfer the occupancy information of a vehicle or a stop to the user through a survey after their mobility is over. The system turns the data into graphs and informs the users at what times the current stop or bus line is busy or not busy. Acquiring Google popular times data, this study investigates the location of the activities during the pandemic when governments called for stay at home in Brussels. To do this, first, the mobility map of the city was created by processing Google popular times data into the GIS environment. The density data acquired from Google for each public transportation stop transferred in a day during the post COVID-19 period. Overlaying this map with socio-economic data that can be obtained from public institutions could help understand the impact of the pandemic on different social groups living in the same city. Income status data of the city of Brussels based on neighborhoods and the data of minority groups who later immigrated to Belgium were focused on in this study. This study assumes that the city's migrant concentrated neighborhoods are made up of lower-income groups who are more exposed to inequalities and argues that the urban poor were not lucky enough to comply with stay-at-home calls during the COVID-19 pandemic. It is estimated that the actual mobility is relatively less in the neighborhoods where people with no immigration background are concentrated in the past.

COVID-19 SONRASI SOSYAL EŞİTSİZLİKLERİ TOPLU TAŞIMA PRATİKLERİ ÜZERİNDEN ANLAMAK, BRÜKSEL, BELÇİKA'DAN DERSLER

ÖZET

Covid-19 salgını, dünyanın dört bir yanındaki şehirlerde hareketliliği ciddi şekilde etkiledi. İlk andan itibaren bu değişimin dünyanın çeşitli yerlerindeki etkileri araştırılmış ve analiz edilmiştir. Pandemi döneminde hareketliliğin hızlı düşüş trendi şehirlerdeki hemen her kişi, kurum ve sektörü önemli bir ölçüde etkilediğinden, yapılan çalışmalar doyum noktasına ulaşmaktan uzak ve çok eşitlidir. COVID-19 pandemisi ve salgın kısıtlamaları aynı kentte yaşayan veya aynı mekanları kullanan bireyler tarafından farklı şekil ve boyutlarda algılanabilmiştir. Kısıtlamaların bulunduğu dönemde bir kesim topluluk evden çalışma sistemine geçmiş ancak azımsanamayacak sayıda bir grup ise bu kadar şanslı olmamıştır. Kısıtlamalara rağmen dışarı çıkmak durumunda olan bireyler kentsel hareketliliği devam ettirmişlerdir. Bu dönemde toplu taşımayı tercih eden insanlar Google popular times uygulaması aracılığıyla ulaşım aracının yoğunluğu, konforu ve güvenliği hakkında bir takım geri dönüşler yapabilmekte ve bu verilerin ortaya çıkardığı sonuç toplu taşım duraklarına özgü olarak tüm kullanıcılara sunulmaktadır. Bu çalışma COVID-19 dönemi kısıtlamalarının hala yürürlükte olduğu ancak normalleşme adımlarının da atıldığı bir dönemde seçilen bir tarihte Google ’un birbirinden bağımsız olarak sunduğu toplu taşıma yoğunluk verisi üzerinden kentin tamamını kapsayan bir yoğunluk haritası oluşturmakta ve Brüksel kentinde mevcutta yer alan sosyo-ekonomik arka plan ile bir araya getirerek, kriz döneminde ortaya çıkabilecek sosyal eşitsizlikler konusunda anlamlı sonuçlar çıkarabilmeyi amaçlamaktadır.

Google, Popular Times uygulamasını aslında COVID-19 pandemisinden de önce uygulamaya almıştı. Popular Times, toplu taşıma kullanan kişilerin hareketlilikleri sona erdikten sonra bir ulaşım hattına veya durağa ait doluluk bilgilerini anket yoluyla kullanıcıya alabildiği ve kendi veri setinde barındırabildiği bir sistemdir. Uygulama verileri grafiklere çevirerek mevcut durak veya otobüs hattının hangi saatlerde meşgul olduğunu veya olmadığını kullanıcılara bildirir. Bu çalışma Google'ın popular times verilerini kullanarak, pandemi sırasında merkezi yönetimin Brüksel’de evde kalın çağrısı yaptığı dönemde farklı sosyo-ekonomik grupların toplu taşıma kullanımı üzerinden hareketliliğini araştırmaktadır. Bunun için öncelikle Google popular times verileri Coğrafi Bilgiler Sistemine (CBS) ortamına işlenerek şehrin toplu taşımda kullanım yoğunluğu haritası oluşturulmuştur. COVID-19 sonrası dönemde ise belirli bir gün için popular times verileri elde edilmiş ve bir haftalık bir zaman diliminde CBS ortamın işlenmeye başlamıştır. Her toplu taşıma durağı için işlenen bu veriler yine CBS ortamında test edilmiştir. Daha sonra 4000'in üzerindeki durak sayısının sadeleştirilmesi amaçlanmıştır. Çünkü durakların 2 veya 4'ü aynı güzergâhlara ait olabilmektedir ve aynı veriye sahiptir.

Her durak için veri girişi yapılması planlandığından veri girişi süresini araştırma zamanlaması açısından kısaltmak da sadeleştirme yapmak için ikinci neden olmuştur. Durak sayısının sadeleştirilmesi için CBS araçlarından biri olan 'point to area'

fonksiyonu kullanılmıştır. Bu fonksiyon sayesinde belirli uzaklık içerisinde kalan veriler tek bir çatı altında toplanabilecektir. Aynı anda yürünebilirlik üzerine literatür taranmış ve yaklaşık olarak 400-500 metre toplu taşım için yürümenin doğal sınırlar içinde kaldığı belirlenmiş ve aynı güzergâha ait durakların dışarda kalmasını engellemek amacıyla 500 metre mesafe üzerinden ilerlenmesine karar verilmiştir. Bu Brüksel metropoliten alanının 500 metre kenarlara sahip karelere bölünmesiyle elde edilecek kare bir şeklin ortaya çıkması demektir. Her kare bölmenin içinde kalan duraklara atanan verilerin aritmetik ortalamaları alınacak ve kareye ortak bir değer atanacaktır. Bu işlemin yapılması için öncelikle popular times yazılı verisi bir indeks oluşturulacak şekilde numaralandırılmış ve her durağa bir değer atanmıştır. Durak verilerinin aritmetik ortalamalarının alınmasından sonra Brüksel metropoliten alanının toplu taşıma durak yoğunluğunu gösteren tematik harita elde edilmiştir.

COVID-19 pandemisi hem kentler arasında farklı etkilerle hissedilmiş hem de aynı kentte yaşayanlar arasında farklı algılanabilmiştir. Bu tez alışması pandeminin aynı şehirde yaşayan farklı sosyal gruplar üzerindeki etkisinin toplu taşıma üzerinden anlaşılmasına yardımcı olmayı amaçlamaktadır. Dolayısıyla içerisinde Brüksel'in geçmişten gelen sosyal dokusu incelenmiştir. Özellikle Brüksel metropoliten kentinin mahalle bazında gelir seviyeleri, göçmenlerin yoğunlaştığı mahallelerin geldikleri ülkeye göre incelenmesi, eğitim durumu, yaş aralıkları ve genç yaş gruplarının yoğunlaştığı yerler gibi sosyo-ekonomik verileri üzerinde durulmuştur. Bu çalışma, kentin göçmenlerin yoğunlaştığı mahallelerin, eşitsizliklere daha fazla maruz kalan düşük gelirli gruplardan oluştuğunu ve kent yoksullarının COVID-19 salgını sırasında evde kal çağrılarına uyacak kadar şanslı olmadıklarını varsayarak başlamıştır.

Brüksel'de sosyal ve ekonomik araştırmalar arasında eşitsizliklere değinen birçok çalışma ve açık kaynak proje bulunmaktadır. Bu araştırma bir takım kamu kuruluşlarının projeleri ve akademik çalışmalardan sıklıkla faydalanmıştır. Kamu alanında yapılan çalışmaların başında Wijkmonitoring gelmektedir. Wijkmonitoring, kelime anlamıyla mahalleleri izlemek anlamına gelmektedir. Mahalle yoğunlukları, mahallelere ait demografik veriler, yaş ve cinsiyet üzerinden sahip olunan veriler, ait olunan ülke/vatandaşlık bilgileri ve daha fazlası yer almaktadır. Sosyo-ekonomik veriler, sosyal yönleri farklı kategorilere ayırarak Wijkmonitoring platformu tarafından sağlanmaktadır.

Brüksel'deki mahallelerin kültürel ve sosyal çeşitliliği için sahip olunan vatandaşlık verileri temel alınırken, ekonomik faktörler için işsizlik ve gelir seviyesi verileri kullanılmaktadır. Wijkmonitoring tarafından sağlanan verilere göre, Brüksel'in bazı mahallelerinde göçmen oranları diğerlerinden çok daha yüksek olmaktadır. 15 farklı ülkeden vatandaş grupları Fransız, Türk, Kuzey Afrikalı, Sahra Altı Afrikalı, ilk 15 AB ülkesi ve sonradan dahil olan AB ülkeleri olmak üzere kategorize edilmiştir. Yapılan araştırmalar sonucunda Brüksel'in merkez ve Kuzey ilçelerinde yer alan Zavel, Marollen, Stalingrad, Anneessens, Kuregem Bara, Kuregem Veeartsenij, Kuregem Dauw, Hertogin, Weststation, Historisch Molenbeek, Koekelberg, Havenwijk, Oud Laken West, Oud Laken Oost, Noordwijk gibi mahallelerinde tarihsel olarak daha fazla göçmenin yerleştiği gözlemlenmektedir. Kuzey Afrika ve Sahra Altı Afrika'dan gelen nüfus ve 15 Avrupa ülkesinin vatandaşlarının yaşadığı mahalleler nispeten bölünmüş durumda olduğunu gösteren saygın akademik çalışmalar bulunmaktadır. Bazı ilçelerde, AB'nin üyesi ilk 15 ülke vatandaşlarının yoğun olduğu yerler bulunmaktadır. Fransa, Hollanda veya Luxemburg gibi ülke vatandaşlarının

yaşadığı yerlerde genel olarak sosyal veriler yaşayan kişilerin eğitimli olma olasılığının daha yüksek, gelir seviyesinin daha üstte olduğu yerlerden oluştuğu gözlemine olanak vermektedir. AB üyesi olmayan ülkelerde doğan insanların yoğun olarak yaşadığı mahallelerde ise eğitim seviyeleri düşmekte ve gelir seviyesi aşağı çekilmektedir. Özellikle gençler arasında eğitimsiz ve işsiz bulunanların oranı artmaktadır. Toplumun refahı için sıralanabilecek temel göstergelerde bu mahalleler diğerlerine nazaran daha geriden takip etmektedir.

Google toplu taşıma verilerinin test edilmesinden sonra ortaya çıkan tematik harita mekânsal anlamlı sonuçlar çıkarmak amacıyla bahsi geçen sosyo-ekonomik verilerle çakıştırmayla bir korelasyon sağlanmaya alışılmıştır. Yapılan sentezler sonucunda çalışma açısından ilgi ekici ve orijinal sayılabilecek sonuçlara erişilmiştir. Öncelikle toplu taşıma verileri kriz dönemlerinde kentsel dinamiklerin anlaşılması amacıyla önemli bir potansiyel sunmaktadır. COVID-19 döneminde sokağa çıkma kısıtlamaları döneminde toplu ulaşım her ne kadar kesintiye uğrasa da Brüksel özelinde işletilmeye ve belirli grup insanlar tarafından kullanılmaya devam etmiştir.

Yoğunluk verileri ile sosyo-ekonomik haritalar bir araya getirildiğinde Brüksel'de AB vatandaşı olmayan insanların daha yoğun yaşadıkları yerlerde toplu taşımada yaşanan yoğunluğun daha yüksek olduğun gözlemlenmiştir. Durak yoğunluklarının daha yoğun olduğu noktalarda genel olarak işsizlik verisinin daha yüksek çıktığı, gelir düzeyinin görece daha düşük olduğu, eğitim düzeyinin azaldığı, daha genç nüfusun yaşadığı gözlemlenmiştir. Bu sosyo-ekonomik veriler kentte yaşayan görece daha yoksul ve kırılgan grupların daha fazla toplu taşıma kullanmak zorunda kaldıklarına ve belki de daha fazla COVID-19 bulaşma riskine sahip olduklarına işaret etmektedir. Dolayısıyla Brüksel'de mahalleler arasında COVID etkilerinin farklı gerçekleştiği savı doğrulanmaktadır. Geçmişte göçmenlik geçmişi olmayanların kişilerin yoğunlaştığı mahallelerde sosyo-ekonomik kırılganlığın ve kriz dönemlerinde net hareketliliğin nispeten daha az olduğu tahmin edilmektedir. COVID-19 veya ilerde oluşabilecek farklı bir kriz esnasında toplumsal bağışıklığının sağlanması amacıyla bu alışmadan elde edilebilecek veriler kullanılabilecektir. Brüksel'de mekânın tarihsel gelişimi birçok eşitsizlikler barındırmaktadır ve bu durum ilerde etkili bir risk yönetimi planlamasının önünde engel oluşturmakladır.

COVID-19 sonrası hareketliliğin yeniden eski seviyelere yaklaştığı dönemlerde GIS uygulamalarını kullanarak sağladığımız toplu taşıma istasyonları yoğunluk haritasına göre gelecekte yaşanacak bir kriz durumunda şehirde yaşayan bazı gruplar daha savunmasız kalmaktadırlar. Bu kapsamda yoğunluk verileri birleştirilip her 500 metrede bir duraklar birleştirilerek tüm şehre dağıtıldığında kültürel ve tarihi farklılıkları olan grupların yoğunlukta yaşadığı ve halk arasında göçmen mahalleleri olarak bilinen mahallelerin toplu taşıma altyapısından daha yoksun olduğu ortaya atılabilecek bir fikir olmuştur. Bu durum iki farklı türde sonuç üretebilir. Bu mahallelerde işsizlik oranlarının da diğer mahallelere göre yüksek olduğu göz önüne alındığında, sosyal, ekonomik ve kurumsal olarak daha kırılgan olan göçmen gruplarının temel hizmetleri sağlamak için dışarı çıkmak zorunda kaldıkları ve ulaşım olanaklarına daha fazla ihtiyaç duydukları söylenebilir. İkincisi, bu mahallelerin COVID-19'un yayılmasını önlemek için fiziksel gereksinimleri karşılaması çok daha zor görünüyor. Toplu taşıma araçlarını kullanırken aşırı yoğun olarak işaretlenen duraklarda ve ulaşımda bu duraklardan geçen hatlarda 2 metre sosyal mesafe gibi sağlık koşullarının sağlanması mümkün görünmemektedir.

Başta sağlık krizleri olmak üzere gelecekte herhangi bir kriz yaşanması durumunda, yönetimlerin afetin doğasından kaynaklanan fiziksel gereksinimleri yaratması yapılması gereken ilk şeydir. Bu makaledeki CBS tabanlı çalışmamızın bir sonucu olarak, Anderlecht, Sint-Jans Molenbeek, Elsene ve Sint-Joost-ten-Node ilçeleri pandeminin ortasında yüksek toplu taşıma doluluk oranlarından mustarip oldukları anlaşılmıştır. Bu durum, virüsün yayılma oranlarının daha yüksek olması gibi bir senaryo ile gelen çalışmaların ilk nedenlerinden biri olabilir. Yeni bir veri kaynağı olarak, Google veya diğer cep telefonu sağlayıcı verileri gibi teknolojiler, doluluk oranlarını belirlemeye ve bilim insanları ile kamu politikası yapıcılarına yön vermeye yardımcı olabilir. Anderlecht, Sint-Jans Molenbeek, Elsene ve Sint-Joost-ten-Node'da daha yüksek toplu taşıma doluluk oranları, bu ilçelerde bisiklet gibi yeşil ve alternatif ulaşım araçlarına daha fazla ihtiyaç ve yatırım yapılması gerektiği yönünde bir düşünce ortaya koymaktadır. Daha yüksek toplu taşıma kullanma oranları aynı zamanda bazı ekonomik sonuçlara varma eğilimini ortaya çıkarmaktadır. Bu mahallelerde yaşayan insanlar Brüksel'in diğer mahallelerine göre daha az maaş kazanması ve evde kal çağrılarına rağmen daha fazla dışarı çıkmak durumunda kalmaları meslek grupları veya iş kolları üzerinden afet ve sağlık krizlerinin etkilerinin farklı olduğu ve bu durumun mekânsal analizlere etki edebilecek nitelikte olduğu fikrini düşündürmektedir. Kimi ilçelerde daha az gelir ekonomik veriler, sadece maaş farkını değil, aynı zamanda ne tür işler yaptıkları konusunda da bir bölünme olduğunu düşünmemizi sağlamaktadır. Sint-Pieters Woluwe'de yaşayan çoğu insan gibi daha yüksek vergi beyanında bulunan ve daha yüksek gelir elde ettiği gözlemlenen mahalleler, yaptıkları işin doğası gereği uzaktan çalışma gibi esnek iş fırsatları yaratma konusunda daha fazla beceriye sahip olabilir. Daha fazla eğitim veya teknoloji odaklı işler böyle bir pozisyon için daha uygun olabilir ve bu da insanların sosyo-ekonomik altyapısı düşük mahallelerde ne tür işler yaptıkları sorusunu beraberinde getirmektedir. Büyük olasılıkla, ilk 4 mahallede daha az kâr getiren işler, daha az teknolojik çıktı ve daha az eğitim gereksinimi olan fiziksel işler olma eğilimindedir.

Bu çalışma, afet durumlarında Anderlecht, Sint-Jans Molenbeek, Elsene ve Sint-Joost-ten-Node ilçelerinin sadece herhangi bir sağlık krizinin fiziksel gereksinimlerinden değil, sosyal- toplumsal altyapı eksikliğinden de muzdarip olabileceğine dikkat çekmektedir.

Çalışma kapsamı göçmen gruplarının yaşadığı mahallelerde bulaşma oranının yüksek olduğunu doğrulayan sonuçlar vermektedir. Kriz dönemlerinde toplu taşımanın önemi göz önünde bulundurulursa, bu çalışmadan elde edilen verilerin gelecekteki krizlerde yapılacak çalışmalara yardımcı olması beklenmektedir. Kriz dönemlerinde dahi toplu taşımayı daha yoğun kullanması gereken grupların sosyal ve ekonomik açıdan kırılgan göçmen kökenli bireylerden oluştuğu görülmektedir. Bu alandaki çalışmalar, herhangi bir kriz anında toplu taşımanın yoğun olarak kullanıldığı bölgelerdeki toplulukların daha güvenli hissetmelerine ve afete karşı daha dirençli olmaları yönünde yapılacak çalışmalara destek olabilir.

Ayrıca merkezi ve yerel yönetimlerin toplumu korumak amacıyla ortaya koyduğu politikaların orta ve uzun vadede kentsel yoksulluğa maruz kalan mahallelerde durumu iyileştirmeden çok daha kötüleştirme eğiliminde oldukları konusu akıllara gelmektedir. Google verilerinin kullanılarak kriz dönemlerinde toplu ulaşım verilerinin analizi ve anlamlı mekânsal analizlerin ortaya konma durumu henüz çok

yeni ve daha yoğun çalışılması gereken bir konudur. İlerleyen dönem çalışmalara sosyal kurumların eksikliğinin bulunduğu mahallelerde veya topluluklarda kriz dönemleri nasıl ve ne düzeyde bir kırılganlığın oluştuğuna dair araştırılmaların yapılması önerilmektedir.

1. INTRODUCTION

Since December 2019, world countries and international organizations have been coping with the COVID-19 coronavirus pandemic. In this process, the policies developed to protect people's lives had a temporary or permanent effect on everyday life. The agenda of COVID-19 policies was the stay-at-home calls made by governments since mid-March 2019 (WHO, 2021). This call was met with seriousness by the masses of people who were shocked at first, and it was revealed by analyzes on the mobility made later.

In the call, there were suggestions or sanctions such as not leaving the house unless it is necessary, temporarily closing the offices of the sectors that could work from home, prohibiting social and cultural gatherings, social distance, and the use of masks in public areas (info-coronavirus.be, 2021). While the governmental calls were similar in most of the countries, their effects were different in each region. Because one thing was certain, each nucleus community has its perception and response style was different from each other (Bonaccorsia et al, 2020).

It did not take long for some inequalities to become visible in urban space where inequalities in society can be represented. Some basic requirements such as adjusting the social distance and ensuring the use of masks were the point of discussion for many in providing adequate urban and transportation infrastructure.

Among the discussion, first, the call is basically about the existence of sufficient urban space. Considering that the densities of neighborhoods in the city are not the same, it will be more difficult for some people to fulfill even these basic recommendations than for other parts of the city. Inequalities and the impact of the pandemic on more vulnerable groups were one of the first issues that science dealt with (Atun, 2021). By examining many socioeconomic data such as income level, education level, health accessibility, unemployment, and labor market, it is quite possible to draw meaningful conclusions that can help in subsequent crises by analyzing them together with big data.

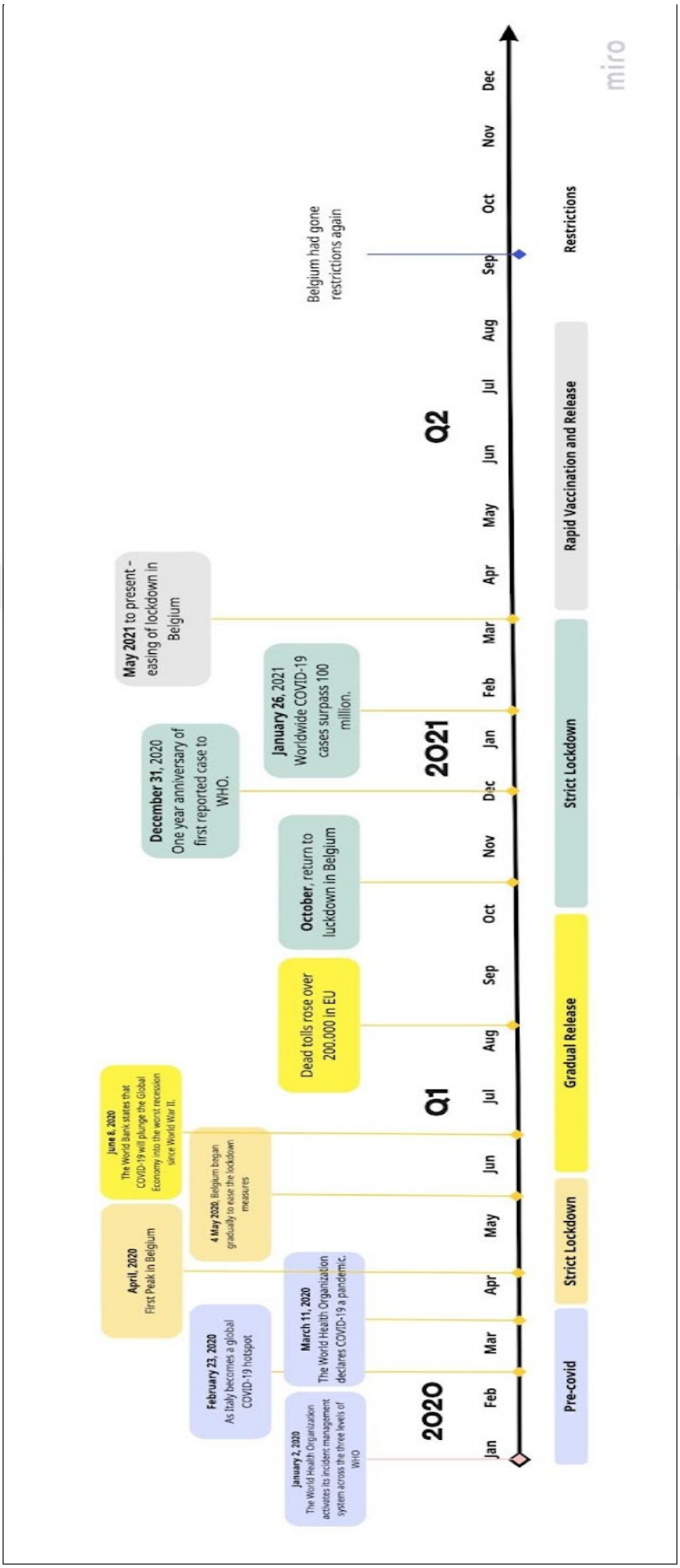

Figure 1.1. COVID-19 Timeline in Belgium

In this context, governments and the European Union have also called on mobile operators and telephone manufacturers to publish their mobility data to be made available to scientists. As a respond, global companies such as Apple and Google have made public the data on the mobility change in metropolitan cities since January 2020. Apple presented mobility data in leading metropolitan cities in the graphs presented as mobility trends. According to these data, in January, February and April 2020, the first months when a pandemic was declared and the calls to stay at home were made, the mobility hit bottom. There was a net decrease compared to normal periods between October 2020 and April 2021, when the lockdown was experienced again with the second wave, and non-essential mobility was restricted. Based on this data, it is understood that the government's calls were received seriously by the public. Still, certain groups had to continue their mobility, especially after the second wave.

Like Apple, reports and graphs containing mobility data have started to appear in Google as well. However, Google has put a more important service than Apple on its agenda as a data set. Google, which currently offers routing services on Google maps to its customers, has started to present a survey investigating the comfort of transportation through this application. This data basically collects the congestion rate experienced in the stop and transportation route from the user through a survey and presents it to other users graphically. This application is called Google Popular Times and it is already the subject of many studies and it has been seen as a reliable data source in the academic community. This study believes that Google data will play an important role in illuminating the questions listed above. Popular times data, which is already reflected on the stops and transportation routes independently, can be prepared for meaningful results by showing them on the same mapping in the GIS platform. This study aims to select a date in the post-covid times of the re-opening process, transfer the Google popular times data to the GIS environment and compare it with the socio-economic data.

1.1. Problem Definition

The federal records of Belgium show that 35% of the inhabitants living in Brussels have no Belgian citizenship. A better look at statistics revealed that 71% of the individuals have different backgrounds or migrant stories according to the Local Integration and Integration Monitor report published in 2018 (VRT, 2018). Districts

and regions have different rates of foreigner roots such while the rate of foreigner origin happened 43% in Watermael-Boitsfort, it's slightly more in Ixelles with %49 and 90% in Saint-Josse-ten-Node with foreigner roots (Statbel, 2021).

There has been a rapid rise in the total numbers of migrants living in the Brussels capital region, starting from the 1970s. In the 1990s, the percentage of the population born in Brussels decreased in time. Only 40% of people living in Brussels were born thereafter receiving an industrial attraction from other parts of the world (Deboosere, 2009). Changes in demography directly impact spatial organization and developments in urbanization in the city.

The main issues come around suburbanization and urban decay areas in the center of the city. According to several works focusing on relations between demographics and urban development, after masses of migration started in the 1970s, people living in the places where received many newcomers tend to migrate to rural areas and it led to a long process of suburbanization. The city center began to remain empty after the migration of native people who were considered as wealthy parts of the city and it reduced the net income of the neighborhoods and prices for rent. The new condition of the center was charming for newcomers with relatively lower prices and close its locations to other parts of the city. So, the neighborhoods that collapsed in time due to suburbanization become new hubs for migrant communities and concentrated domination of some groups of people.

After a short time in the 1990s, Turkish and Moroccon dominated neighborhoods were already settled and led to a huge level of diversity combined with migrations from new members of the European Union (Kesteloot, 2009). The ideas that explain the urban development of Brussels based on social diversity can be confirmed from the spatial distribution map of some minorities based on nationalities, published on the Wijkmonitoring. While the wealthy people left the city, central neighborhoods became poorer, and the newcomers become part of the urban poor (Deboosere, 2009).

In other words, the mobility data obtained from Popular times will inevitably contribute to observing the impact of Covid-19 on these groups in areas where immigrant groups live intensively. In Brussels, just like in all major cities, strict measures, including a curfew, have been implemented due to the Covid-19 pandemic. However, it has been observed that these measures are not implemented or eliminated for some social groups. The observation can be taken from the mobility reports

provided by Apple and Google which indicates an increase in the general mobility in the second restriction period and after. However, some other people continued to stay at home during this period.

The analysis of the mobility trend could make a difference in thinking about the social and economic capacity of the urban poor in terms of coping with covid-19. The fact coming from public transportation data which contain indications of more intensive use in poor neighborhoods during the Covid-19 period points to the emergence of a vital risk in poor neighborhoods in times of disaster, due to the economic difference between the two groups living in the city. The study held about the social and economic vulnerability of migrants in Italy confirms that disasters create greater pressure and impact on those who are less lucky in terms of economic and social capital and are less informed (Atun, 2021). Therefore, some questions need to be figured out regarding the problems arising during COVID-19 times among the vulnerable groups.

In other words, it is possible to mention a difference between the 1st, 2nd, and subsequent waves. Based on the changes in mobility levels during the national and city-wide lockdowns, this study investigates who stayed at home during the 1st wave but had to move during the 2nd wave. Which groups remained at home, and what aspects provided them with the comfort of staying at home while others had to go outside? It asks explicitly which common socio-economic and demographic aspects do individuals who had to be mobile during the COVID-19 waves share.

1.2. Purpose of the Thesis

Brussels, which has welcomed immigrants for a long time for economic and political reasons, has been the subject of many academic studies on integration with immigrants. The immigrant groups live close to each other in the city and have very limited communication and interaction with other parts of the city (Deboorese, 2009). The situation that diversity and segregation created over years was analyzed by many researchers. There are many signs that neighborhoods are in a weaker position compared to other local neighborhoods in terms of economic and social institutions.

The main reason for economic and social vulnerability is an economic erosion that happened over years by the loss of wealthier native people moving to rural areas and periphery neighborhoods of the city. This has created a challenge on the policies to

reach sustainable development in the coming years due to a lack of balance between neighborhoods (Kesteloot, 2009).

Discussions coming around imbalance triggered questions around socio-economic disparities and lack of providing similar equal opportunity between a child born in a migrant family in the city center and another born in a wealthier family in the periphery. This study aims to create an understanding of socio-economic disparities by bringing together Google mobility data and the socio-spatial pattern created for many years starting from the 1970s.

1.3. Methodology

During the literature review, the practice of multi-discipline research tends us to ask more questions about some other social phenomenon that happened around this issue over years in Brussels. The inner and external migrations to Brussels created a very diverse community living together but with less integration. Eventually, lack of integration and socio-economic differences concluded losing ties between communities and a process of isolation and alienation of some groups. There are some similarities around these groups such as having less income level, being part of migrant family history and culture.

When the isolation comes together with social inequalities of individuals it stipulates anger in migrant communities against the government and native people who already live here and have better conditions. The process of feeling different by migrants has been seen as the main reason for the rise of riots and some events include violence by some researchers (Kesteloot, 2009). This study aims to find out some difficulties of urban poor with lower incomes and migrant backgrounds face during COVID-19 times. By doing this, it explores the ways for reducing socio-economic inequalities and increasing resilience in future crises.

A field study was conducted in Brussels and focused on the conclusions that can be obtained from the analyzes made after the fieldwork. The data collected during the fieldwork is of secondary data type, a kind of busy times data provided by mobile phone providers. In the first part the geo-locations of the public transportation stops were collected from the public transport authority of Brussels. In the second part the most convenient data source was selected based on a few indicators. Around many

mobile phone providers google was the most convenient data source for this study because of its wide range of user numbers, their size of impact and methods.

1.3.1. Introducing Google data

There are two important sources of Google for urban mobility. The first one is the monthly mobility trends report provided for every region around the world; called community mobility reports (CRM). The community mobility reports offer a wealth of sources on the mobility trends as well as changes in everyday life during COVID-19 (datastudio, 2021). In that sense, it's a vital source of information to examine the working from home and stay-at-home calls and other policy advice from public institutions. It allows analyzing the places that have been most and least in use during pandemics such as parks, pharmacies, hospitals, temporary health facilities, transportation nodes, stops, and some other points of interest. The data provided in the Google services is aggregated from mobile phone signals (Aktay et al., 2020).

The extend of this study is limited to Brussels Capital Region in Belgium. CRM reports has been preparing for the three parts of Belgium; the Flanders, Brussels and the Wallonia, so this work exclusively focused on the data related to the Brussels metropolitan region. Even though the ups and downs are similar in major cities in Europe there may be some differences in mobility trends depending on the dates and types of restrictions, socio-economic pattern of the city. Similarity in the mobility trends may be higher among the Belgian cities.

In a closer look at CMR, there is a line chart of mobility trends in the Flanders, Wallonia, and Brussels Capital regions of Belgium. If we compare all three regions it is not surprising that the peak and bottom points of mobility have received in similar dates because of the federal decision-making authority of the Belgian government. As it stated in the Belgian Constitution; Belgium is a federal state composed of communities and regions (belgium.be, 2022). As it seen usual in federal administrations, if the federal government decides to give a decision of restrictions, it tends to set rules for all three regions at the same time. However, the overall situation was a little harder in Brussels than in other regions. Although other regions have already opened shops and serve some numbers of people with distance in September 2020, Brussels had to keep the strict restrictions by the central government due to

relatively higher numbers of cases. Even though many settlements had already passed the top orange zone in the EU covid-19 map, Brussels had to stay there for a while longer than the vast of the country (Brussels Times, 2021). The CMR reports may contribute for efforts to understand the relation between the impacts of the disaster and mobility trends in the selected regions.

On the other hand, Google Maps has dominated the navigation industry as it was most downloaded navigation app in 2021 in the United States and European region (statista.com, 2022). The add-ins embedded in the application such as popular times makes the app more sufficient and more rational for users. Besides, the use of crowdsourcing methods and collecting data from the users has led us to selecting google maps and its embedded add-ins as the important main data source in the dissertation. Therefore, Google collects feedbacks from users by using a survey offering some questions about the crowd times, comfort, and security. Crowdsourcing applications are seen as more reliable sources since the data is provided directly by the user. they are preferred because they make the tasks that require a high labor force simpler to perform which this study separates a significant place to the literature about its applications and other cases from other parts of the world (Behrend at al, 2011).

An application provided by Google for some years has suddenly come into the discussions due to its potential to make people feel less secure in everyday mobility. The service called ‘popular times’ provides the exact busy times of a venue as well as a transportation stop or line in the case of preventing a mass use of the same place by users more than capacity during COVID-19 times. The application has a simple user interface shown in figure 3. explains the busy time of a transport stop in the Brussels, Belgium. It is simply based on tracing the geolocations of mobile phones and crowdsourcing data which is working integrated with the Google maps app. Besides geo tracing, Google maps ask a few questions including the ones trying to assess the travel comfort and wait times after each time someone searches for the best routing and finishes its travel. So, the application combines historical and aggregated data from crowdsourcing and geolocation of smartphones and brings an average expected use of that spot-on a given date.

> As a novel data source, Google “Popular Times” can give information on when a venue is mostly visited and live waiting time, as well as average visit duration, based on aggregated and

undisclosed data from users who have opted to share their geotrace using their mobile devices. Such information can potentially improve real-time demand estimation for transportation planning applications (Timokhin and Antoniou, 2020).

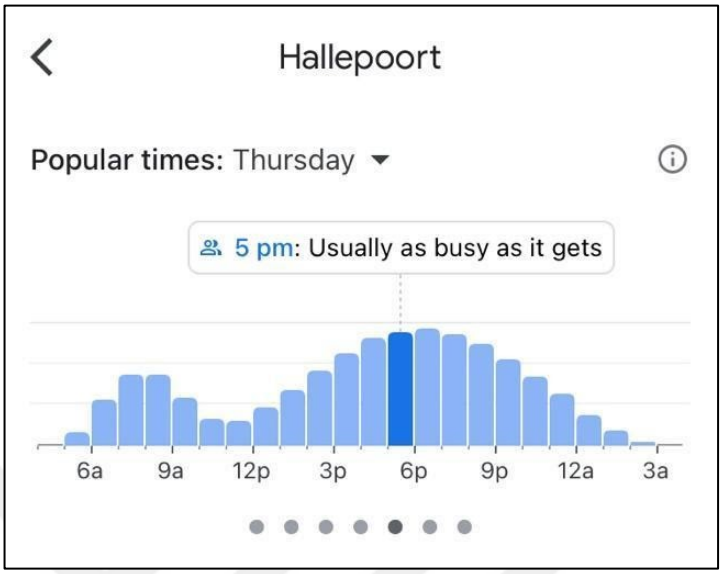

Figure 1.2 Google popular times interface for Map's users

Live visit and waiting for time data that Google made available to public attention may help not only its customers but also scientists and policymakers. This study intends to use Google popular times datasets by combining separate data in the GIS. To do that, each public stop is examined in the Google datasets and an index is created to transform the written data into a statistical form. And then a couple of GIS analysis tools are performed to better understand the mass and row data that we gathered from Google.

In the middle of October 2021 which could be defined as the post-COVID-19 era, the data is acquired on Wednesday, Thursday, and Friday at 17.00pm during weekdays. The data was collected from mobility.brussels platform as shapefile and added to the GIS application with other data collected. The points of interest were over 4.000+ in the first place when the data was taken from the mobility authority website and this raw data was analyzed in GIS with the point-to-square method. In this way, every 500 meters is considered a distance that pedestrians can easily walk, and the stops are gathered under a single square. While calculating the density for each square, the arithmetic means of the numbers representing the densities of the stops were taken as a basis. After processing the density data spatially on the map, it is now understandable

for us to see the density of public transport use of the neighborhoods we have chosen due to their socio-economic characteristics.

While arranging grid system with many squares of 500 meters, popular times data was ready from the Google Maps user interface with entering values to the new column.

Each square of the grid has given a name contains a code such as A-16, M-8 or R-4 and the process of giving them an index number started from the first square which was A-1. To determine the crowd of the transport stops for A-1, the steps were

1. Getting into application and taking the popular times crowd data for selected transport stop
2. Appointing an index number defined in the methodology
3. Doing the same process for each stop in the square
4. Writing them on a paper and getting their mean by using this formula
5. Appointing the new value to the square
6. Doing the same process for each square

Each crowd value of stop represented in the values of squares thanks to this method.

$$\overline{X} = \frac{X_1 + X_2 + X_3 \ldots X_N}{N}$$

Where
$\overline{X}$ = the mean
X_1 = the first value
X_2 = the second value
X_3 = the third value
X_N = the last value
N = the number of valuse

Figure. 1.3. Formula for mean

To determine popular times, wait times, and visit duration, Google uses aggregated and anonymized data from users who have opted into Google Location History. Popular times, wait times, and visit duration are shown for any business if it gets enough visits from these users.

The owner of the venue can't manually add this information to its location, and it appears only if Google has sufficient visit data for the venue. So, the visit data has a historical perspective, it's an aggregated value collected over a certain time.

- **Popular times graph**: This graph shows how busy a location typically is during different times of the day. Popular times are based on average popularity over the last few months. Popularity for any given hour is shown relative to the typical peak popularity for the business for the week. For example, in the image below, 8 PM–9 PM on Saturday is one of the more popular times of the week for the business.

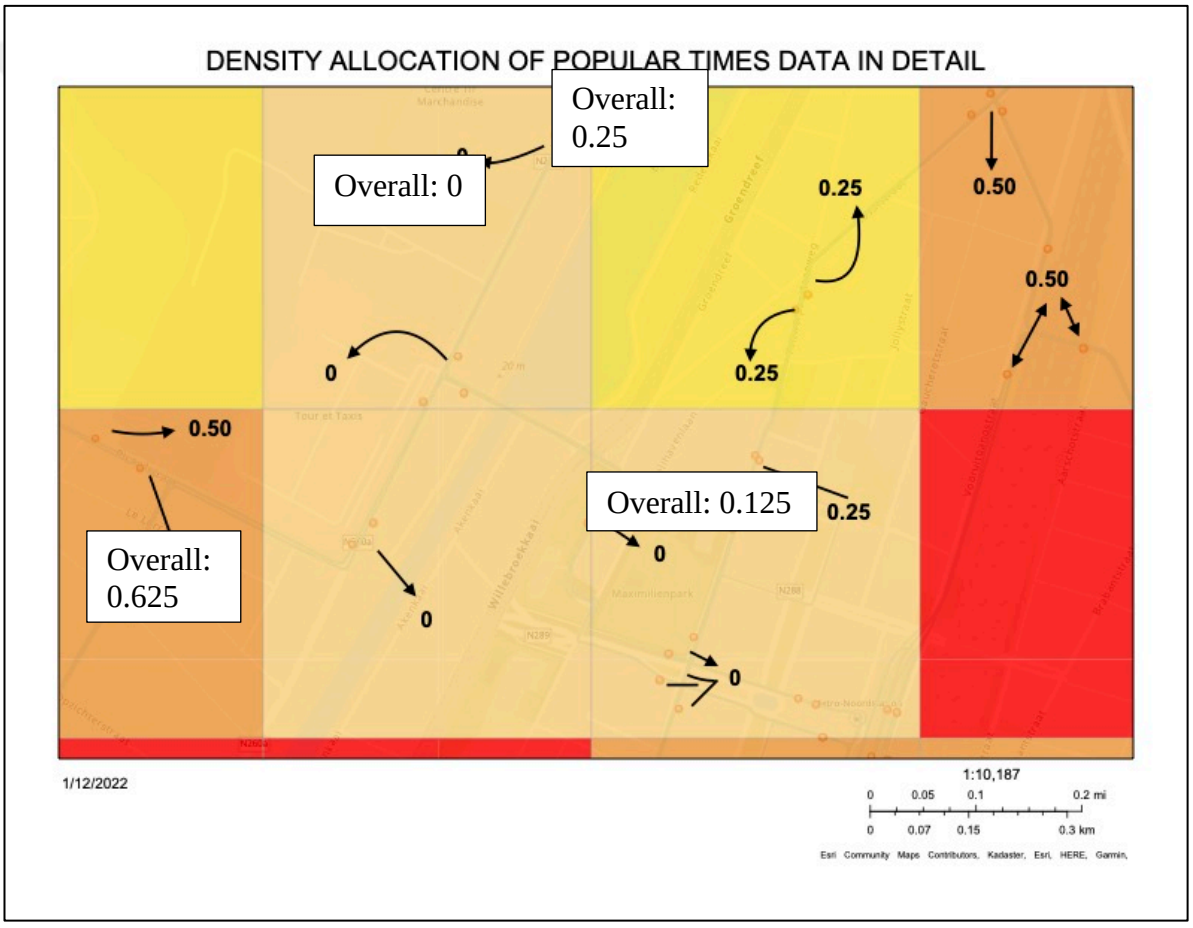

Figure 1.4. Process of Getting Mean for Each Square

- **Live visit data**: This data shows how active users' location is right now. Live visit data is updated in real-time and overlaid on the popular times' graph. For example, in the image below, the highlighted section of the graph represents how active the location is right now compared to its usual level of activity.

- **Visit duration**: This data shows how much time customers typically spend at its location. Visit duration estimates are based on patterns of customer visits over the last several weeks.
- **Wait time estimates:** This data shows how long a user would have to wait before they receive service during different times of the day. It also shows the peak wait time for each day of the week. The displayed wait time is based on patterns of customer visits over the last several weeks. Wait time estimation differs for different business types. For instance, a sit-down restaurant's wait time reflects how long customers wait before they are seated (Google Support, 2021).

With this service, Google both shares instantaneous density data and creates an incoming prediction by blending the data historically. Although this data does not have a dataset including past dates, the summary density information presented to the user is obtained from data taken at a certain time-frequency and presents the mobility trend according to the past times as well.

Table 1.1. Classification of Google Data

GET1	GET2	Index
Busy as usually gets	Very Crowded	1.00
A little busy	Crowded	0.75
Not too busy	Not too crowded	0.50
No data	Not crowded	0.25

For each public transportation stop, an index value must be assigned to each data to transfer the categorical data provided by Google to the GIS portal as numerical data. To do that an index is created in Table 2. These values will be used later in the visualization part. For this reason, 4 different numbers between 0 and 1 were assigned for 4 different categories obtained from the data.

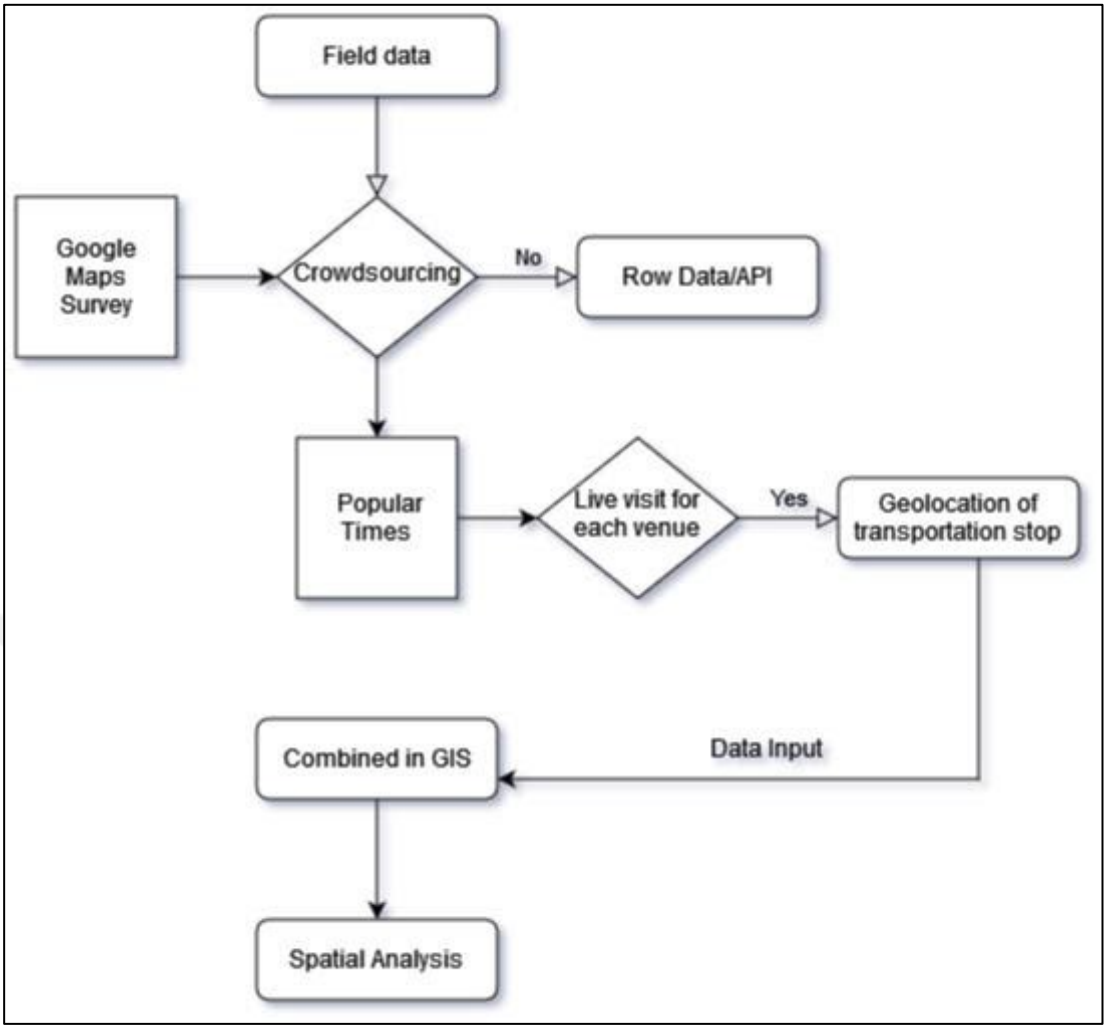

Figure 1.5. Key Steps in Data Collection and Processing

A score of 1.00 was assigned for the category “as busy as it gets”, the highest density data, and 0.75 points were found suitable for “a little busy” immediately following it. The next category “not too busy” was given 0.50 points, while the last data “not busy” was given 0.25 points. With this method, the first stage has been completed to transfer the categorical data. Since it was thought that it would take a long time to enter each data one by one for more than 4000 stops, this figure was reduced to 400-odd numbers in ArcGIS application using the point to a square method, and the same method was followed for each stop.

After getting written values for each transport stop, the data converted to numerical thanks to our indexing in the table 1.4. A mean of index was taken for each square that has more than one stop. When the embedding index score is ended, the symbology of the data is converted to the from simple to gradual increase. The da ais also classified

and each class received a color. From that moment the data was ready to making compares with other types of data.

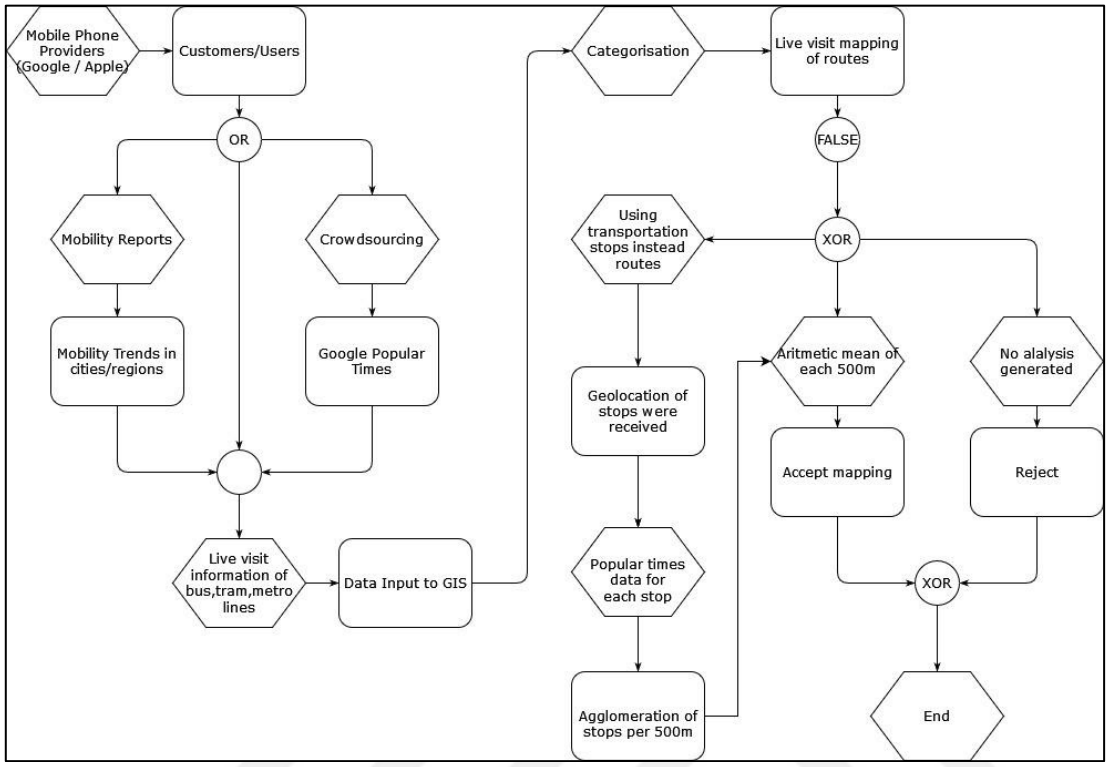

Figure 1.6. Data Collection and Analyzing Tools Methods

1.3.2. STIB and social data collection

Within the scope of this study, other sources that may help while making spatial analyzes were also used. These resources consist of mobility reports provided by mobile phone providers and open-source resources created by public institutions in Brussels to be able to correlate together. Quantitative methods were used while making these analyzes and comparisons which are explained in detail in the data & analysis chapter.

Brussels Intercommunal Transport Company (STIB) which operates thousands of transportation lines everyday has made some basic mobility data available within the open-data policy on their platform. However, the data in their systems is not far away from geo-locations of stops or bus lines. The data that we need is the dissertation is something specifically prepared by the author using google data that has neither an API nor editable. In order to get editable API data a meeting was arranged with STIB in Brussels. A few questions were directed to the official personnel of the institutions.

The officer addressed a solution without an API or a dataset but a written explanation of the public transportation trends in Brussels during COVID-19 times. The short description of the main public transportation trends during restrictions and in the time of easing the restrictions is provided with some statistics which will be presented in the findings chapter.

On the other hand, the data that explains socio-economic status were collected from web portals of public authorities through opendata.brussels, statbel.be and wijkmonitoring.brussel. In addition, vectoral data acquired from the relevant public authorities, some recorded meetings were held with individuals who live in a place with higher numbers of non-Belgium and non-EU country citizens in one of our control neighborhoods where is Sint-Joost-ten-Node.

Couple of questions were directed to 4 people living in the neighborhood and the length of the interviews ranged from 10 to 60 minutes. The question was about the social and economic infrastructure of migrant communities asking how they feel today since their relocation from their home countries, do they feel secure with COVID-19 restrictions, how their daily routine and jobs affected by governmental calls to stay home, do they get daily trips to the other parts of the city for any reason?

The first person was a 52-year-old local shop owner in the neighborhood. I met with the person in a coffee shop (called *kahvehane* in Turkish) and he responded to our questions for 60 minutes. The answers were mainly about how vulnerable they are as migrants and how they received a personal and institutional level of exclusion and marginalization here in Brussels. He believed that many negative things happened to them is because of malevolent attitudes of the Belgian governments to the Turkish and Muslim population. He faced a cut off from his sales during COVID-19 restrictions, closed his store for an uncertain period and received support from the government. He mentioned he can make a livelihood with governmental support for now but hopes to re-create his business in a medium term. Second person was a 25-year-old young individual working in a grocery store. His job is suspended for an uncertain time, and he has got a new one in another local store owned by his uncle. He is making daily trips from work to home, and he does not really like to travel to other parts of Belgium. He believes that the best place to be is his homeland where his parents came from, so

he is considering each seasonal holiday by going to his village in Turkey. He doesn't believe that he got a cut off income or reductions, he is satisfied with his job and expects to get back to the old one before COVID-19. The third and fourth persons have has relatively similar answers, both complaining about life and taxes during almost all meeting. They all agreed that there was not any migration from their homeland for at least 20 years because of restrictive policies of the Belgian government. The only people who migrated recently are the ones who got married with who a person already living in Brussels or a Belgian citizen.

To start the work, the demographic, social-cultural, and administrative data in Brussels were researched and these data were obtained from the relevant public authorities such as mobility.brussels, or wijkmonitoring provided by Brussels city. While this study required research work for socio-economic data provided by open sources, some collaborations were provided with local communities and a local professor of architecture who created a wealth of studies about mobility issues and data analysis in Belgium / Brussels. The meetings were categorized under two aspects, community meetings and technical meetings with scientists. It investigated how migrant communities feel about difficulties about COVID-19 times related with social and economic integration issues in the neighborhoods that the study would like to have a closer look at. To make a broader brainstorm about social dimensions the researcher arranged several meetings with a local professor to discuss the social change in Brussels in recent times and spatial organization developed around masses of migrations and demographic change.

Data that the study wants to use for each transportation stop has already been collected by Google maps by asking Maps users to fill a survey after their trip that they searched in the application. The data provided by popular times about busy times of a venue are easily accessible via the google maps app to its customers and it aims to make a kind of warning to users who have concerns about social distance issues during COVID-19 times in each mode of transportation. After transferring the density data of all the stops one by one to the data of the stops transferred into the GIS platform, it will be understood more clearly how the density in the city is distributed and which region is more active during the pandemic. Finally, the points of stop data can be converted to area data on a neighborhood basis. Income status, language spoken or other

demographic data that is already spatial will be overlapped with the mobility data from new data acquired on GIS via popular times.

Public transportation in Brussels is well-developed in time. Almost every settlement around Brussels is accessible by the means of public transport such as buses, tram, metro (De Vos and Witlox, 2013). Therefore, it means even the districts in the rural parts of the city accessible by bus and contains a well-developed bus network infrastructure. That's why the terms used in this work such as not sufficient or lack of infrastructure may be a very developed network in another place and different region. The work intends to make comparisons between the cities in Belgium or Europe, so almost every region mentioned is a very developed region of the world. The social and economic indicators are much higher than any places around the world, Belgium ranked 21st place in the list of GDPS per person which is much higher than most of the countries and populations among almost 200 countries.

2. LITRERATURE REVIEW

The chapter of literature review focuses on the mobility trends in COVID-19 times, how important to use new technologies in urban mobility, tracking public transportation movements by using signals from mobile phones and finally the concept of popular times and mobile crowdsourcing as a method to collect mobility data.

2.1. Mobility Trends During COVID-19 Pandemic

As the pandemic started the governments called the people to stay home to prevent more casualties that created strong restrictions on social and economic life. The impact of the restrictions has happened almost on every sector that we have in the cities. Public transportation had faced one biggest impacts of the pandemic by governments since they tried to implement restrictions on human mobility. The main reason for this was not only the number of cases but the extent of the spread of the virus that led governments to call people to stay home and not to go out until a second order.

The call led to people suddenly stopping going to their work and school and dramatically caused a bottom point in terms of any kind of transportation. Wielechowski et al. (2020) state that the usage of public transport in Poland dramatically decreased after the declaration of government in favor of strict restrictions which lead to fear among people to take distancing rules very seriously.

The most impacted means of transportation was seen as air traffic and public transportation in the city. The reason might be that each kind of transport requires a physical existence in the same space for long times which may result in hazardous situations if we consider the spread time COVID-19 and 15 minutes.

Gutiérrez et al. (2020) drew a research prospect for the future in the very first times of the global COVID-19 pandemic. In this study, conjectural problems are listed as the possible rise of private vehicles and the decline of using public transport due to fear of using public spaces and the inequalities that COVID-19 created in the low-income level neighborhoods in terms of establishing distancing rules in these neighborhoods

which are relatively denser than any other place with higher income levels. Finally, it emphasizes the importance of using information technologies, big data and GIS as the method to process complex inputs coming from masses of people and places.

Jenelius and Cebecauer (2020) examine the impact of COVID-19 on public transportation by looking at data based on different modes, tickets sales, ticket validation and passenger counting data during mobility recommendations. The study supports the existence of a huge decline in public transport and dramatic change in travel behaviors of people living in Sweden in terms of modes.

The dramatic rise of COVID-19 cases follows a decrease after a couple of months with the help of the strict restrictions of the governments to prevent deaths. Restrictions have created some breaking points with peak times and bottoms. According to mobility records provided by mobile phone providers and operators such as Google and Apple, the first months of the restrictions have faced the most dramatic change in comparison with other months of the year.

Following the 'stay at home' calls by the government, the immobility of the people made the number of cases decrease and the governments opened social life to a certain level to prevent its bigger impact on the economy.

One another call by governments was the call to mobile phone providers to open their data to public, private and academic sectors to develop research works. Google and Apple paid attention to receiving these calls and published public mobility reports. A set of updated report series called mobility trends by Google has created a comprehensive tool for academic use to understand mobility trends during the pandemic.

As soon as the reports prevailed many researchers showed interest in them, and many works were published based on Google's data. In most of the works, Google data has been seen as a confident data source and a source to be examined in many more ways.

According to Google mobility reports, the first months of the pandemic were the worst in terms of the number of travelers in the city. In the first ease period after the first strong restrictions, we see a comparative change in the total number of users. The study

of Lee, Qian and Schwanen argues that monitoring mobility of people under lockdown processes creates a wealth of sufficient resources to understand the impact of everyday life on different socio-economic status of people by using mobile data and a variable set of statistical models. They prove how important it is to use this kind of data to prevent such an impact again for the coming lockdowns in case of another disaster happening in the future (Lee and Schwanen, 2021.)

Although many people had to stay home again, it seems like there is an increase in the number of people who must travel and a rise in transport demand which makes us think about the difference between the two periods. According to an article by Beck, Hensher, Wei, working from home is getting encouragement from public institutions and people who change its daily working behaviors in this way tend to continue even after the pandemic.

Working from home (WfH) will be a key aspect for the organization of public transport and urban mobility as it has positive impacts on working efficiency and timing, but the study addresses that WfH is only concentrated in the urban areas and households with higher incomes (Beck et al., 2020.)

The Covid-19 and travel restrictions have created different impacts as well on various social and economic groups. There are many ways to examine these impacts in a city like Brussels which includes groups of concentrated groups of migrated background people. In the sense of following similar impacts on people who have similar background and socio-economic status, the concentration of some groups of people may create an opportunity to follow up travel trends in a specific area by using the method of using mobility data. Borkowski et al. (2020) addresses that the impact of the pandemic is perceived separately among different social identities based on gender, income level or educational level in their study that happened in Poland.

Bonaccorsia et al. (2020) made remarkable discussions for the conclusion of different capabilities of municipalities and their resilience against pandemic. It supports the positive correlation between the income level of people and mobility data which explain how mobility is higher than other municipalities in lower income cities. The article supports the impact of socio-economic status on the daily mobility of the people living in Canadian cities during COVID-19 pandemic.

Another work is based on three aspects related with the limits of the space: indoor home, outdoor home, and everyday activities by Fatmi (2020). According to the results of the survey, people who receive lower income have greater mobility in the city and middle-income people have the most leisure time at home. Although mobility decreases up to %50 percent in general in the city, the sectors of health, education, law, community, government, and sales and services seem to have an increase in their mobility against the mobility trends in general.

Coven and Gupta expressed the question of how different social groups are affected by the covid-19 pandemic specifically in terms of urban and national mobility trends. There are 3 outputs from the date mobile GPS they used; first the higher income people living in New York left the city since the pandemic started. Second, the neighborhoods that hispanic and black people live in which are also known as lower income neighborhoods are the ones who have mobility data during restrictions, not only daytime but also at night. It shows that these neighborhoods have no opportunities to leave the city and have to workday and night (Coven and Gupta, 2020.)

Finally, one another study on Turkish migrants who live in the North of Italy provides that this group of people suffers lack of information in terms of disasters which creates remarkable vulnerability in this community during a disaster. This means disasters create greater pressure and impact on those who are less lucky in terms of economic and social capital and less informed (Atun and Fonio, 2021).

So, within all these studies the first question was how covid-19 impacted the travel behaviors of different social-economic people in Brussels? Secondly, if the pandemic happens again what kind of lessons or differences can we create?

To explain the effect of disparities between social groups during the COVID-19 pandemic in the Brussels metropolitan area with mobility data, some questions have been particularly produced for the Brussels case. While the governments called citizens to stay at home during the COVID-19 pandemic, was public transport mobility higher in lower income neighborhoods than middle-upper income groups in Brussels? Does the lack of integration that had occurred over many years and isolation of some groups that arrived in Brussels later affected the conditions of vulnerable communities in Brussels during COVID-19 pandemic?

2.2. Using Mobile Phone Data for Tracking the Mobility Trends

We need some capabilities that allow us to investigate the urban phenomena mentioned above through public transport, vehicle, or pedestrian mobility. Today, people's close relationship with mobile devices and the internet is progressing even more, which further increases our capabilities in terms of research techniques.

Every new technology is based on the relationship between human and device or between device and device or is dependent for some reason. This relationship can also be between a human and a mobile device, or it can work between the device and a used transportation.

Moreover, after the smartphone usage figures reached the highest levels today, technological trends have focused on the artificial technology of devices and increasing communication between devices. Every device that persons carry on them creates the opportunity for researchers to conduct deeper and more accurate research on certain phenomena. This situation is also seen because of the use of every data generated because of communication between devices by researchers, governments or technology providers for the purpose of providing better transportation systems.

It is obvious that statistical methods and flexible models such as machine learning create clearer and more understandable crimes in terms of applications such as short-term traffic forecasting (Vlahogianni et al., 2005) and passenger tracking models (Papathanasopoulou and Antoniou, 2015). Of course, one of the most important factors in urban transportation is the basic features of mobility.

Many factors may influence a person's mobility choices, and this is ultimately strongly dependent on his or her psychological state. However, after this selection process is settled, the activity of a person for a long time may begin to become ordinary and routine. This situation causes the person to take the same road for the same purposes over and over. Travel behavior exhibits some level of regularity, which describes the extent to which individual spatiotemporal choices repeat over time. According to activity-based travel theory, travel behavior is dictated by preferences, constraints, and needs which recur over time, at least to some degree (Kitamura and Hoorn, 1987).

Getting mobile data from individual's smart phone as a living and moving sensor requires a processing of big data and then it provides a great potential for understand current state of spatiotemporal behaviors of persons (Zhao et all, 2020).

> The spatiotemporal aspects of our lives can be segmented into episodes of travel and activity participation. A travel episode, or trip, is defined as "the travel required from an origin location to access a destination for the purpose of performing some activity" (McNally, 2007), and an activity episode refers to a discrete activity participation (time allocated to activities) at a location (Bhat and Koppelman, 1999) (Zhao et all, 2020).

Based on these explanations of Bath and Koppelman (1999), we deduce that every human action is an episode of the day. Both trips and activity episodes are basic components of spatiotemporal behavior, characterized by several attributes chosen by individuals. Activities have long been recognized as the fundamental driver for travel demand; trips are usually derived from the need to participate in a certain activity at a certain time and location (Zhao et all, 2020).

When millions of episodes in motion by many different people come together in cities, they lead to the formation of a pattern. While it is sometimes useful for some studies to monitor and research individual movement, pattern analysis can be more explanatory.

In everyday urban mobility, millions of people move from one place to another for different or similar reasons becomes vital data for those who do research and develop policies in the field of infrastructure and transportation planning. Examining such movements will lead to more consistent, comfortable, and more affordable transportation investments to be made between the two locations. A travel/activity pattern describes the structure of travel/activity instances over a period; each pattern corresponds to a set of preferences and constraints that dictate the specific choices.

Although stable in the short term, these patterns are also subject to change over months or years, contributing to the long-term behavioral dynamics. Individual travel-activity patterns may change when people move, change jobs, shift work schedules, purchase a new car/bike, or any other life event (e.g., a child starts school) that may alter their travel and activity routines. In the long term, a dynamic travel/activity pattern refers to travel/activity patterns that change over time (Zhao et all, 2020).

Therefore, large, or small events that occur in cities by humans or nature may cause the transportation pattern to change over time. An example of this is the implementation of more ecological transportation decisions, which are promised to be implemented because of the success of the greens in a mayoral election.

However, the temporary but collective restriction created by the COVID-19 pandemic in transportation is already at the beginning of the events that occurred in the 21st century and that most affected transportation movements.

Today, 2 years after the first pandemic announcement, people's perception of public spaces in general, and therefore public transportation, has changed seriously during the reopening process these days, when we are officially and de facto in a pandemic.

In other words, several events that occur in the long or short term not only change the behavior of the person, but also affect the emergence of different transportation habits over time. The reading of these changes by decision makers, especially local governments, will help cities to become more durable in terms of transportation in the future.

2.3. New Technologies and Methods in Urban Mobility

According to Statista, 6.378 billion people are currently using smartphones which makes 80.69% of the world’s population operate everyday life with a smartphone (bankmycell.com, 2022). Since smartphones placed every person's pocket after the 2010s, the data collected by mobile phone providers and applications have become more important for many sectors currently operating goods and services.

Given the widespread availability of smartphones and ubiquitous connectivity, users are now planning their transportation activities through smartphone apps which enable them to reach various services easily. They also receive real-time information regarding their trip as advanced sensors are widely available. Therefore, they can reconsider their choices based on the latest updates (Antoniou C., Efthymiou D., Chaniotakis E., Atasoy B., et all, 2020).

One of the biggest mobile applications and mapping providers Google has recently revealed google popular times as the best example for collecting information on public

transportation and providing real time travel data with passengers. As many companies started to collect data and information about aspects of everyday life such as daily mobility of a person, the data related to individuals has become even more important recently. The reason for this is that when the data of each person living in urban space come together with other people it is called now as big data and consists of a not-limited resource for research and policy making strategies.

Therefore, it is an ethical discussion in many countries such as the USA to use big data for public services or manipulation of public services with using big data provided by global or regional technological companies.

Many location-based data providers and regulator companies have now been suspected by public authorities as to the result of questions of public opinion in developed countries. Beyond these discussions, mobility data provided by providers has the potential to make even more impact on decisions on public transportation and any change on travel habits of people making everyday mobility.

Smart Mobility is broadly defined as the family of mobility solutions that use appropriate technologies and methodologies and that may leverage the availability of big data for the sustainability of transportation systems (Benevolo et al., 2016).

Since the COVID-19 pandemic has started the discussions around smart mobility become more important. COVID-19 introduced some standards to people while using public spaces and public transportation to prevent the spread of viruses. One of the first requirements is practicing 2m of distance from other people at a certain level. So, are the transportation infrastructures in many countries capable of implementing that?

For many scientists, it is a faraway target in public transportation to provide safe mobility with enough areas for everyone using public transportation. The problem is the lack of free space in the vehicles during mobility. That’s why in many countries, governments have not only called people to stay away from themselves and gatherings but also, they urged people to stay away from public transportation as much as they can and not to use if it is not obligatory.

On the other hand, discussions and solutions around smart mobility are well established to be perceived as a guidance for smarter, safer, and healthier use of any means of public transportation.

Smart Mobility is acclaimed to bring about benefits including gains in safety, reduction in individual travel costs due to increased efficiency of operation, greater consumer choice, and more sustainable travel (Docherty et al., 2018).

To make public transportation more reliable and safer, governments called mobile phone users and technological companies to develop smart mobility applications and publish their databases for good use of these data for smart mobility and other systems. So, what kind of mobility data would fit the needs of customers to reach a safer and healthier mobility experience? In which directions can these data be used?

There are three key aspects of a smart mobility structured according to data processing which are prediction, optimization, and personalization. Prediction stands for the getting real time data from the field and processing it for the future use of application such as traffic congestion. Second is the optimization corresponding to the efficiency taking from data acquired in terms of time efficiency, being cost friendly, reliable, minimizing distances or networks to a venue application. Finally, personalization defines a space for everyone to extract their preferences, store and share them to other users (Antoniou et all, 2020).

Google and Apple have recently started to reveal mobility trends in their reports since the COVID-19 pandemic started. The reports are being seen as a key input to understand future predictions of mobility trends in any case of another restriction period by governments or any future crisis. These reports are categorized based on date in a simple way and any given date between January 2020 and present has a number that represents a busyness or usage rate on that date.

There are many other providers that provide traffic congestion data or smart traffic solutions such as TomTom which is one of the biggest in the sector. What they offer is simply a prediction of the traffic and mobility services on a predicted date in the future. There are many applications for optimization as well which Google popular times provides a good example.

In the first phase of the popular times maybe it would be better to place the first data collection part. The data in this application is quite different from other providers which is simply a survey offered to transportation users. Google maps already provides the best routes for any given directions on their system.

The application is now collecting user opinions based on their travel experience. In every trip a person makes a survey after it to rate the crowd during travel. The survey filled by thousands of users in different times on each day of week, provides to other user busy times data which could make some difference on possible routes of a person when it is considered with COVID-19 and safety issues related with that.

It is obvious that some issues had impacted the trust on public transportation in the past such as global terrorism or violations of personality in the temporary places of the means of transportation and COVID-19 pandemic may be one of the biggest health crises that humanity faced in the 21.th century. So, it is not predictable that the trust on public transportation has reached its weakest level for a long time and some measurement needs to be applied to protect the sector.

Another important development in the smart mobility sector is personalization. The travel habits are likely to be in a continuous movement. The mobility start for a job or education might be extended all year a movement between the same places and dates. The personalization of mobility might help a person to find quicker and better services in time.

Personalization happens with collecting information of places such as home or work, collecting data of possible routes or advising some other places you may like near your destination or the place you want to spend some time., the process is not something a person really needs but it is something to create a more personal experience which makes greater pleasure during mobility.

2.3.1. Google Popular Times and mobile crowdsourcing

Google popular times is an application that hosts data from various sources based on crowdsourcing methods from their smart phones, it gives an information on when a place is busy, how much a user need to wait for service, average visit duration by tracking smartphone user’s geo-locations as real time data. It creates a great potential

to predict transportation estimation, demand, optimize it (Timokhin and Antoniou, 2020).

Google popular times offers two kinds of location data based on the rates of the customers. The first one is for the venues and the second one is for modes of transportation. For example, a bus stop has a crowd rate based on crowdsensing applications of popular times in recent times. This is a temporary space that is a simple point. One other data is for a bus line which doesn't refer to a point but refers to a line that passes over many points. So, each point has a crowd rate as well as the bus line has also a rate for crowd situations. Each transportation stops and line has live crowd data at the moment on Google popular times.

The data for the venues includes average number of visitors Number of pictures, price segment, average rating, number of reviews and the data of the transportation point and lines includes the number of visitors on almost every hour of the day and night during weekdays and weekends. With actual behavioral data collected from aggregated and anonymized data from the Google Location History (Google, 2021)

> Google Popular Times offers the potential for both deeper and broader insights to those who are seeking to understand, analyze, anticipate or predict consumer and tourist behavior (Timokhin and Antoniou, 2020).

This data is recently being used with other sources in academic research about urban mobility and it is seen as a reliable source so far for many scientists. In addition, Google replied with mobility trend reports during COVID-19 times to the calls of governments to make the data they have available public. There is a platform called data studio by google to provide all the mobility trends of each month since pandemic started for almost every country or region. It's already part of many scientific works focused on urban mobility, public transportation, and alternative modes of transportation during COVID-19 times.

Mobile applications have the advantage of being in the pockets of many people at the same time. The wide use of smartphones makes easier and wider data using these data methods based on mobile phones (See, 2016). There are many academic works about social-metrics of social distancing as well during COVID-19 times and they are based on mobile data coming from mobile phone providers.

> Mobile Crowdsensing (MCS) refers to the wide variety of sensing models by which individuals collectively share data and extract information to measure and map phenomena of common interest (Ganti et al. 2011). Recently, various kinds of applications have been developed to realize the potential of MCS throughout daily life, such as environmental quality monitoring, noise pollution assessment (Maisonneuve et al. 2009; Rana et al. 2010), and traffic monitoring (Zhang et al. 2014) (Liu J., Shen H., Husnu S. Narman, Wingyan Chung, and Zongfang Lin. 2018).

In the times of higher impact of climate change, the rising numbers and impacts of disasters makes everyone think about smarter policies and technologies about prevention of loss of nature and lives. Mobile crowd sensing is most likely to be seen as part of many projects aimed at preventing disasters, transportation issues and so on. But there some problems arise around acquiring data coming from tech companies and using them for the studies. The data provided by mobile phone operators is generally big data and it does not always make sense to tackle a bunch of a lot of data and excel sheets.

To make it sufficient, there are some other startups specialized on processing big data for academia and some other institutions. Google makes crowdsourcing happen by asking a few questions to Google Map users about comfort, security and crowd situation of the transportation vehicle or stops. Every time a passenger asks for a routing or a destination, the system sends a survey after detecting the trip is over. As we consider the Google maps users create a profile, comment on a venue, and establish their contribution page then it may go into the definition of the social media as well. Social media, crowd sensing and collaborative maps as the current methods for Geographical Crowdsourcing Information have crucial importance in terms of disaster risk management by raising awareness and solving some challenges (Albuquerque et al., 2016).

Social media companies and navigation services with social media characteristics such as Google maps might make huge contributions to the research by collecting user's data from in the field of risk management before, during and after a crisis.

Most of the time, creating big datasets about customer's behaviors is a process with long times and higher cost than other operations. Companies or institutions may need to design big operations with a lot of personnel to collect the data and prepare them

for good use. However voluntary crowdsensing applications offer companies the opportunity to create datasets with very low costs, which they can create with great expense and high labor force, and lead to the prevention of vital problems in disaster situations (Goodchild and Glennon, 2010). While thinking about digitalization of industrial processes and the use of big data for good use crowdsensing can be of great help in the community building stages and can play a leading role in the participation of citizens in the system (See et al., 2016).

3. SOCIO-ECONOMIC PATTERN IN BRUSSELS

Brussels and Belgium have a structured and wide range of open data that a social scientist or policymaker would like to review year by year. The data provided by public institutions as open data is the main source in this study to better understand the social pattern in Brussels and around. One of the main sources is the platform of Wijkmonitoring that includes most of the socio-economic data year by year (Wijkmonitoring, 2021).

There are many academic outputs analyzing the social pattern of Brussels, and economic organizations based on the open-source data such as Wijkmonitoring and other public authorities. In this chapter, Brussels' social and economic structure is presented based on the open-data sources. The data explaining socio-economic status of the different neighborhoods will show how social pattern impacted the everyday mobility in a date in the middle of the COVID-19 pandemic. The social, demographical and economic indicators used in this chapter are the income level of people, age groups, education level, tax return per neighborhood, household and family numbers, migration, unemployment.

3.1. Social Structure and Spatial Organization in Brussels

Brussels is one of Belgium's oldest and major cities in history, always occupying significant importance to its region and country. The suburbanization movement that emerged after the World War II left its mark on the Belgian cities and, therefore, on Brussels' urban development. Suburbanization in 1960s enabled many wealthy families living in the city to move to the outskirts of the region, and the number of people who migrated into the city was less than the number of those who left the city. The trend of depopulation of the city center ended in around 1995 and the process of deindustrialization of Brussels Capital Region continues which has started in the early 1960s (Vandermotten, 2009). Increasing international migration and biological increase due to the young groups staying in the city led to an increase in the urban population following 1995. With the young population always present in the city and

the elderly population moving away, the death rates decreased considerably in the 90s. On the other hand, when the birth rates were higher than ever and combined with the migration movements to the city, the situation resulted in substantial population growth (Deboorsere et al., 2009). This study examines the data acquired from Wijkmonitoring, one of the open data public sites where social data can be categorized and followed well.

However, before starting to analyze socio-economic data stored in Wijkmonitoring infrastructure, it is useful to have a look at the institution's glossary to make it clear some definitions that we use in the context of the social-economic pattern.

As it shown in the figure 3.1., the term of the first crown refers to the neighborhoods between the avenues of the inner ring and the central ring, formed by Avenue Churchill (in the south), the military avenues (in the east: General Jacques, General Meiser, Brand Whitlock, August Reyers, General Wahis) and the railway lines (to the west). From a municipal point of view, they are usually associated with Anderlecht, Etterbeek, Ixelles, Koekelberg, Molenbeek-Saint-Jean, Schaerbeek, Saint-Gilles and Saint-Josse-ten-Node. Due to its spatial size, Brussels City is considered separately.

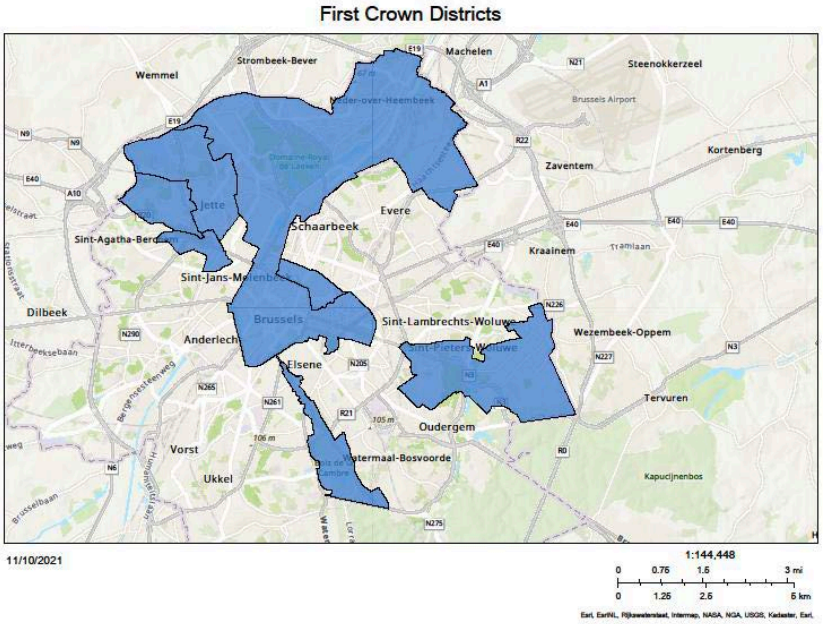

Figure 3.1. First Crown Districts in the Brussels Metropolitan Region

In figure 3.2., the second crown corresponds to the following areas: Anderlecht and Molenbeek beyond the station West, Auderghem, Sint-Agatha-Berchem, Laken Noord, Neder-Over-Heembeek and Haren, Evere, Ganshoren, Ixelles beyond the General Avenue Jacques, Jette-North, Schaerbeek past Avenue Lambermont, Uccle, Watermael-Boitsfort, Woluwe-Saint-Lambert and Woluwe-Saint-Pierre on the other side.

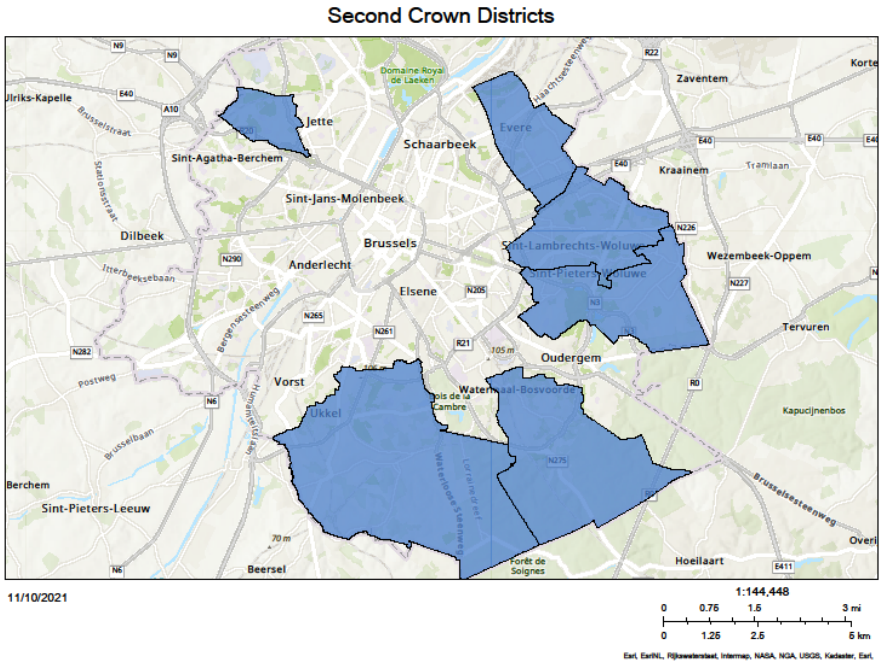

Figure 3.2. Second Crown Districts in Brussels Metropolitan Region

Figure 3.3 shows the Pentagon is the term that defines the zone of Brussels located within the avenues of the inner ring road. It is the city that was originally protected by the city walls. The name of this zone comes from the shape that follows the route of the old city walls.

This region is the very central of the city and the one with many administrative buildings, wide boulevards, and shopping places as it has touristic potential. Pentagon includes the residential and the working office of the King and many consulates. It is an attraction point to many tourist every year with protected architecture of the buildings and the aggregation of the services such as restaurants or fashion shops.

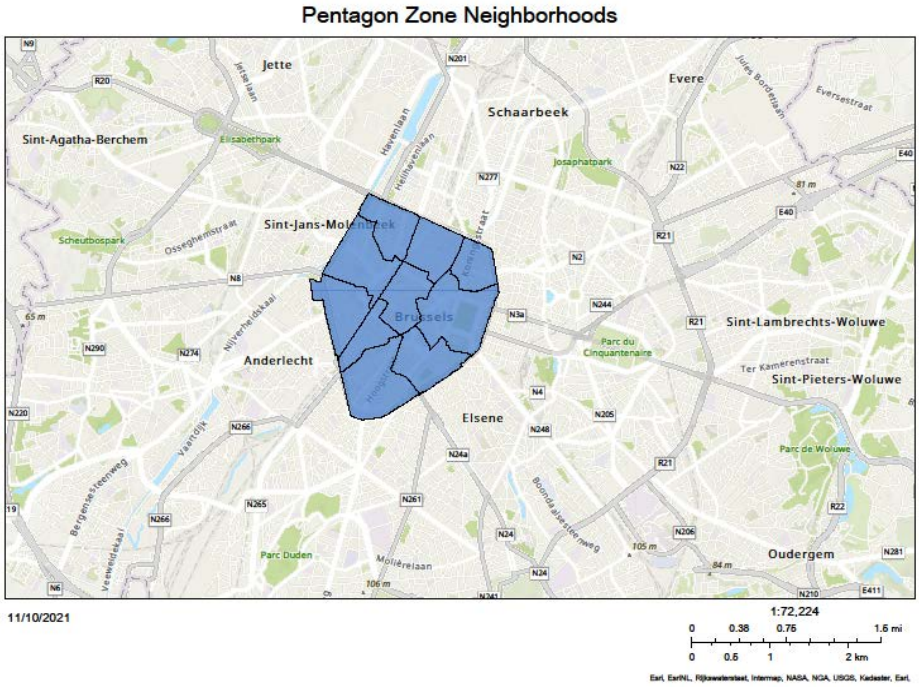

Figure 3.3. Pentagon Zone Neighborhoods in Brussels Metropolitan Region

In the figure 3.4., poor crescent defines the area where the economically weaker population groups have lived for several decades. It includes the districts in the first crown North and West that are among the poorest in the Brussels Region and form a crescent around the city center. The neighborhoods of this area are:

- within the Pentagon, the west of the North-South junction and the Marolles;
- the east of Anderlecht and MolenbeekSaint-Jean (between the railway and the canal);
- to the north, the municipality of Saint-Josse, to the west of Schaerbeek and the industrial areas along the canal.
- in the south, the low parts of Saint-Gilles and Vorst.

In the remaining of this section, an assessment of the different socio-economic and demographic groups living in the neighborhoods will be made.

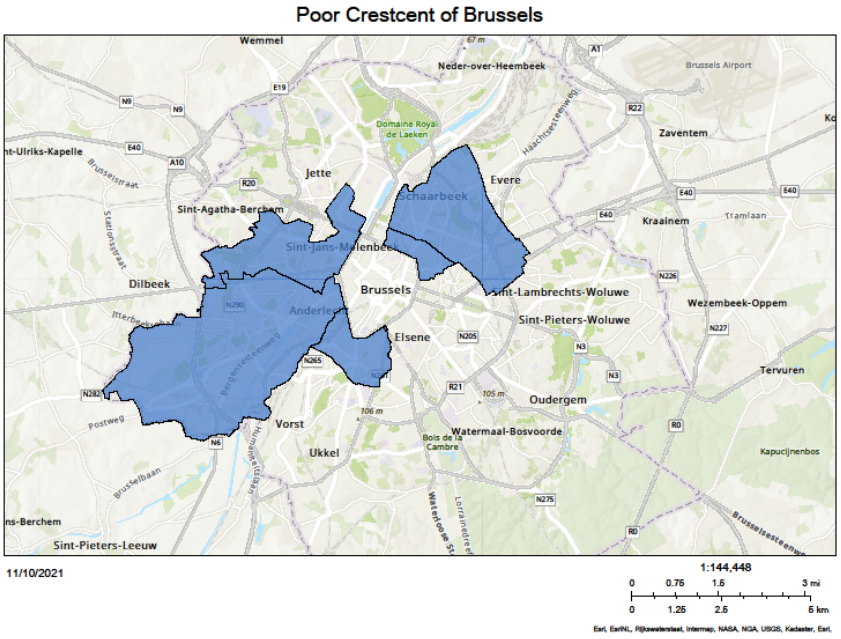

Figure 3.4. Poor Crescent Neighborhoods in Brussels Metropolitan Region

3.2. Selected Social and Economic Analysis

First, I start analyzing the demographics in children age in the figure 3.5 because of couple of reasons. The first reason the number of children that needs to movement every day for educational purposes makes their parent mobile as well and occupy a significant part of everyday mobility in the city center (Macharis et al. 2021). Children aged 3 to 5 are the first age group for whom school plays a role. Education is not yet weaselly for them, but many of them are already going to kindergarten. The spatial distribution of this age group is of course related to the choice of place of residence of the parents.

Nevertheless, children in this age group have their own needs, such as reception structures and relaxation areas (park, playground, ...). Educational purposes and mobility for entertainment or playing time are one of the main reasons for the young adults who has a small child in this age. The significance part of the residential mobility can be defined as the everyday mobility for the needs of children in education age (Crowley, 2003).

The distribution of the total number of children aged 0- to 17-year-olds according to the neighborhoods can give an impression about which neighborhood the families with children live in. This study acknowledges the importance of the share of educational mobility inside the residential mobility.

In the context of basic mobility needs of children, the neighborhoods with more children may be seen as the most demanded places for the public transportation and daily mobility for the educational purposes. In this sense the neighborhoods with higher children's rates might show a more residential mobility rates during normal times before pandemic. The higher shares of children may tend to higher declines in public transportation during the governmental calls for lockdown due to the online education and stay home calls.

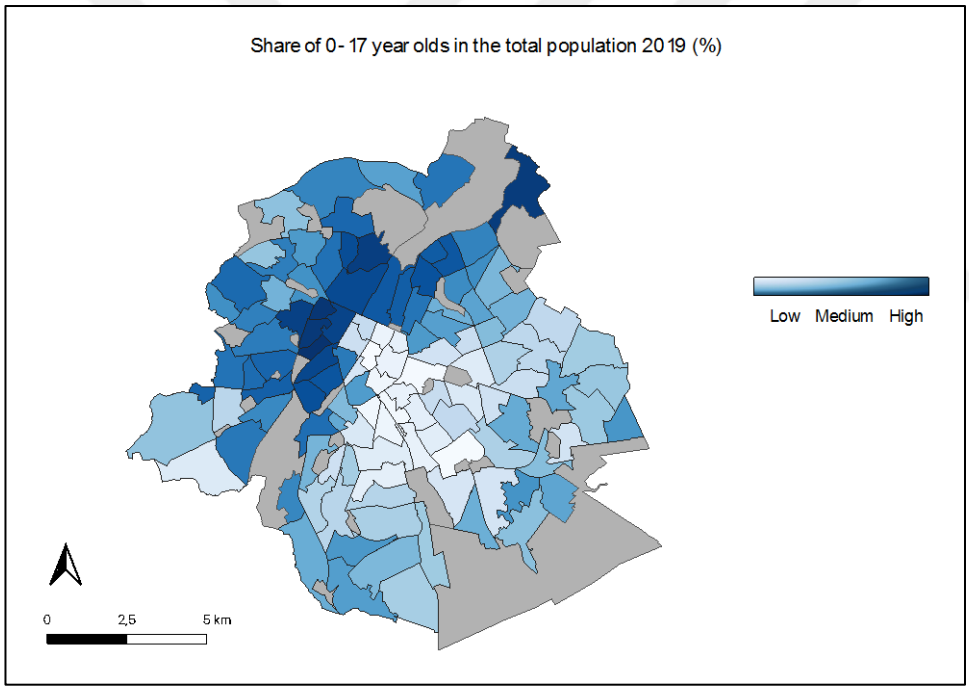

Figure 3.5. Share of 0–17-year-olds in the total population, 2019 (%)

As it can deduced from the figure 3.5 the number of children age of 0-17 years old is relatively higher in the many neighborhoods in first crown defined in the beginning of the chapter. The first crown is a region that includes neighborhoods with higher rates of citizens from non-EU countries and lower rates of economic indicators such as income tax return and employment. In this context the mobility in the neighborhoods

with higher children may take more residential mobility trends relating to educational purposes after re-opening of the schools during COVID-19 pandemic.

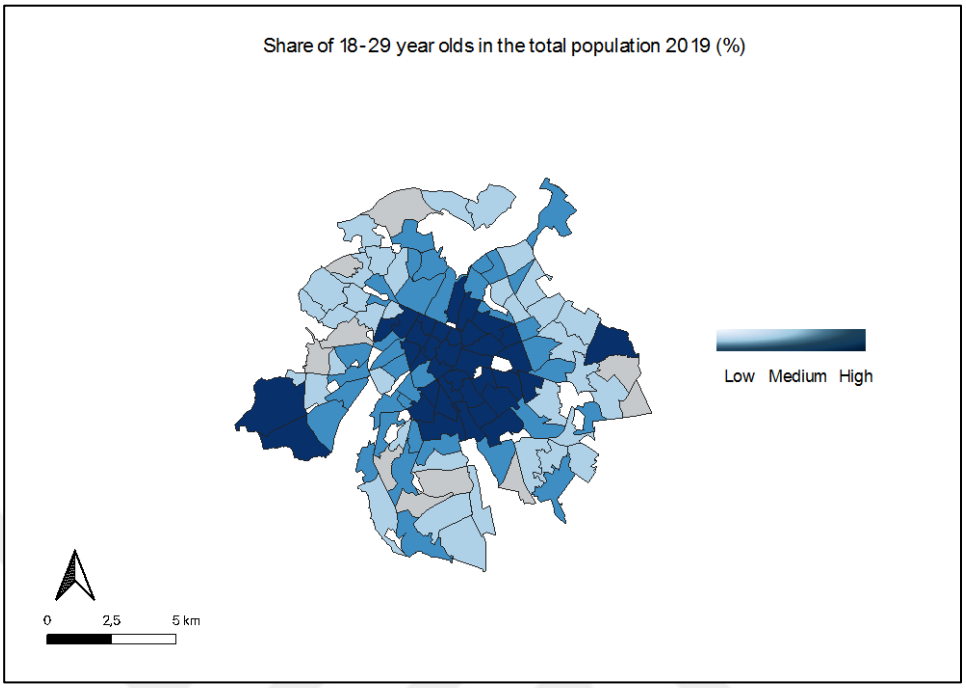

Figure 3.6. Share of 18–29-year-olds in the total population, 2019 (%)

As it is indicated in the figure 3.6, the 18-29 age group can be described as the city dwellers par excellence. It mainly consists of young people in their emancipation phase or, in other words, young people who leave the parental home in search of independence. The city is a place for better jobs and smoother for a higher education, a place where they find a wide variety of rental housing and more opportunities for relaxation and active social life.

However, it is necessary to point out an important limitation in the data used. Young people who come from outside Brussels and follow a higher education there often live in a "kot" (student room) while their legal domicile remains at their parents' address. In 2019, young adults aged 18-29 are mostly overrepresented in the central districts of Brussels, from the Pentagon to the east of the first crown (the neighborhoods near the European district, and the neighborhoods between the Pentagon and the University district). Their relatively large weight in these neighborhoods is explained, among other things, by the high number of rental homes, the proximity to the city center, and higher education institutions.

Conversely, young adults are underrepresented in the outer districts of the region, partly because the housing there is less suited to their needs and their financial possibilities and because of the greater distance from the city center and the various more centrally located university/college districts.

An exception to this is the Kapelleveld district, which also has many higher education institutions on its territory. This is also the origin of the high proportion of 18–29-year-olds that this district has among its population, despite its location on the periphery of the region. According to the studies, polarization is not only limited to Brussels but has also evolved into a form that will create polarization within Belgium. Because in the period when high-income groups from Brussels moved to Flanders and Wallonia, a clear income difference between rural and capital cities began to emerge. The formation of economic imbalance in Belgium was understood with Brussels lagging in many economic indicators and it was feared that it might cause major problems. It created a situation that is against the principle of sustainable and balanced growth of cities and regions.

The neighborhoods that placed in the first crown is the region that has received not only internal but also external mobility during in history (Wijkmonitoring, 2021). Immigration movements to Brussels were influential in the emergence of a very diverse social structure. So much so that almost 50% of the population began to form people who were not born in Belgium (Deboorsere et al. 2009). Firstly, immigration started in the 1970s when workers from Turkey and Morocco settled in this region.

The process of decline of prices in the central neighborhoods made the urban decay areas attractive for the immigrants who came to the Brussels. Migrant workers were able to establish a life of their own here, and this resulted in later arrivals flocking to these neighborhoods. Although most of these immigrants initially worked, their incomes and cultural backgrounds were not sufficient to provide their children with a good education. For this reason, the children born here and the new generations that came after were left uneducated, left behind in equal opportunities, and tended to do informal jobs, including illegal ones (Corjin et al, 2017).

Migrants settled in the central neighborhoods perceived as strangers by people who already live in these places, and it facilitate the speed of the suburnisation from the

central to the periphery (De Boek at al, 2017). Socio-economic vulnerability tend to new residents to make jobs that never happened in Brussels including illegal ones. Thus, the perception of central places become places with violating rules and social order in the eyes of Belgian citizens living in the rural regions (Kesteloot, 1998).

Very limited communication and ignoring integration issues led to a polarization and a reaction to socio-economic inequalities by individuals living in the central neighborhoods by organizing uprisings, which often saw violent incidents, were met with great fear by those in other Belgian cities (Kesteloot and Loopmans, 2009).

At this point, strong criticism of immigrant public policies may be made by activists and scientists. Considering that the first migrations of workers to Belgium were planned by the government to close the unskilled worker gap in their country like some other Western European countries, the passive act of central and local governments in the coming years is the main source of concerns about the integration of newcomers (Derudder and Taylor, 2003).

In the following years, with the emergence of problems related to immigrants and the intensification of these problems especially in some districts located in the center, solution proposals began to be discussed.

Moreover, some ideas such as creating even smaller local administration units by increasing the number of administrations were put forward to bring these problems to light and increase the participation of some districts to give them more freedom to raise their voice (Kesteloot and Loopmans, 2009).

Therefore, according to Wjikmonitoring database 9 groups of foreign nationalities were categorized:

- EU-15 (excluding Belgium, including the UK) (Germany, Austria, Luxembourg, Netherlands, Denmark, Spain, Portugal, Finland, France, United Kingdom, Greece, Ireland, Sweden, Italy);

- Europe of the 13 new Member States (accessed in 2004, 2007 and 2013) (Latvia, Lithuania, Bulgaria, Malta, Cyprus, Poland, Estonia, Czech Republic, Romania, Slovakia, Hungary, Slovenia, Croatia);

- Rest of Europe: the other countries that still belong to the geographical continent of Europe.
- Turkey.
- North Africa (Algeria, Libya, Tunisia, Morocco, Egypt);
- Sub-Saharan Africa (all African countries except the countries of North Africa).
- Latin America (All countries of the Americas are included in this nationality group except the United States and Canada);
- Rest of the OECD (countries not belonging to Europe, Turkey or Latin America) (Australia, Canada, South Korea, United States, Japan, New Zealand, Israel);
- Other countries (this group includes all other nationalities, as well as refugees with an unknown country of origin, those whose nationality is undetermined, and the homeless/stateless).

The European Union was divided into 2 classes. Indeed, it is important to distinguish between the EU-15 (excluding Belgium) and the 13 other countries that were recently added (2004, 2007, and 2013) as the socio-economic situation citizens of these countries might be different.

In the figure 3.7, share of citizens of first 15 European Union Countries (excluding Belgium) is shown on the map such as citizens of The Nederlands, Luxembourg, France and others. The ration of citizens from first European Union countries are getting less and less in the neighborhoods in the center and in the Nortwestern part of the city. However, Ixelles is one of the exceptions that nationals from first Central neighborhoods of Brussels, which non-European migrant worker groups previously chose as their residence, reached another dimension in diversity when the European diplomatic elite came to the city in the 1990s when these changes were experienced

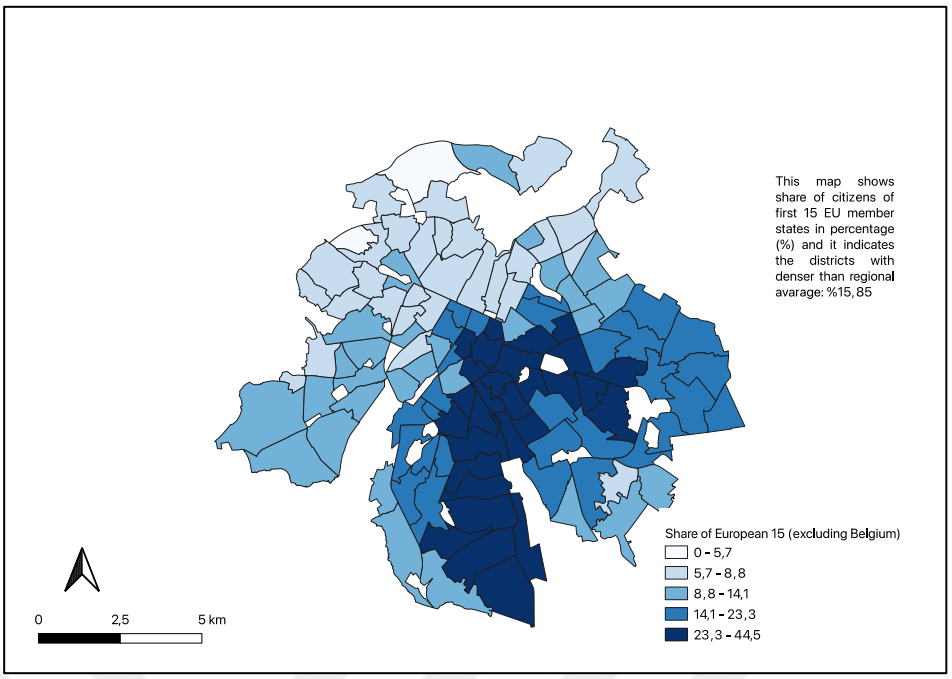

Figure 3.7. Share of Citizens of First 15 European Union Countries (excluding Belgium)

Families of non-European workers, European business owners and workers, and diplomatic elites created a completely different atmosphere in the city. This atmosphere was completely different from Belgium and other European cities (Loopmans and Kesteloot, 2009).

Nationals of the former "European Union of 15" countries form a large group of foreigners in the Brussels-Capital Region. They have been present in the region for a long time. In 2019, almost one in six inhabitants of the Brussels Region is a foreign national with a nationality of one of the countries of the EU-15 (excluding Belgium).

The following eight nationalities together make up more than 90% of the group: The four European countries from around the Mediterranean (Italy, Spain, Portugal, Greece). Nationals from these four countries, whose migration history has strongly determined the foreign presence in Belgium and the Brussels Region, have always seen the Brussels Region as a gateway to the country. Nationals of Belgium's four neighboring countries (France, Netherlands, Germany, Luxembourg) have always had a presence in Brussels, with people coming here for business opportunities.

The French are also the most important foreign nationality in the Brussels Region and have seen a remarkable increase over the years. Nationals from the countries of the EU-15 (excluding Belgium) are not evenly distributed within the Brussels-Capital Region, according to observations of Wijkmonitoring, a relatively striking concentration in the south-eastern quadrant of the region, with higher percentages around the European district and in the neighborhoods around Louiselaan-Waterloosesteenweg and Tervurenlaan. Europeans (EU 15) (excluding Belgium) are less represented in the north and west of the region.

Almost all districts of the second crown have a percentage of foreigners (EU-15) that is higher than the regional average. The highest concentrations (more than 25% of the inhabitants and even 40% or more in some neighborhoods) occur in the European quarter and around it, in the east of the Pentagon.

Their share, on the other hand, is much lower in the neighborhoods in the north and west of the region. Here their share is less than 10% of the population. Between 1998 and 2008, the share of EU-15 nationals (excluding Belgium) decreased slightly (from 14.68% to 14.26%). After this, it increased strongly until 2017 (15.94%), after which it decreased very slightly again.

Figure 3.8. corresponds to citizens from non-EU countries according to their percentage in the total population in 2019. There are three major community born in a non-EU countries and migrated to Brussels later; individuals coming from Sub-Saharan countries such as Congo and Nigeria, migrated from Morocco and Algeria and finally person who left their homeland, Turkey for seeking jobs in Brussels. Individuals who received Belgian citizenship are not included in the statistics, therefore the ratios of the non-EU persons include citizens of other than Belgium and EU countries. It was previously mentioned that the non-European population immigrating as workers in the 1970s and living in Belgium acquired citizenship in the 2000s. It is observed that people who acquire citizenship afterwards continue to live in areas with a high immigrant population. As a result of the interviews, it was observed that only the people who started to earn a lot of money left their districts. Therefore, there are still people who acquire citizenship in places where the immigrant population is high, although it is stated that people who subsequently acquire Belgian citizenship are not counted among the immigrants mentioned here. As a result, places

with a high immigrant population are also likely to be places where people with a migrant background but naturalized.

The mapping research attends different colors to each community and the darker color goes, the higher immigration density. The central neighborhoods and the first crown places show a darker color than the periphery. The colors are getting lighter in the peripheries due to a decrease in the ratio of the citizens from countries from other than EU.

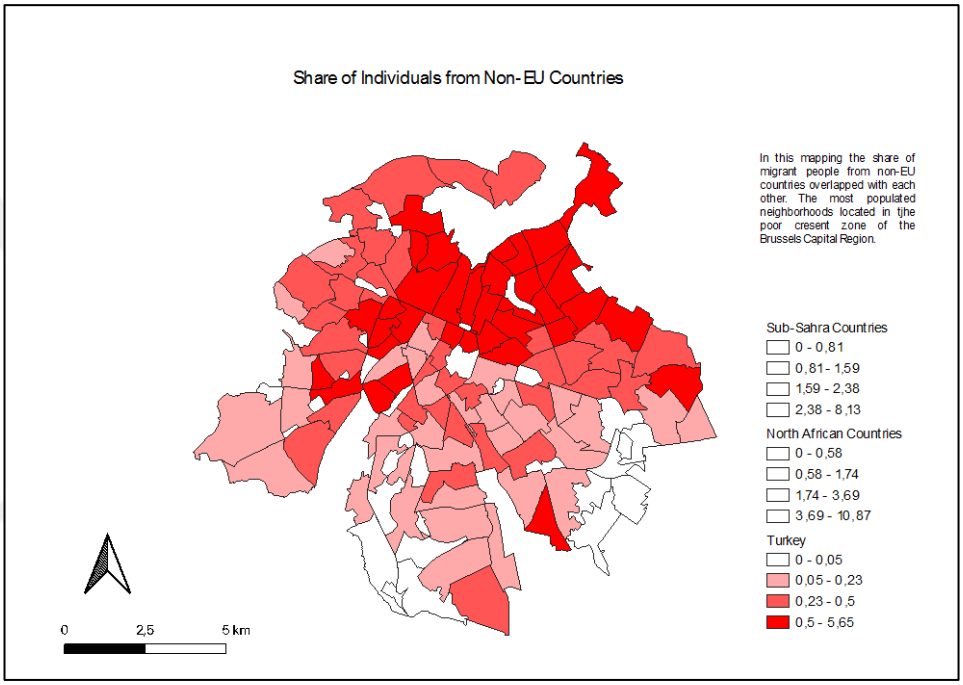

Figure 3.8. Share of Individuals from non-EU Countries

The population with a North African nationality is relatively more present in the poor crescent. The North Africans have a relatively stronger presence in the western districts of the poor crescent. They make up more than 6.5% of the population of these neighborhoods. By extension, they have a relatively stronger presence than the regional average in the other districts of the poor crescent in the first place, and in the rest of the region west of the Channel in second place. Their share is lowest in the south-eastern quadrant, but mainly in the south-eastern districts of the region, which belong to the debt of Uccle, Watermaal-Bosvoorde, and Woluwe-Saint-Pierre. Here their share is less than 0.6%. Between 1997 and 2019, their share has fallen sharply, from 8.23% to 3.35% of the total population. Overall, the decrease has nothing to do

with the decrease in immigration from those countries, but with the large number of North Africans who have become Belgians.

Within the region, the spatial distribution of North Africans has hardly changed between 1997 and 2019. Since 1997, but then with much higher percentages, the concentrations were highest in the neighborhoods west of the Pentagon. More generally, North Africans were remarkably relatively more represented in the poor crescent and relatively less present in the south-eastern quadrant of the region. Between 1997 and 2019, their share in most of the poor crescent's neighborhoods fell dramatically. In contrast, in the northern and western second crown districts, from Laeken to the south of Anderlecht, their share has increased (Wijkmonitoring, 2021).

In 2019, citizens of Sub-Saharan Africa represented 2.3 % of the Brussels population. In the past, these subjects were mainly Congolese, which can be explained by Belgium's colonial past (Demart, 2003). However, the share of Congolese within this group is decreasing (55% in 1997 compared to 29% in 2019). This decrease is explained on the one hand by the increasing number of Belgian nationals and, on the other hand, by the rise of immigration from other countries (Hooghe et al., 2008).

Sub-Saharan African nationals are generally better represented in the so-called poor crescent and university districts. The percentage of citizens of Sub-Saharan Africa is highest in the poor crescent (mainly in Cureghem Dauw, i.e., 8%), in the university districts (University, Kappeleveld), in Matonge, along the Kroonlaan and finally in the north of the Pentagon.

At the regional level, their share is greater in the north-western half and smaller in the south - eastern quadrant. The share of this group within the population increased between 1997 (1.39%) and 2012 (2.53%), and between 2009 (1.84%) and 2012. Subsequently, the share of this group stagnates before falling further to 2.28% in 2019. The geographic distribution of Sub-Saharan Africans remains similar between 1997 and 2019. Relatively speaking, they are most numerous in Matone and in the university districts in 1997, while they are more numerous in 2019 towards the poor crescent. Between 2012 and 2019, their share also decreased in several neighborhoods outside the poor crescent. In Matonge, the share of Sub-Saharan Africa decreased between 2015 (5.5%) and 2019 (4.1 %) (Wijkmonitoring, 2021).

However, the uninterrupted demand for workers from the labor market and the fear that workers will be unemployed if they return home have resulted in a mutual increase in their stay. This situation took so long that these people gained Belgian citizenship and managed to set a good example for their relatives in their native land who were suffering from unemployment.

Years later, when the order they established started to attract people staying at home, these first immigrants were at the center of the arrival infrastructure from the very first period and formed an informal network. The first immigrants who came seeking a way to reach these people or contacted them before they arrived. After the communication was established, this network provided a job and accommodation environment for the newcomers to the city and made it very easy for them to cling to life. The effect of this situation on the spatial organization resulted in the organization of each arrival infrastructure network in its own spaces.

Each group more concentrated in its own place. This situation, on the one hand, makes it much easier for the newcomers to do their daily work, but on the other hand, it has minimized the opportunities to meet and interact with the Belgian citizens residing in the city (Van Hamme et al. 2021). For this reason, today, in the data prepared and shared by the public authorities of Brussels about the place of residence of people with origin of the earth, non-Belgian immigrants with the same origin live close to each other.

According to the data, neighborhoods, and settlements in the canal region of Brussels stand out in places where Moroccan, Algerian and other North African communities live. The population with Moroccan origin forms the most important group in this respect, amounting to almost 13% of the Brussels population in 2001 (Deboorsere, Eggerickx, Van Hecke, Wayens, 2009). It can be mentioned that there is a higher rate of Moroccan origin people in the canal area of Brussels. This group can be shown as relatively the most densely populated group among all other non-European immigrant groups (Kesteloot, 2013).

On 1 January 2019, almost a quarter of people in Turkish descendent in Belgium lived in the Brussels-Capital Region. Since the 2000s, the population with Turkish nationality very often acquires Belgian nationality. Many people are Turkish by birth

but later become Belgian. Since Belgian nationality in the National Register takes precedence over foreign nationality, those individuals who are both Turkish and Belgian are considered Belgian in the official statistics, and therefore also in these cards. In the region, the Turks are particularly strong in the neighborhoods around the Haachtsesteenweg in the first crown or outside the first crown. Strong concentration of Turks has mainly formed in the neighborhoods in the first crown in the north, around the Haachtsesteenweg, the Brabantstraat, and in the center and north of Sint-Joost.

In 2019, these neighborhoods had more than 3% residents with a Turkish nationality and no Belgian nationality. The Haachtsesteenweg, with its many Turkish restaurants and shops, is the beating heart of the "Turkish Quarter". There is also a relatively strong presence of Turks in other neighborhoods close to this zone. This is the case, for example, in the districts of Collignon, Noordwijk Oud Laeken Oost, Daily, and Helmet, where Turks make up more than 2% of the total population.

Persons from Turkish descendent make up more than 0.6 % of the population in the neighborhoods near the Canal, Laeken, and Cureghem, and they are also well represented in Historic Molenbeek. Everywhere else in the region they are much less represented and make up less than 0.6 % of the total population. The number of Turks (non-Belgians) has fallen sharply between 1997 and 2016, and so has their share of the total population. Their share decreased spectacularly, especially between 1997 and 2003. In 1997 their share among the Brussels population was still 2.4 %. However, little has in the spatial distribution of these changed residents: very strong concentration around Haachtsesteenweg, in the center of Sint-Joost, and relatively strong presence along the Canal (Wijkmonitoring, 2021).

The lowest rate among non-European immigrant groups is found in Turkish neighborhoods. An important reason for this is that the first Turkish workers who came in the 1970s and their children are now Belgian citizens and are not represented in the statistics as it mentioned before.

In some recorded conversations with Turkish citizens, such as in Sint Joost or in Schaerbeek, it was stated that the number of Turks who came here decreased with the end of the 1990s, and as of 2007, it came to a point where it was completely cut off due to the strict immigration policies of the Belgian government. It has been observed

that the Turks living in the neighborhoods now settled here many years ago. In the interviews, the impression was conveyed that only a few Turkish citizens came here through marriage. Therefore, it is understood that the majority of the Turks living here are of worker origin, and they came from Turkey during the years of worker migration.

Globalization and capital movements also played a major role in forming these migration flows. By the 1990s, Brussels became a frequent destination for capital groups, which required skilled or unskilled labor.

By the 2000s, Brussels had 2 000 foreign companies, which accounted for 234 000 jobs and 40% of the Brussels GDP (Loopmans and Kesteloot, 2009). These numbers mean that if the workers' families are considered, a considerable number of people, perhaps half a million, will begin to live in Brussels. This situation, which was seen as an economic success for many, resulted in the coming together of people from a wide variety of social backgrounds. Most of the recent migrations were seen in 2015, and the immigrant profile is quite different from the migrations happened before as countries they come from and the cultures they belong to.

The preference of living place and mobility patterns may also change depending on age. Diversity pushed the over-age conservatives further away from Brussels and intensified migration to the countryside. However, this right of immigration was met with a counter-migration movement later. Massive diversity, which came together in the city center, was not found anywhere else in Belgium, and it has become incredibly attractive to the young population living in the Belgian countryside. Young Belgians, who have come to the age of breaking away from their families and looking for a new place to live (Beaten, 2001), were impressed by the creativity of multiculturalism and the relatively cheaper price of these neighborhoods (Van Hamme et al., 2021). Because of the people with high income left the city center, there were sudden fluctuations in prices in the central neighborhoods. This turned out to be an oasis in the desert for the young population who did not yet have a regular income or even if they were below the general average (Corjin, 2017).

With the 2000s, a different dimension opened in the migration in Brussels. The EU, of which Belgium is a part of 15 member states, has decided to expand its borders and to include especially central and eastern European countries in the union. The EU's

decision to enlarge meant greater diversity for Belgium and Brussels in particular, which had previously been the focus of interest for entrepreneurs and investors from countries such as the Netherlands, Germany, and France. In fact, with the inclusion of central European countries such as Austria and the Czech Republic in 2004, and then the inclusion of Eastern and Northern European countries such as Romania, Bulgaria, and Lithuania in the 2010s, the number of the population with the right to free movement has increased incredibly (Kesteloot and Loopmans, 2009).

Brussels, which has already accommodated many immigrant groups in the past and whose arrival infrastructure has been shaped informally and formally, was openly inviting to people who wanted to immigrate both in Belgium and in Europe (Swyngedouw, 2019). Having a large market and formerly involving many industries also created an attractive environment for private entities for profit and entrepreneurs. This situation played a role in the emergence of large Bulgarian and Polish populations in Brussels (Meeus et al., 2020).

The most striking year of the city's migration was undoubtedly the Syrian civil war in 2015 and afterwards when millions of refugees who were able to cross into Europe via Turkey dispersed to European cities. Brussels was able to host a significant number of these millions of refugees. Among the reasons for this are that Brussels is a point of arrival and has hosted many immigrant communities who came here in the past, and therefore the arrival infrastructure is strong, it is in the middle of a country and one of the biggest regional institutions in the world that has many opportunities in monetary and societal means. As the de-facto capital of European Union, Brussels is not only offering a secure environment for a while but also place as the way to the capital of the United Kingdom for many migrants, refugees, and asylum seekers (Daher, 2018).

Because there are discussions that the government did not provide even some basic services to the migrants, and they arrived into harsh conditions in the middle of winter in 2015. Refugees in and around Maximilian Park found themselves in a network of volunteers that emerged in a completely informal way. A group of Brussels citizens came to the park and welcomed as many people as they could accommodate in their own homes. This was an unmatched offer for asylum seekers who had been living in cold weather for days. Afterwards, the number of people who joined the movement increased, and the refugees who were guests of these people often found a warm place

to stay for the number of days they needed (Daher,2018). This aid played a vital role in their finding a job and re-clinging to life, and many asylum seekers found employment where they could achieve a decent standard of living and were able to maintain their lives. This fresh network took on a different and newer form of the arrival infrastructure, which was again informal and more traditional, throughout the country (Meeus et al., 2019).

Brussels has become one of the places where inequality, spatial and social segregation is highly concrete. Differences emerged between neighborhoods, both in urban and social infrastructure (Criekingen, 2003) and even the basic needs were ignored in vulnerable and immigrant-populated neighborhoods (Reas at al., 2009). Therefore, all problems became an unbreakable cycle.

Refugees, asylum seekers, and all other migrants are still discussed in Brussels and Belgium. For many times they become targets of far-right political parties. From time to time, extreme right-wing parties react to the little progress made by the public authorities and organize protests, followed by violent incidents (Brussels Times, 2019). Social and economic experience is reflected in the relations of people and societies, and people living in neighboring neighborhoods have become invisible and ignorant of each other.

This study aims to discuss how the invisible walls built between the neighborhoods due to migration patterns became more prominent during the COVID-19 period by using open-source mobility data. Because especially, the economic imbalance between neighborhoods has become more apparent during the curfews imposed by governments during the COVID-19 pandemic. Poor and migrant neighborhoods were not able to stay at home as they worked in physical activities. However, in high-income neighborhoods, the residents, mostly working in white-collar jobs, were able to work from home, therefore, did not have to travel frequently (Sulyok, 2020).

In case of investigating the income levels of the neighborhoods over tax revenues, we obtain results in parallel with the information given above about social and demographical indicators. It has been observed that neighborhoods that are more advanced in tax revenues show that, during the migration in Brussels, it was an area that attracted wealthy people from the city center (usually periphery neighborhoods)

or that people from Europe and some developed OECD countries had a higher proportion among immigrants from other countries.

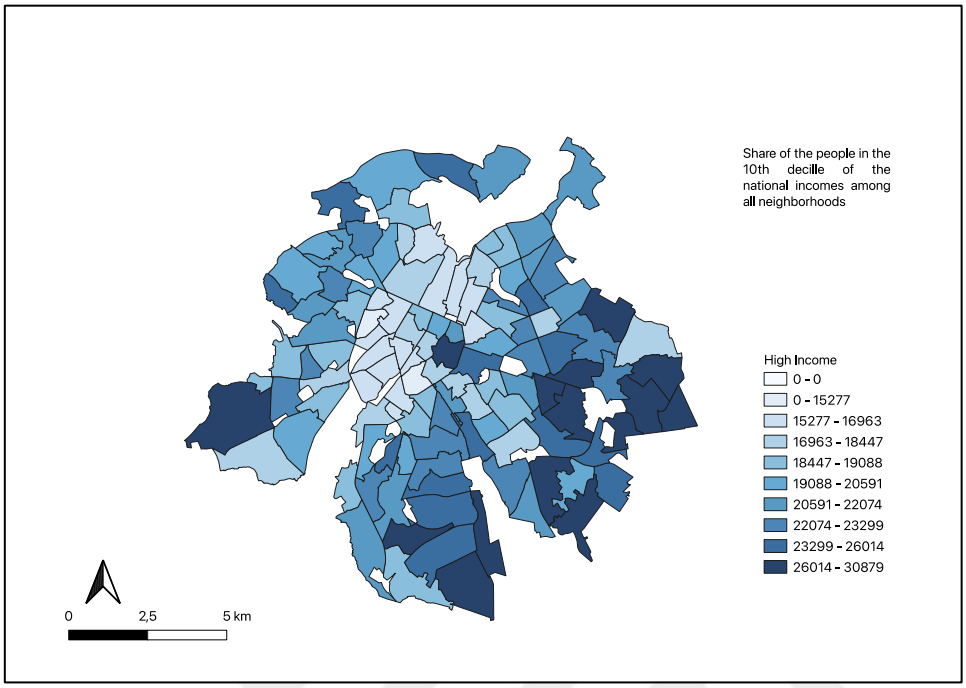

Figure 3.9. Neighborhoods with Income Levels (High Income) in Brussels

In the income tax distribution map in the figure 3.9 provided by Wijkmonitoring, it is observed that the income level is high in the Southern neighborhood of Forest, where French immigrant groups live, and in Saint-Pieters Woluwe, where mostly EU diplomats, people from OECD countries such as UK, USA and wealthy Belgians live in the neighborhoods in South and East directions.

Therefore, within the scope of this study, the level of infrastructure in these neighborhoods will be determined from the public transportation usage data. It is thought that a study to be conducted on the differences in terms of equality of opportunity between those living in these neighborhoods and those living in low-income neighborhoods will have interesting results. Another outcome of this figure is the situation of the Anderlecht district. Anderlecht is a neighborhood with a higher Belgian population compared to other districts, and some of its neighborhoods have a higher income level. This has resulted in commonality between Anderlecht and the other high-income county, Saint-Pieters Wolowe, which provides us with an opportunity for effective comparison.

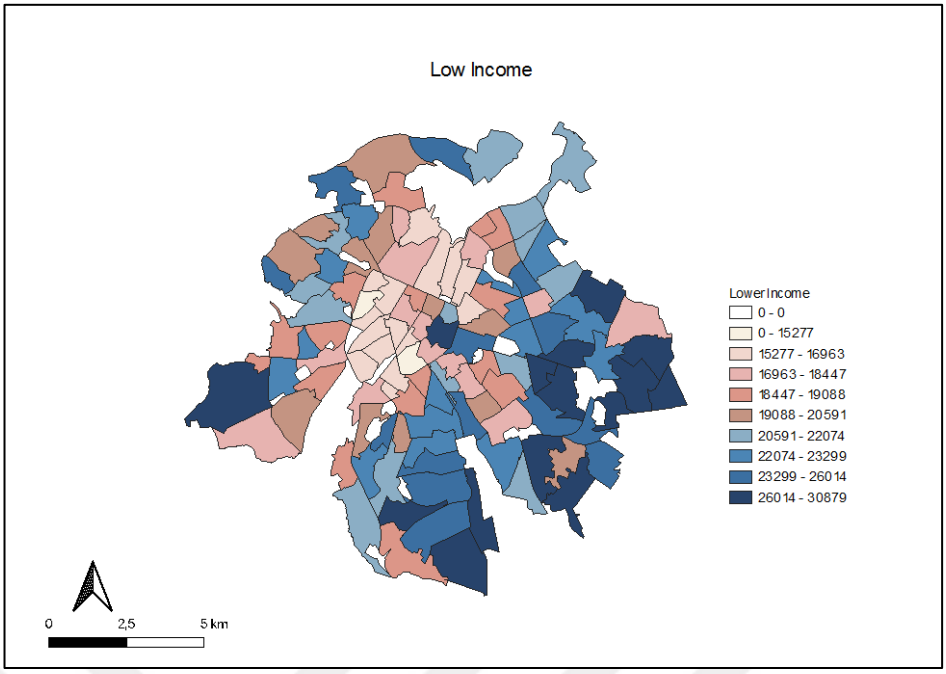

Figure 3.10. Neighborhoods with Income Levels (Low Income) in Brussels

As it can be seen in the figure 3.10, the neighborhoods that placed in the first crown and pentagon zone has relatively lower income values than the neighborhoods in the South and Eastern region and European neighborhoods.

The income level gains a momentum to the peripheries with the influence of the suburnisation 30-40 years ago. Income level might show the relations between the mobility trends and economic status of the communities or individuals. This study investigates how economic status of the persons has created a positive impact on their lives during COVID-19 times.

Less income may mean greater risk of poverty (OECD, 2019) compared with other places in the city. Even though overall population wealth is much higher than the world average, places with lower income levels shown in Figure 3.10 may have a higher likelihood of falling into poverty than places with better economic conditions in Brussels. Neighborhoods that have the most risk to get into poverty is shown in the figure 3.11, the first crown district suffers from the lack of economic means of struggle against poverty and inequality.

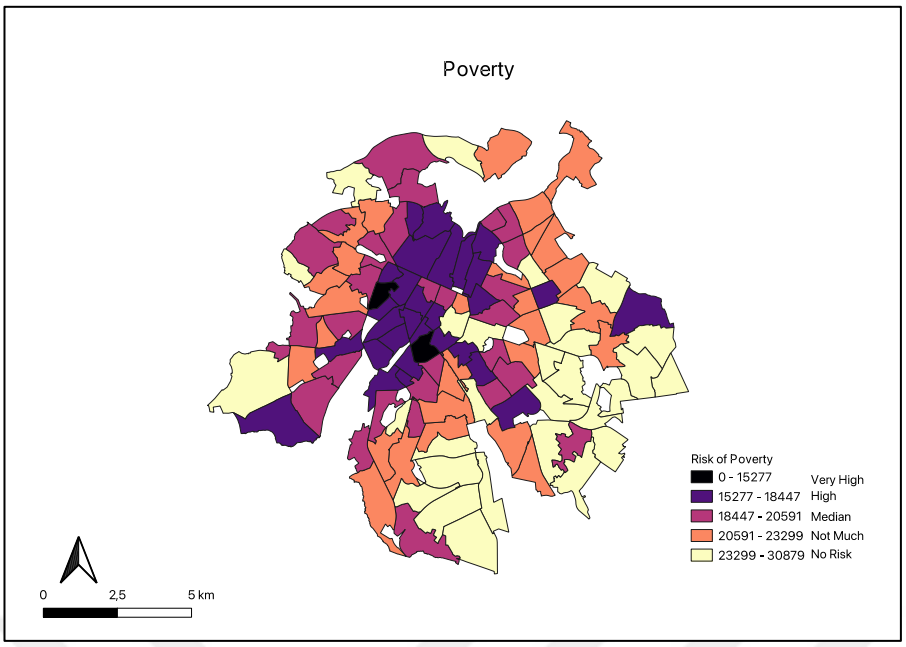

Figure 3.11. Neighborhoods with Risk of Poverty based on Income Level

Even though the places with lower incomes are marked as at risk of poverty, the works recognize that even the smallest income level in Brussels may be over income status of many regions around the world as Belgium has a developed economy and infrastructure. The comparison between the districts has been made according to its region, the extend was Europe Economic Area and Belgium while comparing the cities and communities within each other.

The scope of this study has previously underlined the importance of 5 different neighborhoods in 5 districts. They all have different types and amounts of incomes, migration levels from different groups of countries, and some indicators such population density which makes an understanding of living conditions. To better understand the needs about the urban mobility and the social-economic status of the districts, this chapter uncovers the details of social pattern and economic status of the neighborhoods with the development of Brussels Capital Region.

In the figure 3.12, the study makes an analysis on the car ownership and socio-economic status of the neighborhoods. The previous chapter investigated that there is an imbalance between districts in terms of economic indicators in Brussels. Sint-Joost-ten-Node is one of the poorest districts around them and performs higher numbers of migrants received in the past. Nevertheless, Sint-Joost-ten-Node has the highest

number of car ownership around the districts that we want to focus on, which shows unexpected data in terms of basic urbanization and economic discourse if we think that their purchasing power is lower, and they live in a very central location.

The second place with a high number of cars is Woluwe which shows higher income level and suburban characteristics. This mapping shows us locations of the selected neighborhoods, and which selected neighborhoods are most car centric.

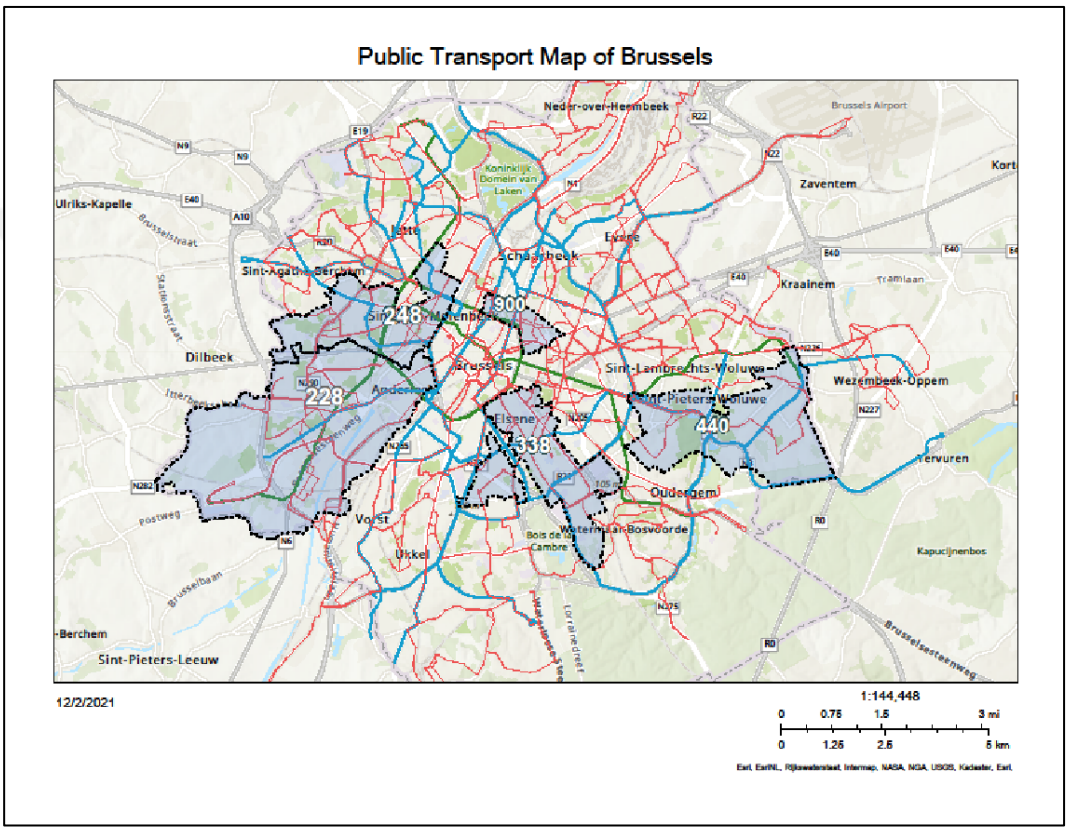

Figure 3.12. Public transport Map of Brussels with Borders of Selected Neighborhoods

3.3. Main Characteristics of Control Group Districts

Table 3.1. shows some indicators belongs to our first neighborhood, Anderlecht as the important place to make outputs about the socio-economic status of the Belgian middle class. Even though the share of foreign nationality is under the average of Brussels the city has been facing economic difficulties, the wealth index is under the Brussels average as well and the unemployment is slightly over from the Brussels overall.

Table 3.1 contribute some detail to the study that Anderlecht has not too much foreign nationals but not a really developed economy as well. Therefore, we can say that middle-class Belgian citizens are the major community living in the district. The presence of car is slightly under the Brussels average which shows us that there is a mixed use of transportation means.

Table 3.1.: Socio-Economic Indicators in Anderlecht (2021)

Indicator	Anderlecht	Brussels-Capital Region
Population density (number of inhabitants per km²)	6,749	7,500
Share of the population of foreign nationality in the total population (%)	32.4	35.3
Share of EU-28 nationals (excluding Belgium) in the total population (%)	19.4	23.3
Wealth index (Belgium = 100)	63	78
Employment rate (15-64 years) (%)	52.6	55.3
Unemployment rate (15-64 years) (%)	18.8	16.3
Average monthly rent for a two-bedroom apartment (euros)	702	770
Ordinary expenses of Municipalities (euros per inhabitant)	1,459	1,930
Water consumption (m³ per capita)	42	47
Number of cars per 1000 inhabitants on August 1	338	404

Ixelles as it always has been important due to high proportion of migrant residents from Sub-Saharan countries. Table 3.2 shows us the share of populations that has foreign nationality is much higher than Brussels average with 36% of the foreigner nationals are from EU-28 countries out of 49%.Both number of populations from EU and non-EU countries are higher than average, it means the diversity is higher as well. One of the most important spatial aspects is the existence of the Shuman neighborhood (known as European neighborhood) in close to this area, the personnel of the EU bodies prefer to live around this neighborhood.

Therefore, the wealth index is higher than Brussels average with lower unemployment rates which might cause a wrong perception due to high presence of vulnerable people living in. The observations that I made for this study shows us the gap between wealthy people and urban poor is higher than many other places. The ordinary municipality expense is very close to Brussels which might give us a clue about build environment and transportation infrastructure in the district.

Table 3.2.: Socio-Economic Indicators in Ixelles (2021)

Indicator	Ixelles	Brussels-Capital Region
Population density (number of inhabitants per km²)	13 679	7,500
Share of the population of foreign nationality in the total population (%)	49.0	35.3
Share of EU-28 nationals (excluding Belgium) in the total population (%)	36.2	23.3
Wealth index (Belgium = 100)	89	78
Employment rate (15-64 years) (%)	57.4	55.3
Unemployment rate (15-64 years) (%)	14	16.3
Average monthly rent for a two-bedroom apartment (euros)	869	770
Ordinary expenses of Municipalities (euros per inhabitant)	1,915	1,930
Water consumption (m³ per capita)	59	47
Number of cars per 1000 inhabitants on August 1	338	404

Molenbeek-Saint-Jean that is the one of the oldest neighborhoods of Brussels that received major part of migrations from north-African countries, especially with a consolidated identity with people from Morocco.

Table 3.3. shows some indicators belongs Molenbeek as the important place to make conclusions about the socio-economic status of the migrant communities. The district is dealing with harsh economic difficulties with a wealth index number way too under the Brussels average and the unemployment rate is dramatically over Brussels overall. The table contribute some details to the study that 30% percent of the Molenbeek is foreigner nationals and half of them comes from non-EU countries. The presence of

car is way much under the Brussels average which shows us that there is a mixed use of transportation means. The average monthly rent for a two-bedroom apartment is much lower in Molenbeek compared with the ones in Ixelles and Saint-Pieters Woluve which is parallel with economic status of an average family in the neighborhoods.

Table 3.3.: Socio-Economic Indicators in Molenbeek-Saint-Jean (2021)

Indicator	Molenbeek-Saint-Jean	Brussels-Capital Region
Population density (number of inhabitants per km²)	16 314	7,500
Share of the population of foreign nationality in the total population (%)	28.3	35.3
Share of EU-28 nationals (excluding Belgium) in the total population (%)	14.0	23.3
Wealth index (Belgium = 100)	57	78
Employment rate (15-64 years) (%)	46.9	55.3
Unemployment rate (15-64 years) (%)	23.5	16.3
Average monthly rent for a two-bedroom apartment (euros)	682	
Ordinary expenses of Municipalities (euros per inhabitant)	1,915	1,930
Water consumption (m³ per capita)	41	47
Number of cars per 1000 inhabitants on August 1	248	404

Sint-Josse-ten-Noode is a neighborhood that workers from Turkey settled between the 1970s and 1990s. The presence of people from Turkey is still high even though majority of them granted Belgian citizenship after 2000s (Wijkmonitoring, 2021). Table 3.4. shows some indicators belongs to Saint-Josse-ten-Noode, Molenbeek as the important place to make conclusions about the socio-economic status of the migrant communities. The district is still hosting a high rate of migrant nationals with 44% over Brussels average, half of it nationals of non-EU countries. It deals with harsh economic difficulties with a wealth index number way too under the Brussels and even Molenbeek average, it may be placed the poorest district around others. The unemployment rate is dramatically over Brussels overall as well. Table 3.4 contribute some details to the study that 30% percent of the Molenbeek is foreigner nationals and

half of them comes from non-EU countries. The presence of car is way too much over Brussels average which shows us that transportation is car centric here. One interesting detail is the expense per inhabitants by minimalities, Saint-Josse performs much higher expense than Brussels average, maybe with the impact of new kind of policies to establish balance in development of districts.

Table 3.4.: Socio-Economic Indicators in Saint-Josse-ten-Noode (2021)

Indicator	Saint-Josse-ten-Noode	Brussels-Capital Region
Population density (number of inhabitants per km²)	23,358	7,500
Share of the population of foreign nationality in the total population (%)	44.4	35.3
Share of EU-28 nationals (excluding Belgium) in the total population (%)	26.1	23.3
Wealth index (Belgium = 100)	51	78
Employment rate (15-64 years) (%)	47.5	55.3
Unemployment rate (15-64 years) (%)	23.3	16.3
Average monthly rent for a two-bedroom apartment (euros)	659	770
Ordinary expenses of Municipalities (euros per inhabitant)	2,908	1,930
Water consumption (m³ per capita)	53	47
Number of cars per 1000 inhabitants on August 1	900	404

Table 3.5. shows indicators form Woluwe-Saint-Pierre as the one of the wealthiest districts of the Brussels Capital Region. The district performs one the highest income level around all districts in Belgium in the wealth index.

Table 3.5.: Socio-Economic Indicators in Woluwe-Saint-Pierre (2021)

Indicator	Woluwe-Saint-Pierre	Brussels-Capital Region
Population density (number of inhabitants per km²)	4 711	7,500
Share of the population of foreign nationality in the total population (%)	37.1	35.3
Share of EU-28 nationals (excluding Belgium) in the total population (%)	29.5	23.3
Wealth index (Belgium = 100)	113	78

Employment rate (15-64 years) (%)	60.5	55.3
Unemployment rate (15-64 years) (%)	8.3	16.3
Average monthly rent for a two-bedroom apartment (euros)	974	770
Ordinary expenses of Municipalities (euros per inhabitant)	1,450	1,930
Water consumption (m^3 per capita)	44	47
Number of cars per 1000 inhabitants on August 1	440	404

The rent is high and car ownership is slightly over the Brussels average which shows us how transportation infrastructure is developed in balance. The district hosts one of the wealthiest populations in Belgium with employment ratio over Belgium average and higher shares of citizens from EU-28 countries. Therefore, it becomes very interesting the study as it gives opportunity to follow public transportation use of wealthier places than others during COVID-19 times.

4. DATA & ANALYSIS

This research believes that it will not be sufficient to display the complex social, demographic, cultural and historical information of the communities living in Brussels with only traditional methods. Still, some GIS work needed to be done to make a better understanding of combination socio-economic and mobility data. Therefore, the chapter will explain the concepts beyond the data I get, how the study used them, how it gets tested and correlated with socio-economic data.

4.1. Data Collection and Processing

Public institutions in Brussels have already made a shift to GIS in their databases and created several types of files such as xls. or shp. Most of the public authorities have made open data available to users with a good user interface as part of a structured open data program.

Open data websites where everyone can access data are statbel.fgov.be, data.brussels, wijkmonitoring, opendata.brussel.be,mobility.brussels and even some more. In addition, downloading data as API, shapefile, GeoJSON and other spatial formats also provides convenience in terms of usability. The platform that contains the most important neighborhood-based data among these verses can be called Wijkmonitoring.

First, the administrative and local borders in the Brussels capital region were gathered (Figure 4.1). Neighborhood data acquired in shapefile format from Wijkmonitoring as the smallest administrative unit of Brussels. In order to make a correlation between neighborhoods it is important that the neighborhoods are comparable with each other, so it makes the borders and data based on neighborhoods are of vital importance for the research. Although Wijkmonitoring provides a wealth of economic data, some indicators determine demographic and social changes that have been offered in the platform for years. Socio-economic indicators can be received as rates of migrants with

different nationalities, population density, annual growth age structure, level of education, level of income, and tax, that can be obtained from Wijkmonitoring

On the other hand, the vast majority of mobility data were collected from the website of mobility.brussels. On this web service, the data in the hands of the Transportation Department of the Brussels city government are shared and it is possible to access more specific and original data such as the number of cyclists per hour. The database made a big contribution to this research by providing geolocation of public transportation stops, the geolocation data of the line routes. For this reason, both Wijkmonitoring and mobility.brussels have contributed greatly to the functioning and results of the study.

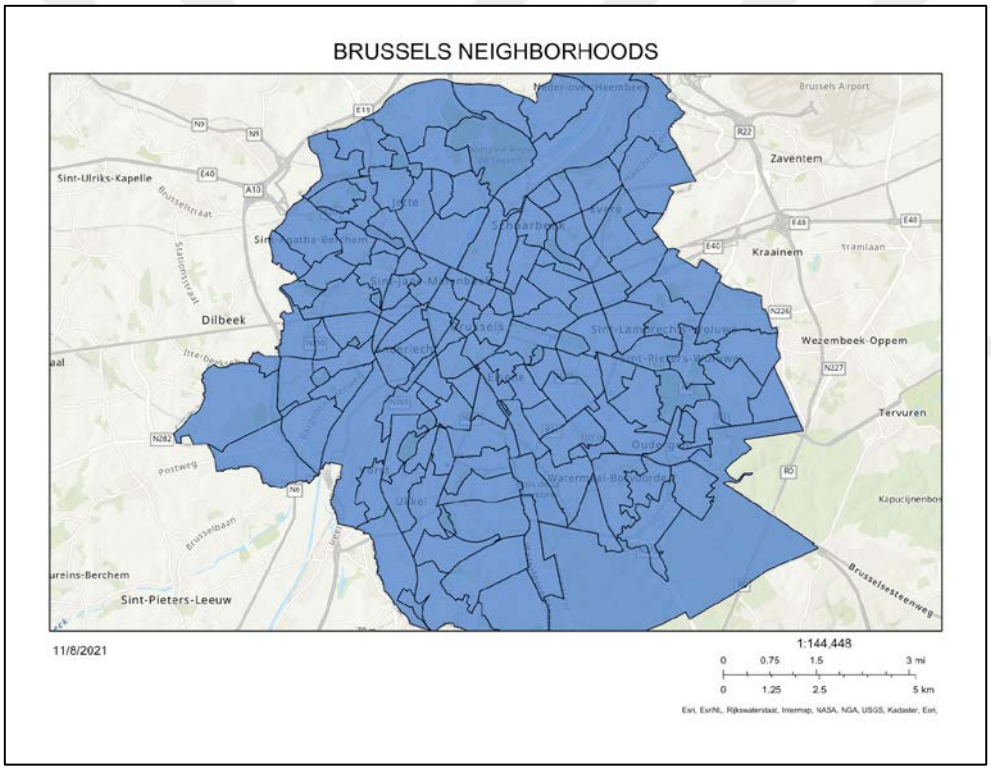

Figure 4.1 Geo-locations of Neighborhoods in Brussels

Administrative units, those geolocations visible on the map in the figure 4.1, are the borders frequently presented in the geo-web portals by public institutions. Since some neighborhoods consist of only 2-3 streets, which indicates the existence of a not very large neighborhood, it helps to better address the existing problems. It is considered that the larger the statistical units mean the larger the number of people and events that local administrations need to deal with, and this may cause small groups or issues to

be ignored more easily. So, it is appreciated in the study that the total numbers and size of neighborhoods are quite convenient for the research.

To make a better understanding of problems and findings, this study aims to create a control group of districts. To determine several neighborhoods to be examined in more detail, research was carried out and a meeting was held with a local professor from the KU Leuven Sint-Lucas campus in Brussels.

Local professor recommends choosing the districts of Anderlecht, Sint-Joost ten Node, Sint-Jans-Molenbeek, Elsene, and Saint-Pieter Woluwe as a control group because of their some of the socio-economic characteristics such as the ratio of people with different nationalities. The study researched the social aspects that could make a difference for findings, and it created a kind of x-ray image of the districts.

According to tables that the research created Anderlecht results by having a concentration of Belgian citizens relatively poorer than other districts, on the other hand, Saint-Pieter Wolewe hosts high-income Belgian citizens or upper-class people from European Union countries which makes the district unique for this study.

It has been observed that there is gradual increase of residents from other nationalities in the districts of Sint-Jans-Molenbeek and Sint-Joost en Node. In this sense, the research confirms the recommendations of the local professor from Brussels.

Finally, the Elsene has been a place for migrants for many years coming from Sub-Saharan African countries, mostly from the Democratic Republic of Congo and Senegal. The district becomes a hub for new highly popular restaurants and some cultural facilities which provide entertainment activities based on Sub-African identity.

According to data provided by Wijkmonitoring, some neighborhoods of Brussels have way higher migrant rates than others. Nationalities from other countries can be categorized as French, Turkish, North-African, Sub-Saharan African, and European from 15 countries in this study.

Results show that the neighborhoods of Zavel, Marollen, Stalingrad, Anneessens, Kuregem Bara, Kuregem Veeartsenij, Kuregem Dauw, Hertogin, Weststation,

Historisch Molenbeek, Koekelberg, Havenwijk, Oud Laken West, Oud Laken Oost, Noordwijk, Brabantwijk are historically receive more migrant population from North-Africa and Sub-Saharan Africa.

The neighborhoods in Elsene/Ixelles have relatively more citizens of the first 15 European countries as well as migrants from Sub-Saharan countries. This could be explained by the close location to the European district which hosts many EU institutions.

While in some neighborhoods there are most people living from first EU 15 countries and they are more likely to be educated and to have technology-based jobs with higher salaries, the neighborhoods listed above include residents who are more likely to be migrants from non-EU countries and have not really received a better education infrastructure from the countries where they came from.

In this study, data obtained from different sources around Brussels have been correlated. Main data sources are data provided by public authorities and mobility data provided by mobile phone providers. First, Belgian public institutions reveal and update main socio-economic indicators every year through several open data platforms which provide us the opportunity to understand socio-economic patterns and historical chances in Brussels. This data contains complex data that may need to be categorized. The vast majority of public institutions have already categorized them and made them available online for everyone to use.

Our second important data source is the transportation-specific information we obtain from public institutions. The data obtained from various public institutions may vary a few types of data such as points or sometimes a line or only a number. The data provided by public transportation authority may be complex and it needs to be processed before being used to make it comparable.

Finally, the data provided by mobile phone providers such as Google or Apple creates a wealth of sources to be examined for researchers. Google brings an important innovation to everyone's life by activating a series of services such as popular times as an application available on smartphones. The data contained here will be a reliable source not only for customers but also for policymakers and entrepreneurs, especially

scientists. The data coming from Popular times are mostly unprocessed and not transferable. Thus, it is not possible for a person who wants to use popular times for an application or a scientific study at first glance because the application is only available for Google maps customers. However, this study intends to use the popular times data normally separately offered to the users altogether in GIS platform.

It is aimed to bring together the density data of these independent points of interest by transferring them to the GIS environment. Moreover, we aim to see socio-economic data together with Google data in the same environment.

Internet and social media may be corporate processes that try to deal with global health crises using as a tool for health surveillance, warning, and response mechanisms before it's late for catastrophe (Velasco, 2014). In response to the COVID-19 pandemic, Google published monthly mobility reports called 'Community Mobility Reports' (CMR) (Google Mobility Reports, 2021). CRM may be seen as the report to record the current change in urban mobility and an early warning system as a response to the pandemic. The reports include monthly changes on urban mobility for almost every metropolitan city in every region around the world. CMRs allow readers to compare the regions as well as the countries. The cities compared to each other could have an impact on the direction of the pandemic in terms of influence on policymakers and scientists.

One of the most important issues to research is in the field of examining the relationship between social interaction and the number of COVID-19 cases. The World Health Organization (WHO) declared COVID-19 transmission and protective measures from the beginning of the pandemic to prevent the spread of COVID-19. The rules for preventing public gatherings may be seen as a disruption of the mobility and interaction of social groups. So, the report may place in a key point for the works to understand the relations between mobility, COVID-19 distancing rules which does not really support each other (Suylok and Walker, 2021).

According to the line chart below, urban mobility faced the first bottom-up in the very beginning of the restrictions calls of governments which shows a very sharp decline in March 2020. The weak trend continued until the summer, and the mobility increased slightly in May, and it reached almost a similar level with a pre-COVID-19 period in

all the summer months. The process allows a peak point and then the bottom due to every rise brings a restriction and each restriction reduces the cases. If the study examines the mobility trends related to city functions, there is a dramatic increase in the number of

people using parks and a dramatic decrease in the number of people using workplaces in Brussels.

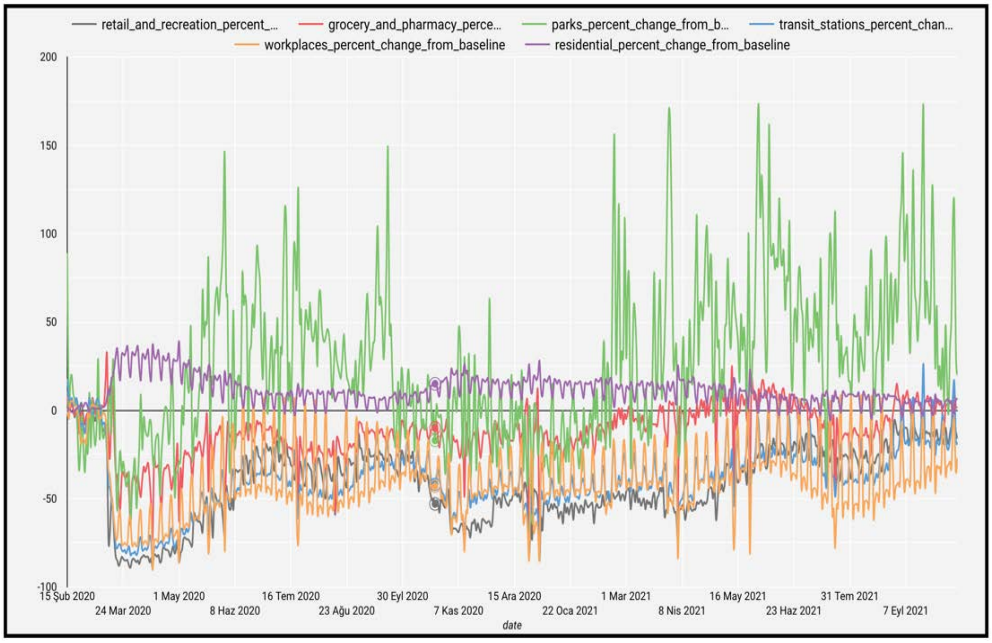

Figure 4.2. Google Mobility Trends Chart (Accessed on 7 September 2021)

One of the studies held on the same issue provides us a timeline of the COVID-19 processes in Brussels by particularly giving a name to each period of the lockdowns and curfew (Macharis et al., 2020). The article structured a few of key impact dates on everyday mobility during COVID-19 in 2020.

The article prefers to define the period between the first lockdowns and summer as ‘strict lockdown’ which results in very limited mobility in the capital region of Brussels. The summer months start with a gradual release and an increase in daily mobility. The next months are defined as a school year with 7-8 months of peak traffic and public transportation trends and then finalize with defining an era called light lockdown which allows people to gather in the public spaces, take lectures together in the classrooms, etc. (ibid, 2020).

In the previous works that we researched in this study, some of them emphasized the impact of the COVID-19 lockdowns on the travel safety and trust issues in the times of re-opening of the schools, restaurants, workplaces, and public places. The importance of social distancing requirements created a feeling of insecurity for many users of public transportation due to a lack of sufficient space (Barkowski et al, 2021).

One of the meetings that it mentioned in the methodology chapter is held with the public transportation authority in Brussels, STIB. I asked questions regarding the available datasets for public transportation's busy times, which they may collect from electronic tickets for every ticket validation. I was hoping to get a positive approach and reach out to a big data dataset at the end of the day. However, the official stated that it is not possible to share a dataset as we want but they offered help with written outputs of the institutions about changes happened during COVID-19 times. Figure 4.3 illustrates the data provided by STIB on a line chart. As is seen from the chart, the limited mobility in the first months of pandemic tend to rise in time but has the highest numbers during school time.

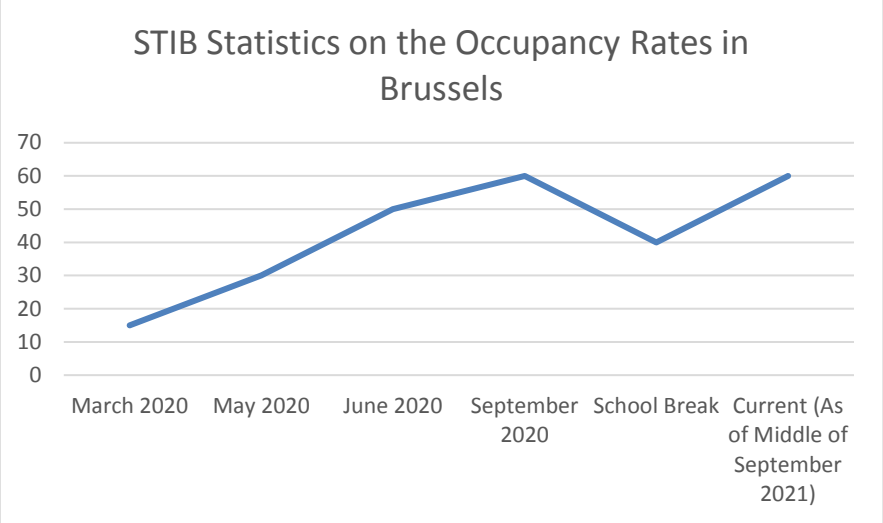

Figure 4.3. STIB Statistics on the Occupancy Rates in Brussels

As the research time was arranged in the middle of September 2021 which is the school period, the work tries to assess occupancy data on public transportation when it's on the highest level as mentioned in the STIB explanation. At this time, schools were

open again but Belgium had gone restrictions again due to rising cases during summertime in 2021.

Information given by STIB (Brussels Intercommunal Transportation Company) is consistent with the monthly mobility charts of Google. STIB stated in the meeting that; During the first lockdown in March, occupancy was only 10% -15% of its level in the weeks before the crisis. By the end of May, the level had risen to 30%, and on the eve of the summer vacation, to 50%. At the start of the September 2020 school year, attendance was at 60% of its reference level, and reached its maximum at the end of September (70% of the reference level). Then, attendance again gradually fell to between 30% and 40% of its reference level during the two weeks of school closure (All Saints holidays extended by one *week).* From the start of the school year, attendance rose again to reach 50% -60% in mid-December. Currently (week of September 6, 2021), attendance is at the same level as in September 2020 (around 67% of the reference level, both in stations and on the surface) (STIB Meeting,2021).

4.2. Analysis and Mappings

Public transport includes bus, tram, metro, partial trains work in internal public transportation and waterbus (brussels.be, 2021). In the figure 4.4 there are bus, tram, and metro lines belong to STIB and numbers of cars per thousand for each district.

The transportation lines are given a number from the density index (red: dense, yellow: moderate, green: not-dense) that we explained in the methodology, according to the density data of popular times application. The date was the 5th of May 2021 which corresponds first ease period with the openings of bars and restaurants, allowing public gatherings in the streets and return to face-to-face education.

Couple of lines in Anderlecht and in Ixelles has showed high levels of densities in the public transportation. Relatively denser public transport could mean either higher use of public transport or that the public transportation needs to be improved. Both Anderlecht and Ixelles have relatively denser population trends in recent years and are located very close to the historical city and the center.

The line which performs high density is going along in the middle of the Anderlecht that may be belong to the densest street of the district. The yellow density code is

crossing on the border of Anderlecht and Molenbeek. The yellow line continues inside of the Molenbeek. The line corresponds with red code in Anderlecht is reaching out to the Ixelles during the day.

There is no red coded line in the Sint-Joost-ten-Noode and Woluwe-sint -Pieters which shows higher numbers of car ownerships than capital region average. The number of car ownership shows extremely higher number of car ownership than other places in Sint-Joost-ten-Noode. It may give clue to a community having a car-centric transportation habits and relatively less dense public transportation.

However, these color codes do not represent the traffic concession situations, most likely there is a denser traffic congestion in Sint-Joost-ten-Noode. However, this mapping works has no longer progressed due to couple of difficulties coming from the nature of the data.

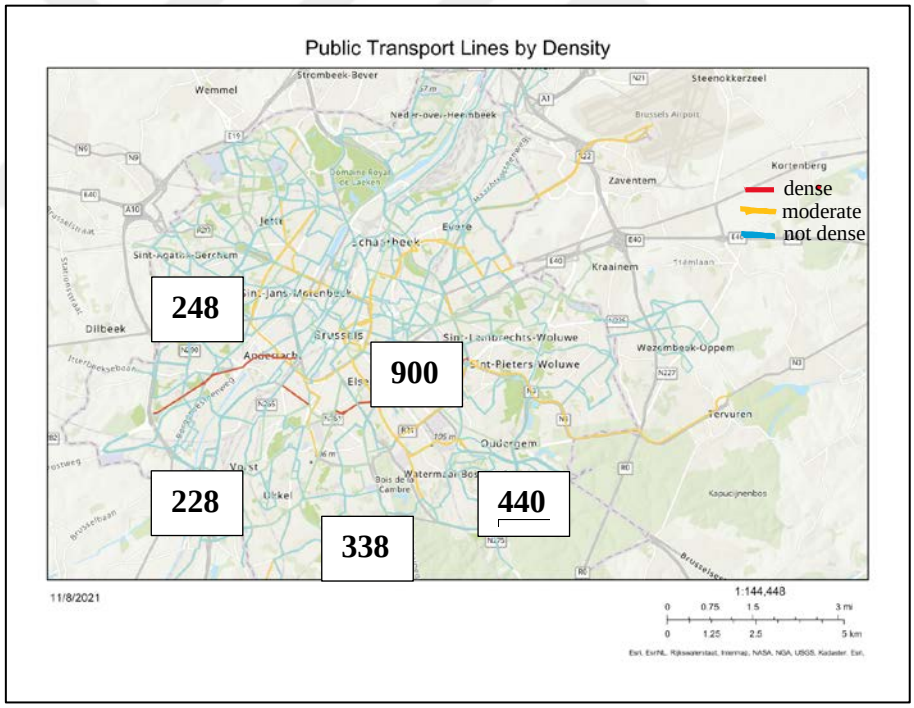

Figure 4.4. Public Transportation Lines with Density Distribution on 5th May 2021and the car ownership numbers per thousand inhabitants.

One of the first data received from STIB was the geo-locations of the line routes. The first reason for this was the idea of creating Google's popular times index, appointing numbers to the transportation lines, and combining them in GIS for further analysis.

Then, a dataset is created in the middle of May 2021 which is post COVID-19 times with easing restrictions from the google data for each transport line.

However, the data acquired from Google did not pair exactly the transportation routes, but it was part of the data of transportation stops. That's why it is considered that this deviation would damage the study results and it simply stopped. No further steps were taken in that direction based on the appointing index values to transportation lines. Then the study specifically focused on the point data of the transport stops. Next steps were getting the geolocations of transport stops and appointing our index value coming from popular times table in the previous chapters.

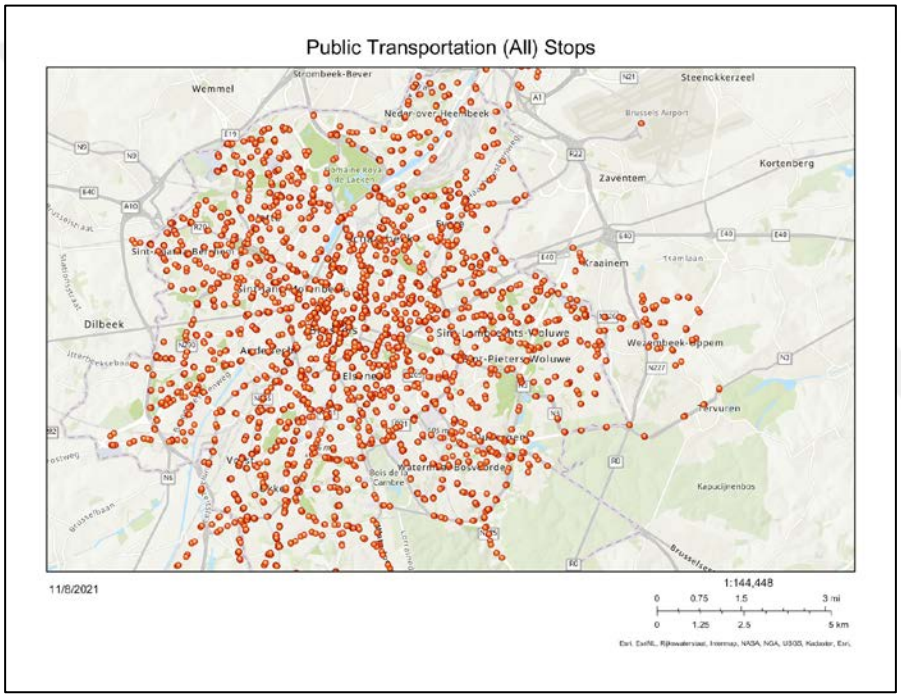

Figure 4.5. Geo-locations of Public Transportation Stops

After receiving the geolocations data, the first thing that the research needs to figure out the numbers of the stops which is more than 4000 spots. If we think the processing google popular times data which is simple and manual, then the numbers over thousands would be a long and problematic way to process the data. That's why we were needed to think to keep numbers as simple as we can. Therefore, that was the first point that we start to consider applying some analysis tools of ArcGIS such as point to area tool. This tool unites each point in each polygon and transform it to a single value.

After deciding on processing row data of geo-locations of stops, we need to decide on a range of the area to unite points. First, we made research on walkable distance of a individual. Even though there are several opinions about walkable distances range between 200- 1.500 meters depending to environmental conditions, Forsthy (2015) suggested that a distance between 400-500 meters could be defined walkable. Moreover, there is one another resource that supports a distance of a 400 meters square in an urban environment would establish diversity and heterogeneity between the urban blocks (Pafka and Dovey, 2016). When we consider how dense Brussels Capital Region is then we decide on to increase the distance %10 and set a grid system of 500 meters to arrange exact catchment of the right scale. The idea is collecting index values of every stop inside 500 meters and taking their average mean by dividing them into the number of total points. Then the new value will be appointed to the area. In the figure 4.6 the grid system is shown with aggregation of stops by its color. The darker colors of purple represent more stops close to each other, lighter color represent a smaller number of stops in a square of 500 meters.

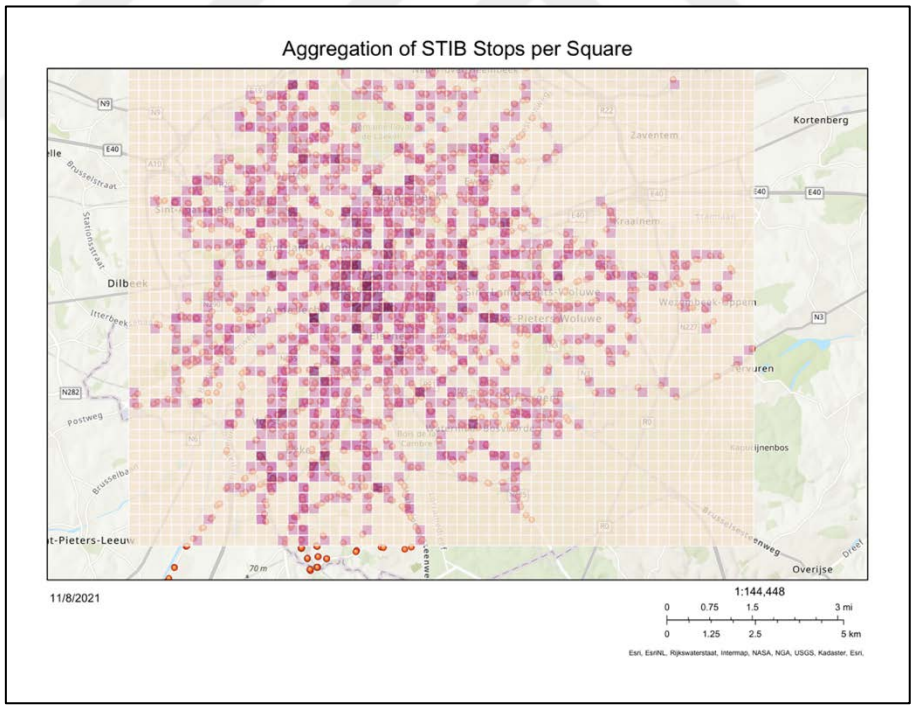

Figure 4.6. Aggregation of STIB Stops per Square of 500 meters

The figure above demonstrates how numbers of stops are relatively denser in the central places than the peripheries. The higher numbers of stops in each square might be understood as higher level of transport infrastructure, higher population, and greater

mobility in that area. Even though peripheries relatively less dense in term of stops, the neighborhood in the South seems to have more darker squares than other peripheral areas. However, number of stops does not mean that the lines in that area are facing crowd in their passenger operations. On the contrary it may be less crowd in the central stops and lines due to more developed infrastructure and higher numbers of operations. Therefore, the popular times data were taken from the Google Maps interface for each stop and their average were taken each square in the grid.

The stops located in the city's periphery include no data or less data most of the time. It is harder to create a dataset and relate to a finding of the data test in those places far away from the city center. The most obvious district is Wolove Sint-Pieters as it is in the periphery of the city and many stops have no data in popular times app. While creating 500-meter squares to collect the close stops together, almost half of the Woluve has been left out of the context as they receive no occupancy data from popular times.

4.3. Findings and Results

While applying crowd data to the squares, it was estimated that the denser and the most vulnerable places had had to get mobile in the post-COVID-19 period than individuals from other parts of the city. Some districts particularly get higher results than others. It is not a coincidence that the higher results correspond to the districts that we decided to take our control group of districts and follow them more closely. As is shown in the figure 4.8, there are some clusters of crowded transport stops in the districts of Sint-Jan-Molenbeek, Elsene (Ixelles), Sint-Joost-ten-Node. The biggest clusters formed in Molenbeek with 13 squares of 500 meters as almost each square is getting so crowd (dense) and relatively dense values. A big proportion of the district gets the highest values in our index score. Ixelles follows Molenbeek as having 11 squares with a red color and so crowd value. Almost each square placed in the Ixelles gets so high crowd index score which means the crowd in the public transport stops are higher than anywhere else in Brussels. However, 4-5 squares in the border with Morelles and Ixelles gets low values of density in the stops due to functionality of this area. It’s the place that office of the King, Prime Minister and some other cabinet members located, so really ap place constantly people living inside. Not only central neighborhoods of

Ixelles such as Matogne turn color red but also the places near Anderlech border get color red from our indexing system.

Even though it is one of the smallest districts of Brussels in size, Sint-Joost-ten-Noode is the one other district which turns completely red color. The district was performing extremely high number of car ownership in the previous figure and now it performs a high-level crowd in public transport. These indicators might show a lack sources to create public policy to develop sufficient infrastructure in the district. The red color is not only limited with Sint-Joost but also, it's neighbor district Schaerbeek has common squares with red color. Therefore, it is interesting because Schaerbeek has really similar socio-economic structure with Sint-Joost-ten-Node with hosting migrants/workers from Turkey for many years.

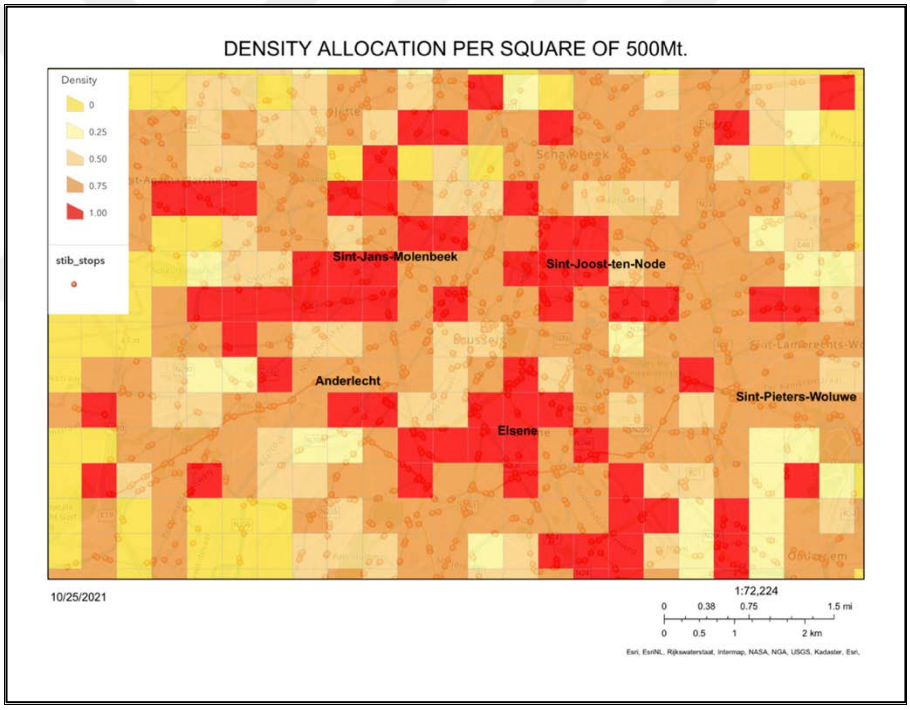

Figure 4.7. Allocation of public transport density in Brussels

As the places that has not too much crowd in the transport facilities, Anderlecht and Woluwe-Sint-Pieters performed different socio-economic aspect in the previous chapters. While the number of foreigners were less in Anderlecht than Woluwe, the districts show almost the same crowd levels with Woluve which has more rates over Brussels average of citizens from EU countries.

In this sense, there might be possible to set an output that middle-upper class Belgians shows similar mobility trends with middle-upper class Europeans except Belgium. In that case, the districts that individuals from non-EU countries living most inside have clearly distinct from the neighborhoods that EU or Belgium citizens live inside. In another way either the everyday mobility trends of communities are distinct from each other, or the public transportation infrastructures are better in Anderlecht and Woluve, so it prevents crowds in the public transport facilities.

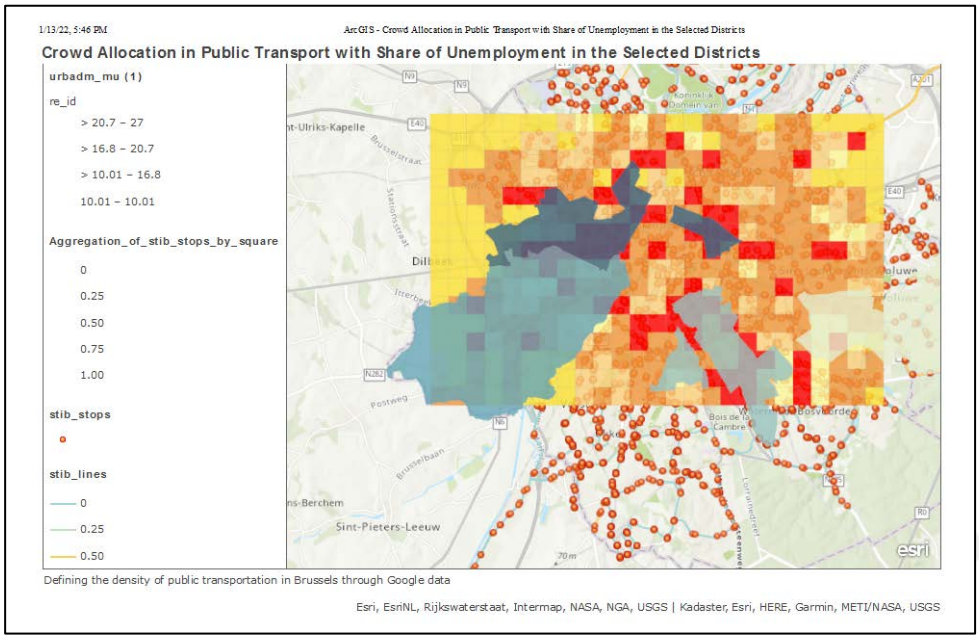

Figure 4.8. Public Transport Crowd Allocation with Unemployment of Selected Districts

When the public transport occupancy levels overlapped with the unemployment data of selected 5 districts in the figure above, it gives way to conclude some interesting points. The districts of Molenbeek and the Sint-Joost-ten-Node has similar numbers of unemployment rates which are dramatically above the Brussels Capital average. Sint-Joost-ten-Node which has highest number of unemployed persons, we previously emphasized the use of public transport and crowd rates are high aw well as car ownership.

According to the figure it is interesting that places with most unemployed reaches busy times during the day in the transport stops and lines. There might be couple of reasons for that; first there may be unrecorded jobs that requires physical presence and labor.

People who have to work under no contract might show a daily mobility, second the transport infrastructure is not really sufficient so even a normal demand for transport facilities creates gatherings in the temporal spaces as bus stops. Either the way the mapping directs us to think about the vulnerability of the Sint-Joost-ten-Node residents in term of using public transport with no distance rules for working and getting to school.

Moreover, there is a moderate rate of unemployment in Ixelles but high rates of busy times in public transport. Sint-Pieters-Woluve performs a low level of unemployment with the 10% and it has not too much red colored squares that means the public transport balance between the usage and infrastructure may possible be sufficient at the moment.

One other possibility for Woluve is the most people have cars, so they really do not need to use public transport. However, this district performed a not so high car ownership rates in the previous chapters, so it would not be so convenient to make a conclusion on car-centric transport. Therefore, there may one more aspect that we like to discuss here in the study. Final idea is that the people working in Woluve does not really in need for mobility in the city, so they are more lucky and easier to work from home.

Some groups living in the city are more vulnerable in the event of a crisis that will occur in the future, based on the public transportation station density map that we provided using GIS during post-COVID-19 times. In this context, when the density data are combined and distributed to the whole city by combining the stops within every 500 meters, it has observed that the groups with cultural and historical differences live in the density and the neighborhoods known as immigrant neighborhoods in the public are more deprived of public transportation infrastructure. This can produce two different types of results.

Considering that unemployment rates are also high in these neighborhoods compared to other neighborhoods, it can be said that immigrant groups, who are more fragile socially, economically, and institutionally, have to go out to provide basic services and need transportation opportunities more in times of crisis, even if everyone is locked in their homes.

Figure 4.8 is created to explain the relation between the mobility and the income level which might be helpful to the discussion about unemployment as well.

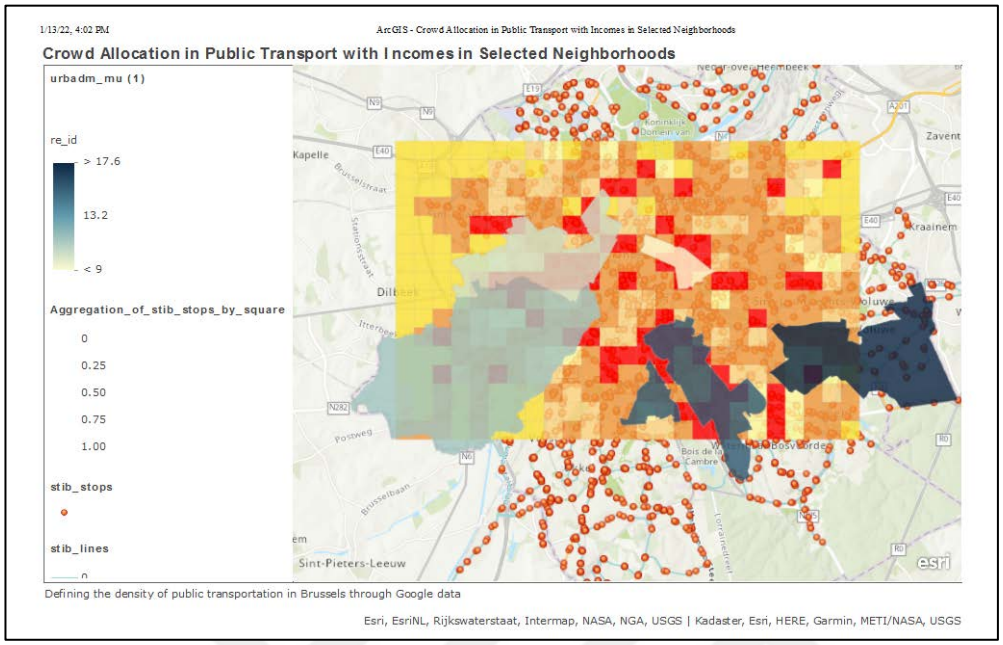

Figure 4.9. Crowd Allocation in Public Transport with Incomes in Selected Neighborhoods

According to the figure above, the neighborhoods receiving less income per inhabitant are facing relatively denser public transportation services. Molenbeek and Sint-Joost are the ones that are not capable to provide a convenient space and service to their inhabitants. This might keep the individuals living here in the danger to get COVID-19 more than other places with more balanced transportation services. However, the less dense public transportation providers, the city of Anderlecht and Woluve was receiving better income levels than the Brussels Capital Region average in 2019. However, the city of Ixelles performs a different indicator and gets dramatically more income per inhabitant from Brussels average but also receives dense usage of public transport. Location of the district is in a key role in that point, the close distance to EU neighborhood, governmental bodies and historical district may make this place attractive to young professionals working for EU or other governmental bodies who receives good salaries that we discussed in the chapter of the social context of Brussels. In the COVID-19 period, the group of young professionals as part of the lucky persons who could work remotely. However, the city has central commercial activities and some other sectors doing its activities in Ixelles such as finance, banks, retail,

consultants who might be another reason for the relatively denser public transport usage.

Figure 4.9 below explains the concentration of EU citizens living in Brussels and their mobility trace on the map. The case of Ixelles and Woluwe shows completely different outputs in terms of urban mobility. Even though these two neighborhoods are the closest ones in terms of income level per inhabitant and both a place where EU national concentrated they show quite different mobility trends. There might be a few reasons for that, the first thing the possibility of people living in Woluve to be part of another social group in terms of the level of education, the status of marriage and having children and age. So, it means that person living in Woluve has more aged from Ixelles and their needs require a car instead using public transport. The social research in the previous chapter supports this idea by examining the age groups living in the selected districts.

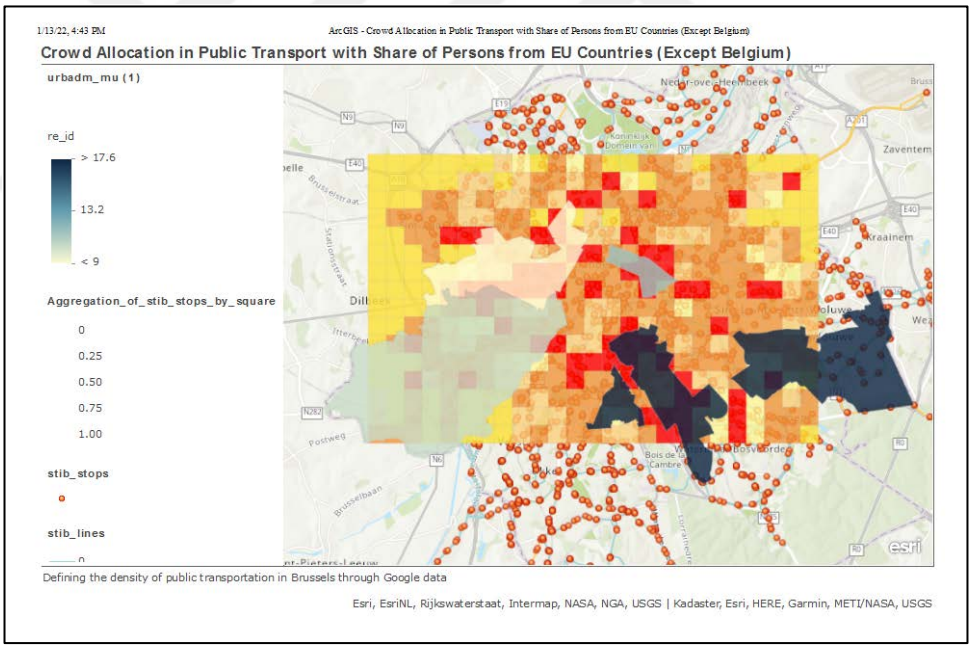

Figure 4.10. Crowd Alllocation in Public Transport with Share of Persons from EU Countries (Except Belgium)

However, Ixelles is just an exemption, the relatively densest public transport use places are the ones with more people from non-EU countries. The figure below shows a mapping that overlaps the places non-EU citizens concentrate and the urban mobility trends during COVID-19 times.

As a place is closer to the city center, art shops and museums, central locations, events in the evening time, Ixelles might create a more attractive image for young people to live there. This interest is so high we observed that there might be ongoing gentrification in the central neighborhood of Ixelles called Matogne creating an identity on African culture with its restaurants, museums, or music events.

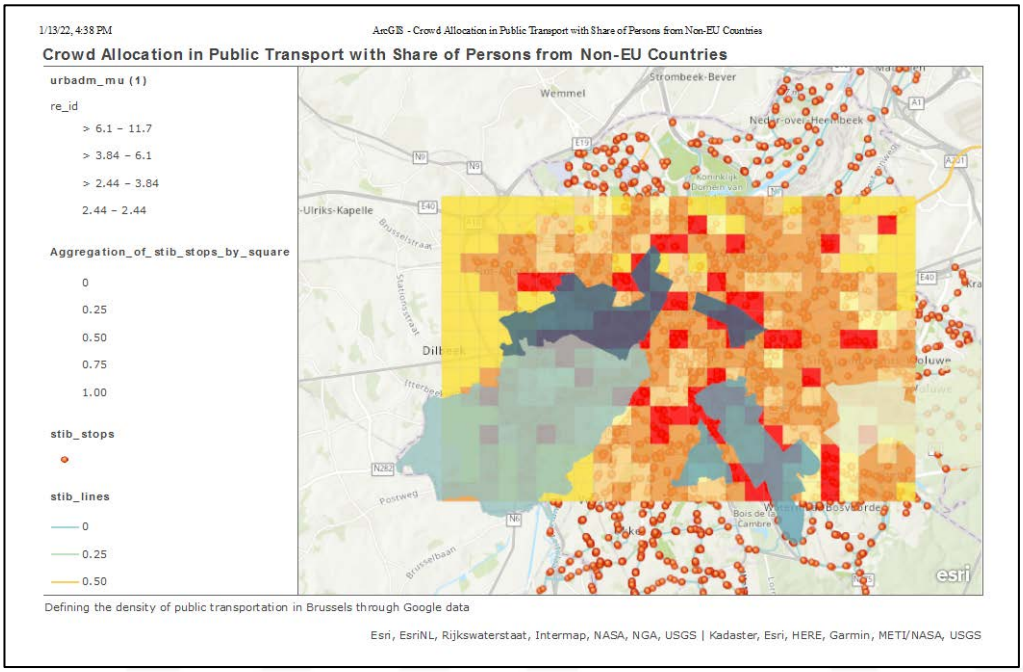

Figure 4.11. Crowd Allocation in Public Transport with Share of Persons from Non-EU Countries

As we emphasized before the neighborhoods of Zavel, Marollen, Stalingrad, Anneessens, Kuregem Bara, Kuregem Veeartsenij, Kuregem Dauw, Hertogin, Weststation, Historisch Molenbeek, Koekelberg, Havenwijk, Oud Laken West, Oud Laken Oost, Noordwijk, Brabantwijk are historically receive more migrant population from North- Africa and Sub-Sahran Afrika and the neighborhoods that citizens of 15 European countries live is divided. The districts in which these neighborhoods are located are Anderlecht, Sint-Joost, etc. Elsene and Sint-Pieters Woluwe. These districts were seen as the districts that were taken into consideration during the analysis in this study to demonstrate the comparison of social data with transportation. The case neighborhoods selected by their more marginal status of social data such as less good living conditions, less accessibility to public transport, higher numbers of migrant background people, and higher rates of unemployment. Only one neighborhood is

selected as the exact opposite of what we listed above. Sint-Pieters-Woluwe is a neighborhood with lower rates of unemployment, lower numbers of migrant people, and higher tax returns than the other 4 cases. In that way, we hope to make a comparison between the cases as they are diverse in social data. Some groups living in the city are more vulnerable in the event of a crisis that will occur in the future, based on the public transportation station density map that we provided using ArcGIS, in periods when post COVID-19 mobility approaches the old levels again. In this context, when the density data are combined and distributed to the whole city by combining the stops within every 500 meters, it has observed that the groups with cultural and historical differences live in the density and the neighborhoods known as immigrant neighborhoods in the public are more deprived of public transportation infrastructure.

Our main finding from the data overview and overlapping them with socio-economic data, certain neighborhoods receive relatively denser and more crowded public transportation levels during COVID-19 times. The neighborhoods that are socially and economically vulnerable shows a denser use of public transportation and crowded transportation stops during pandemics as we predict before started to think about this dissertation study. Therefore, according to the Google public transport data obtained within the scope of this study, the hypotheses we mentioned at the beginning were confirmed.

5. CONCLUSIONS & FUTURE RECOMMENDATIONS

The study focused on determining public transportation trends of the communities that had to go out more than other groups depending on the status of some social and economic characteristics during the ongoing COVID-19 pandemic in the Brussels Capital Region in Belgium. While doing this research Google's data was processed in the parts related to mobility. In addition, socioeconomic indicators were collected from public authorities and processed on the GIS together with mobility data.

Even though the pandemic has impacted almost every region around the world, the impacts and the responses may vary depending on social, environmental, and economic conditions. Since there are many ways to assess impacts on the communities (Xiong et al, 2020) the study adopted methods over public transportation mobility changes by using field data comes from mobile phone providers through the applications that everyone uses in their smartphones.

Using sensor data comes from smartphones, getting row data from some providers who make crowdsourcing apps, or just getting ticket validation numbers from public transportation authorities (Jenelius and Cebebauer, 2020) might be useful to understand mobility trends and the reasons behind it during a crisis.

Previous studies held in Poland (Barkowski et al, 2020) explain the social impact of change in mobility trends, and one other work investigates the impact of daily mobility changes in Canada (Fatmi, 2020), and influence on travel behaviors of the people living in Sweden (Jenelius and Cebebauer, 2020) bring some light to the issues of chancing mobility trends in urban space, their reasons and it's impacts on the communities during a health crisis.

Using methods like sensor data or crowdsourcing by using mobile phones is getting even more popular than ever due to accuracy, low costs and physical difficulties of making fieldwork since the pandemic started. On the other hand, this kind of secondary data provides a more reliable and trustable data source than the traditional methods (Mahajan et al, 2020).

That is why in this thesis, it is decided to carry out a fieldwork using secondary data acquired from Google and some other providers, process it in the GIS, and provide

meaningful output by comparing it with the social-economic data. Moreover, an inquiry about the best methods to be used in this study was made based on the literature. Google popular times was chosen because it is based on the signals from smartphones and crowdsourcing applications embedded into the Google maps application.

Having so diverse social structure and updated open data sources, Brussels provides a wealth of materials to work on social disparities during COVID-19 times. The study focuses on the communities in Brussels that could possibly be considered vulnerable due to socio-economic problems coming from their migration a cultural background.

The problems around vulnerable persons are getting less information as part of disaster management (Atun, 2021), having harsh physical conditions such as no sufficient space for social distance in public transportation while working or traveling somewhere else in the city. Moreover, communities that have no convenient social and institutional infrastructure receive less information which may be vital during a health crisis (ibid,2021). While in a situation that many authorities set rules to minimize the impact of disaster during COVID-19 times, suffering from lack of information and training might result in more cases, casualties, and indirectly blockage of the health system in a particular region. It may create masses of people in vulnerability, and it might be seen as the problem of sustainable and balanced urban development to solve with an approach of supporting vulnerable communities even more.

As a result of collecting, processing the data we obtain, and correlating the socio-economic indicators in Brussels the study comes up with some original conclusions.

1. Public transportation mobility is higher in the neighborhoods that urban poor live in during COVID-19 times including the majority of the people who migrated from other countries to Brussels.
2. The impact of the pandemic has not been perceived in some way or level. The neighborhoods that include higher numbers of migrated people that already show a lack of social and economic stability, impacted more than upper-middle classes.
3. Spatial concentration of individuals who migrated to Brussels and the upper-middle class in different neighborhoods creates an imbalance in spatial development,

especially in urban transportation infrastructure. It deepens the impact of the disaster due to preventing reliable public policies such as establishing a more balanced urban mobility system.

4. The measures that governments have been taking during COVID-19 might help to minimize health-related issues in a short turn. However, it deepens unequal social and economic matters for vulnerable communities in the long turn.

5.1. Further Studies

In case of any future crises, especially the one related to health issues, it is the first thing for any administration to constitute physical requirements coming from the nature of the disaster. As a conclusion from our GIS-based work here in this article neighborhoods of Anderlecht, Sint-Jans Molenbeek, Elsene and Sint-Joost-ten-Node have been suffering from high rates of public transportation occupancy rates in the middle of the pandemic.

As a trusty data source, technologies like Google or other mobile phone providers might help to determine occupancy rates and make a direction for scientists and public policymakers. Higher rates of public transportation occupancy in Anderlecht, Sint-Jans Molenbeek, Elsene, and Sint-Joost-ten-Node tend us to conclude providing more space in public transport which comes with more investments in green and alternative means of transportation such as new bike routes. It may not seem like a coincidence that the persons living in the neighborhoods with fewer salaries use more crowded public transportation utilities. So, the problem may simply base on the providing a budget by local administrations for a convenient public transport infrastructure.

This study tries to show that the neighborhoods of Anderlecht, Sint-Jans Molenbeek, Elsene, and Sint-Joost-ten-Node have suffered from the physical requirements of the health crisis. It also points out that the socio-economic infrastructure needs to be improved. So, these two aspects follow each other and make them in a cause-and-effect relation. From the case of Brussels, we concluded that persons tend to live close to others who look like themselves. This similarity may contain income level, homeland country, or being part of the same economic class from two different countries. Therefore, it makes us think that the people who tend to live close to each other make the jobs close each other such as computer desk jobs or menial jobs and it

may cause a division of labor based on the spatial organization such as a group of people doing same jobs living in the same neighborhoods. Further widening the differences between different groups may lead to inconvenient results in times of crisis. Most likely the jobs bring less profit in the first 4 neighborhoods more tend to be menial jobs with less technological output and less educational requirements. So, the conclusion that these neighborhoods use more public transportation is a reason that they do more physical contact required jobs and mobility in the city even during a pandemic.

This study yields results that confirm that the rate of transmission is high in the neighborhoods where immigrant groups live. If we consider the importance of public transportation during crises, it is expected that the data obtained from this study will help the studies to be done in future crises. It is observed that the groups that must use public transportation more intensively and even in times of crisis are people with a social and economically vulnerable immigrant background. Studies in this field can make progress in revealing more different common aspects of people in regions that use public transportation intensively during any crisis. In addition, it comes to mind that the policies put forward by central and local governments to protect the society tend to worsen the situation in neighborhoods exposed to urban poverty in the medium and long term, rather than improving it. The analysis of public transportation data and the creation of meaningful spatial analyzes in times of crisis by using Google data is a very new subject that needs to be studied more intensively. It is recommended for future studies to conduct research on how and at what level vulnerability occurs during crisis periods in neighborhoods or communities where there is a lack of social institutions.

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