TeMA

Journal of
Land Use, Mobility and Environment

Cities need to modify and/or adapt their urban form, the distribution and location of services and learn how to handle the increasing complexity to face the most pressing challenges of this century. The scientific community is working in order to minimise negative effects on the environment, social and economic issues and people's health. The three issues of the 14th volume will collect articles concerning the topics addressed in 2020 and also the effects on the urban areas related to the spread Covid-19 pandemic.

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METHODS, TOOLS AND BEST PRACTICES

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The cover image is a train passes a rail road crossing that is surrounded by flooding caused by rain and melting snow in Nidderau near Frankfurt, Germany, Wednesday, Feb. 3, 2021. (AP Photo/Michael Probst)

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Investigation of the effects of urban density on Covid-19 pandemic

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Abstract
Decisions regarding land use are amongst the most important decisions of a city planning process, and density arrangement is one of the key parameters for it. The effects of urban density on the Covid-19 infection are investigated in this study through the sample case of İskenderun district, in which 3 different urban density areas are selected for this investigation (high, medium, low). The course of the Covid-19 pandemic was then followed through the number of cases in the period of September-December 2020 for these regions via a novel indicator Pandemic Index (PI). The case data were obtained from the "HES" application developed by the Ministry of Health of the Republic of Turkey to monitor the spread of the Covid-19 pandemic, and the case density maps recorded in the application for this purpose were digitized through an in-house image processing software. As a result of the examination, it was understood that the high-density zone has higher values for Covid-19 "cases and contacts percentage" and "PI rating" (61 and 173 respectively), whereas for the low-density zone these values drop significantly (23 and 39, respectively). The results are indicative that the lack of urban land production and high population concentration, which have become important problems of developing countries and regions due to rapid population growth, are indeed strong factors for the spread of diseases, such as the Covid-19 pandemic.

Keywords
Covid-19; Land use; Urban density; Image processing.

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1. Introduction

Decisions regarding land use are amongst the most important decisions of a city planning process. Land use planning covers a broad range of activities, from the development designs that take on new empty land to put into a function, to reorienting of the existing structures into a new form factor, or to the redevelopment of individual areas or whole neighbourhoods as new building areas with new uses. Determining how the physical configuration of the used area should change, develop, and adapt to meet the present and future needs of their residents, is a crucial task indeed.

Acting as a connection between the spatial dimensions of past and future, urban planning is a fundamental design process that affects every human living in that particular area of the civilized world. The social behaviour, education, health, welfare, agriculture, transportation, and other similar issues that are related to human-human and human-environment relations are directly influenced by the outcomes of urban plans and decisions.

It has long been accepted that the decisions regarding the use of the land must, therefore, take numerous aspects into account, such as economy, industry, education, transportation, religious activities, and agriculture, housing, trade, military, and health affairs. That being said, the potential impacts of a pandemic have not been considered a prevailing aspect in this process, at least at a significant level, until recently. The emergence of the Covid-19 pandemic, however, has changed many aspects of human society, and land-use decisions regarding the urban density are starting to get their fair share of impact from the pandemic as well.

Indeed, the field itself has been open to changes throughout its history. Land use and land cover decisions have already been changing as time progresses, as things that influence these decisions or are influenced by them change over time (Tira, 2021). Up until now, the effects of humans in urban spaces have been the fundamental causes of changes in land, particularly for the last century. Human influence has been so influential that some researchers consider the term "land use planning" as the practice and processes associated with the "urban and regional" strategic planning (Stevens et al., 2018).

Urban health, however, is starting to be seen as a global health priority (Etingoff, 2017), which was further accentuated with the rapid spread of the Covid-19 pandemic. It has been understood that urban planning and related policies can influence public health directly or indirectly, through factors like housing, employment, protection from environmental risks, access to primary health care, and protection and proximity to disasters, etc. The relation between cities and the spread of diseases has been an increasing concern for WHO since the 1990s. A key factor in this issue is the city planning stage, along with the relevant decisions taken during the planning (TÜRKOĞLU, 2020). The mechanism related to the spread of pandemics is now also being added to this list as a very influential factor (Etingoff, 2017). These are, then, being included in the list of factors that are considered when making decisions for deciding urban density.

And yet, the exact mathematical reflection of these mechanism of spread of various types of diseases has not been fully explored in terms of land use decision making. Studies that focus on urban density in different locations of a given town to reveal the effects of it on the incidence rate are only a handful in number. Considering the fact that the world is open to further pandemics, whether born as part of normal social life or following wars and natural disasters, it is important to reveal mechanics that are based on the relationship between population and housing density and the spread of diseases.

That being said, measuring the exact impact of such factors on urban, public, and individual health has been a challenging task. WHO (World Health Organization) has provided certain criteria for cities to be considered "healthy". These criteria include a sustainable eco-system, a clean, quality, and safe physical environment, the fulfilment of the basic needs, an optimum level of public health, access to treatment and health systems, and fewer diseases and more healthy individuals on average, compared to a location's counterparts (WHO, 1997). Covid-19 has shown to the world that large-scale health problems and diseases are not exclusive to underdeveloped regions and countries. In fact, as of January 2021, developed countries have arguably suffered

more than their underdeveloped counterparts, where heavily urbanized and densely populated cities like Istanbul, Beijing, New York, Paris, and Rome had seen the highest spread ratios for the disease as it is seen in the reports of United Nations and World Health Organization (UN, 2020; Covid-19 and Healthy Cities, 2021).
The reaction of the academicians to the Covid-19 pandemic was very fast. This reaction started with health care and vaccine and medicine researches as expected. When the initial panic ended, however, studies in a wider range of fields started to shape up in the literature that involved social, physical, and environmental effects and results of the Covid-19.

The relation regarding the public spaces and the spread of the Covid-19 pandemic has been investigated by Gehl (Gehl, 2020), through surveys performed in Copenhagen. The idea of that study was to understand the mechanics of Covid-19 to be able to prepare alternatives for post-pandemic times, as a way for adaptation to future crises. From the mobility and usage points of view, it was seen that the use of public spaces like recreation areas and parks had regressed to lower levels than that of the streets of trade and city centres.

In the study of Alrouf (Alraouf, 2021), it was proposed that new lessons were learned from the lockdown times and these will be reflected on architecture and planning as novel behaviors. The researcher believes this will be performed through approaching a "new normal" in the way places, neighbourhoods, and cities are designed and planned.

The relation between land-use, urban density and population density is intricate. As the population density only deals with the number of people living in a unit area, urban density covers all the aspects and it is considered as an important factor in understanding the function of cities. Whereas land-use investigated the area in a broader concept, regarding the decisions of human use and density.

There are various studies about the effect of decreasing air pollution and its effects on the spread of Covid-19 (Krecl et al., 2020), involving aspects like the decreases in transportation and industrial activities that took place, particularly focusing on high-density urban areas (Cadotte, 2020). In the example of the Metropolitan Area of São Paulo, the decrease in transportation and industrial activities was found to range between 34% and 68% (Krecl et al., 2020). Similar studies were also performed on intermediate-sized areas as well covering the urban morphology and air-pollution (Oshrierh and Valipour, 2020).

The effect of the pandemic on urban mobility has also been researched as another significant aspect. Fatmi (Fatmi, 2020) discussed that the behaviors of individuals and groups changed drastically during the times of the pandemic, and some of these changes are expected to become permanent. Another study has shown an average of 10% decrease in the "Mobility Index" for a total of 40 metropolitan cities that are in 5 different continents (Soucy et al., 2020). The decrease in mobility has also been determined in the public transport services, with the highest drop observed with 93% in Spain (Aloi et al., 2020).

The relationship between urban activities and urban industrialization with the transmission of the disease and its medical geography was evaluated for Salem, Iran (Salari et al., 2020), and the researchers proposed some managerial data. The effect of urban density on Covid-19, however, has been studied only in a few instances. Carozzi et al. (2020), for example, focused on the link between urban density and Covid-19 spread. It was emphasized in that study that the density variable has influenced the timing of the outbreak in each county, where denser locations were found to be more likely to have an early outbreak. The digitalization in these studies regarding the base data is limited, however, and does not include spatial information. Instead, these focus solely on the number of cases and the population. Only one study that was performed in Turkey (Gündoğan et al., 2020) focuses on the relationship between the urbanization process and the demographic structure, which were examined considering epidemic diseases that occurred in the past, particularly following earthquakes. It has been evaluated in that study that the metropolitan cities in Turkey, İstanbul in particular, have been planned without considering pandemics as a parameter.

Differing from previous studies, this study aims to evaluate the effects of urban density on the spreading mechanics of the Covid-19 pandemic. The well-known phenomena that crowded spaces will increase the spread of contiguous diseases especially within respiratory systems, is tired to be investigated regarding the urban density that directly effects the population density and human interaction within an urban area. As a unique study relying on location and time-based data supplied by a governmental system, it is believed that the reliability of the analysis is more than adequate. It is also hoped that the monitoring of the course of a pandemic with image-processing software will be another contribution of this study to urban science knowledge.

2. Methodology

2.1 Data acquisition

The Republic of Turkey Ministry of Health has developed a mobile application named "Hayat Eve Sığar" (HES, Life Fits into Home) to monitor the course of the Covid-19 pandemic, and the data was also made public through the application. HES was initially published to application stores on the 20th of May 2020 with basic functionality, and the application has been updated numerous times for increased functionality since then. HES is connected to the Ministry's GIS databases and uses GPS to locate the users.

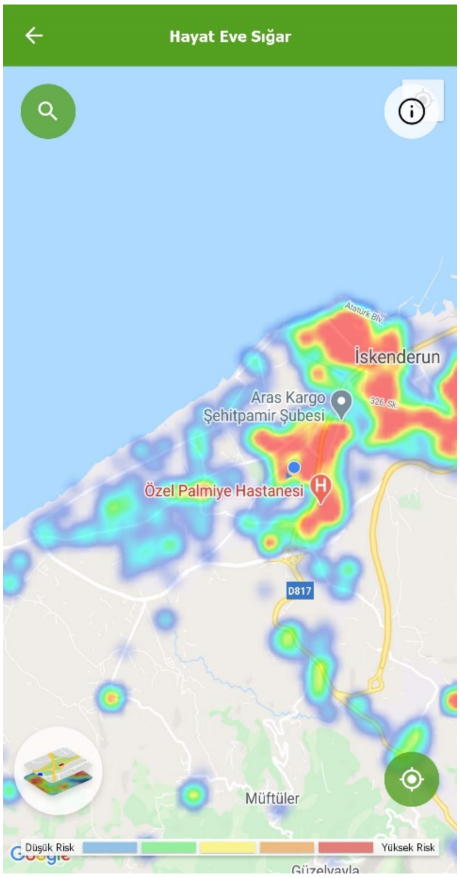

Fig.1 Screenshot of HES application at 22.12.2020

In this study, the data for the Covid-19 cases and people in proximity with infected individuals as determined by official filiation personnel was gathered using the heat map functionality of the HES application. This map (Fig.1) provides a risk potential density for Covid-19 cases and individuals contacted by them using a rainbow color scale legend. The information in this map is updated when the Ministry decides so a methodological update in the data is not the case.

The data between the 9th of September and 27th of December was collected by taking screenshots of the heat map screen of the HES application. The maps are based on the GIS-based databases of the Ministry of Health, which were updated with irregular intervals. For this reason, screenshots as data sources were not taken regularly either, but enough screenshots (Tab.1) have nonetheless been obtained. This time interval covers the second peak of pandemic in Turkey. As like all around the world first peak has caught everyone unexpectedly. The HES started to produce heat maps just after first peak of pandemic in turkey and the data is collected regarding these.

Number	Date	Number	Date
1	19.09.2020	11	27.11.2020
2	22.09.2020	12	28.11.2020
3	30.09.2020	13	02.12.2020
4	02.10.2020	14	06.12.2020
5	05.10.2020	15	07.12.2020
6	16.10.2020	16	09.02.2020
7	01.11.2020	17	13.12.2020
8	06.11.2020	18	22.12.2020
9	18.11.2020	19	27.12.2020
10	24.11.2020	-	-

Tab.1 The dates of the screenshots taken for data collection

2.2 Data processing

For the digitization of the data, the images were processed using an in-house GNU-Octave-based program developed solely for this purpose, which runs on a simple image processing routine. The program classifies the density of the risk using the 6 colour categories as a means of rating. These categories are Red (6), Orange (5), Yellow (4), Green (3), Turquoise (2), and Blue (1). Red defines the highest risk with a coefficient of 6 (number of cases and contacts) while blue represents the lowest density with a coefficient of 1.

Fig.2 The processed image of the case area

Fig.2 shows the image of a processed sample image (for the date 22.12.2020) where all 6 colour groups have been replaced with black colour for sake of checking the consistency of the program. This figure is used for the verification of the image processing as it is seen the heat map of HES application is totally covered.

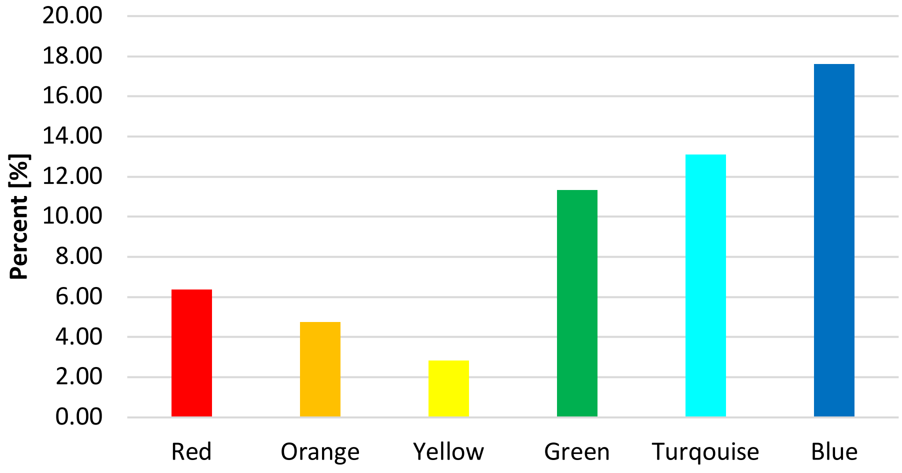

Fig.3 The percent of risk categories in 22.12.2020

The course of the pandemic is evaluated with this digitalization process, where the percentages of the six categories in the land areas represented by the HES screenshot images were calculated. Fig.3 shows a sample for the evaluation of the behaviour of the program. As the percentages of colour levels are separately given. It can be seen that, on that particular day, 55.97% of the land areas (in the processed image) were marked with a colour, at least by the blue (rating 1).

$$PI = \sum_{i=1}^{6} i * Percentage_i \qquad i: 1 - 6: Blue - Red \tag{1}$$

Pandemic Index (PI, Eq-1) is the summation of the 6 categories' coefficients with the percentages calculated. Using the above equation, the weighted sum of this particular day was found as 151 PI. PI is an indicator of the risk level for the Covid-19 in the area, and the higher the number, the higher the risk is.

3. Case Area: Iskenderun

The study has been conducted on the selected parts of the greater Iskenderun urban area. The township of Iskenderun is located on the east Mediterranean coasts of Turkey (Fig.4) and is a district of the city of Hatay. The town has a population of 248.000 in the city centrum, and around 400,000 additional people live in the greater urban area around it that covers parts of Arsuz and Belen districts as well.

Fig.4 Iskenderun in Turkey

The city is well known for its seaports, iron and steel industries, fisheries, and clean seas that see high volumes of tourism activities. As an industrial city with ample amounts of trade and tourism city, Iskenderun presents a very cosmopolitan and complex social diversity. The history of the town starts as early as 333 BC as it was founded by Alexander the Great, with the initial name of Alexandria.

As being one of the biggest counties in the country with a wide range of economic diversity as well as rapid changes in the urban texture and urban density Iskenderun area is selected as a case for investigation of the relation between urban density and Covid-19 pandemic.

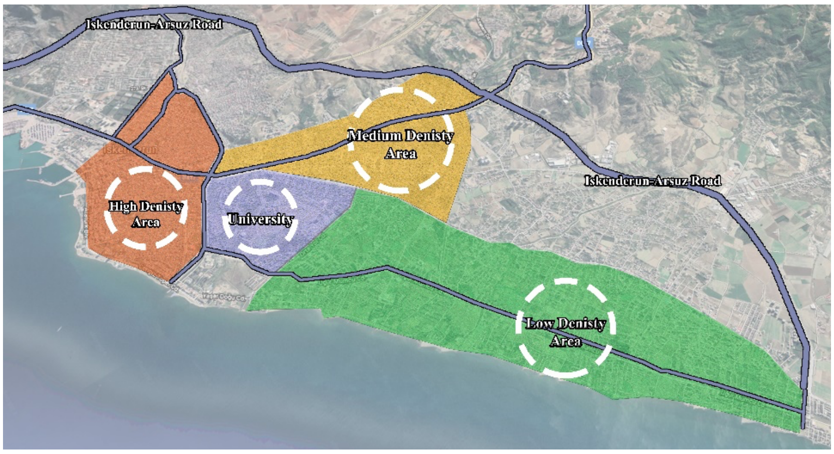

Fig.5 Density zone in the case area

The case areas selected for the study were categorized in one of the three groups as high, medium, and low-density urban areas (Fig.5). The high-density area is mostly consisting of the city centre which has a population density of 301-600 individuals/ha (gross), and where a mixed land-use is in place with trade centres, offices, education establishments, and residences are present (Fig.6).

(a) High Density (b) Medium Density

(c) Low Density

Fig.6 Study areas (Self Photograph archive)

The population of the area has been determined as approximately 60,000 people in 2019. It is also worth mentioning that the average floor number in the development plan of 2020 was between 4 and 6 for this area. The texture of this area has relatively few open areas. When the figure-ground analysis (Fig.7) is examined in order to better analyse the structure and open area relationship of three different tissues, it is remarkable that the voids are quite low in the high-density tissue. Contrary to the high-density texture, the low-density texture shows that the empty spaces are quite high, and the construction is less.

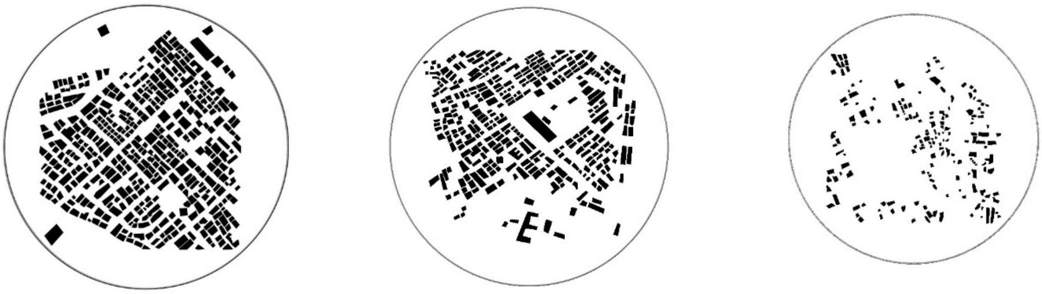

Fig.7 Figure-ground analysis maps of three density zones high, medium, and low respectively.

On the other hand, the medium-density area has a population density of 151-300 individuals/ha (gross) and consists mostly of the "Mustafa Kemal Neighbourhood" where the mainland usage is "housing". There are some small trade and business establishments, and the population was determined as 40,000 in 2019 data. The region can be described as a location where the structures create a discrete pattern and that has numerous open areas. The neighbourhood is on the road that leads to the Belen district.

The low-density area consists solely of the Karaağaç neighbourhood with a population density of 51-150 individuals/ha (gross). This area is appertained to the Arsuz district in terms of civil authority but is geographically located in the greater urban area of Iskenderun. The area has a population of 20,000 according to 2019 data. The land-use area mainly involves housing, with only three stores and large, open, agricultural spaces. The most dominant housing type in the area consists of two-store single housings.

Fig.8 Traffic Density through in the case area

Moreover in order to understand the density in regions traffic density in the area has been mapped (Fig.8) using Google traffic data (Google Maps, 2021) since the traffic data is a crucial indicator for human interaction density as well as other indicators (Kanyepe et al., 2021)

4. Results and discussion

As the aim of the study was to reveal the relationship between the spread of the Covid-19 pandemic in the İskenderun area with urban density, the data gathered from the image processing based computer program was tabulated first (Tab.2, Tab.3 and Tab.4) and for low, medium, and high urban densities, respectively. These tables represent the Covid-19 cases (positives or contacts) for the areas of the defined densities land boundaries. The date, colour level, and total coverage of the Covid-19 patients and contacts and PI (Pandemic Index) is tabulated in these tables as the crucial raw data of the study.

Day_Month (2020)	Red %	Orange %	Yellow %	Green %	Turquoise %	Blue %	Total %	PI
19_09	0.00	0.00	0.00	0.00	0.76	16.15	16.91	17.7
22_09	0.00	0.00	0.00	0.03	0.95	16.85	17.84	18.9
30_09	0.00	0.00	0.00	0.15	0.94	6.89	7.98	9.2
02_10	0.00	0.00	0.00	0.24	2.45	9.15	11.83	14.8
05_10	0.00	0.00	0.00	0.00	0.17	8.37	8.54	8.7
16_10	0.00	0.00	0.00	0.00	0.14	2.26	2.39	2.5
01_11	0.00	0.00	0.00	0.00	1.40	7.81	9.21	10.6
06_11	0.00	0.00	0.00	0.00	0.40	2.78	3.17	3.6
18_11	0.00	0.00	0.00	0.38	5.66	12.63	18.67	25.1
24_11	0.00	0.00	0.00	0.55	5.49	12.18	18.23	24.8
27_11	0.05	0.50	0.58	3.99	7.24	15.14	27.49	46.7
28_11	0.06	0.54	0.61	3.99	6.98	14.46	26.64	45.9
02_12	0.32	0.69	0.67	4.72	10.22	17.29	33.91	59.9
06_12	0.62	0.49	0.83	8.90	18.21	15.61	44.65	88.2
07_12	0.50	0.49	0.45	6.26	17.51	18.01	43.22	79.1
09_02	0.54	0.89	1.21	8.17	14.37	18.56	43.72	84.3
13_12	1.38	1.18	1.74	9.23	14.11	16.03	43.68	93.1
22_12	0.75	0.60	0.65	3.98	12.45	20.16	38.59	67.1
27_12	0.00	0.43	0.77	3.92	8.67	14.11	27.90	48.4
Average	0.22	0.31	0.40	2.87	6.74	12.87	23.40	39.40

Tab.2 The results for the low-density area

A portion of the studied period coincided with the second pandemic peak. As the values represent the density of the cases and contacts for the given times and areas, the comparison of the tables for different population densities reveals that urban density is significantly influential over the spread of the disease.

Day_Month (2020)	Red %	Orange %	Yellow %	Green %	Turquoise %	Blue %	Total %	PI
19_09	0.00	0.00	0.00	4.29	20.31	17.80	42.41	71.3
22_09	0.00	0.00	0.00	4.65	17.30	17.88	39.83	66.4
30_09	0.00	0.00	0.00	1.84	10.64	20.46	32.93	47.2
02_10	0.00	0.00	0.00	1.33	9.75	15.16	26.24	38.7
05_10	0.00	0.00	0.00	0.45	7.62	12.85	20.91	29.4
16_10	0.00	0.00	0.00	0.00	3.03	18.47	21.51	24.5
01_11	0.00	0.00	0.00	5.84	10.74	20.72	37.29	59.7
06_11	0.00	0.00	0.00	0.54	9.07	21.11	30.72	40.9
18_11	0.00	0.51	1.48	12.56	15.08	14.22	43.85	90.5
24_11	0.00	0.31	1.45	14.40	14.12	11.09	41.37	89.9
27_11	7.95	6.44	5.66	17.90	8.67	14.48	61.09	188.0
28_11	8.17	6.80	4.98	18.11	9.18	13.60	60.84	189.2
02_12	9.71	7.96	3.95	15.63	8.39	13.64	59.28	191.1
06_12	16.93	5.95	4.30	13.61	8.34	13.25	62.37	219.3
07_12	15.62	5.95	4.41	15.91	9.02	13.49	64.41	220.4
09_02	15.75	5.80	4.02	14.55	8.49	9.30	57.90	209.5
13_12	23.78	7.47	4.58	15.68	10.08	11.21	72.79	276.7
22_12	10.30	6.94	3.87	11.85	8.11	9.67	50.73	173.4
27_12	3.89	5.56	5.41	20.81	12.76	14.33	62.77	175.1
Average	5.90	3.14	2.32	10.00	10.56	14.88	46.80	126.3

Tab.3 The results for the Medium-density area

Day_Month (2020)	**Red %**	**Orange %**	**Yellow %**	**Green %**	**Turquoise %**	**Blue %**	**Total %**	**PI**
19_09	0.00	0.00	0.00	0.28	19.76	30.63	50.67	71.0
22_09	0.00	0.00	0.09	5.07	24.07	24.63	53.86	88.4
30_09	0.02	0.51	0.67	9.01	14.85	28.93	54.00	91.0
02_10	0.00	0.48	1.51	11.43	17.19	26.27	56.88	103.4
05_10	0.00	0.00	0.00	8.86	21.21	28.00	58.07	97.0
16_10	0.00	0.00	0.00	1.89	15.06	24.81	41.76	60.6
01_11	0.00	0.35	0.90	14.87	26.04	19.23	61.39	121.3
06_11	0.00	0.00	0.00	0.21	8.10	26.95	35.26	43.8
18_11	0.00	1.21	3.05	24.69	20.83	17.18	66.96	151.2
24_11	0.00	0.99	3.16	21.47	21.62	17.54	64.78	142.8
27_11	15.07	9.85	6.98	23.25	13.15	9.40	77.70	273.0
28_11	14.21	11.67	6.62	24.22	12.18	9.62	78.52	276.7
02_12	17.82	13.32	5.37	22.14	10.75	9.91	79.30	292.8
06_12	19.47	7.60	6.14	20.23	9.43	5.75	68.63	264.7
07_12	17.71	7.46	5.46	21.24	9.88	7.86	69.61	256.7
09_02	19.43	7.75	6.69	20.49	9.28	8.72	72.35	270.8
13_12	28.32	9.15	4.61	16.99	8.27	6.30	73.62	307.9
22_12	17.05	10.50	7.22	2.33	11.33	8.05	56.48	221.4
27_12	10.09	6.91	6.69	2.60	12.13	14.53	52.95	168.4
Average	8.38	4.62	3.43	13.22	15.01	17.07	61.73	173.8

Tab.4 The results for High-density area

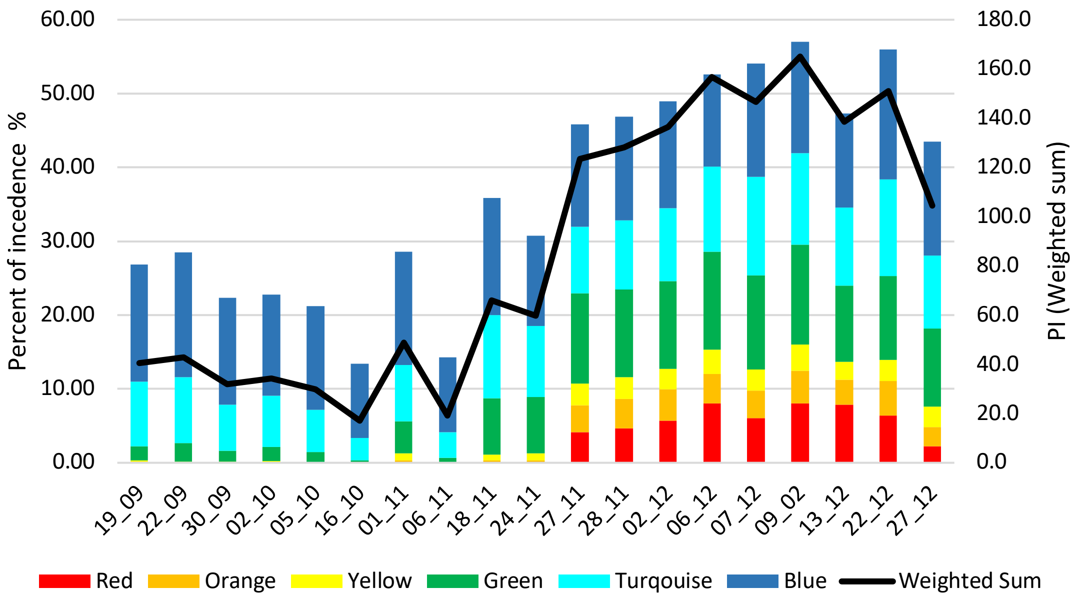

Fig.9 The course of Pandemic in overall Iskenderun

In Fig.9, the situation of the Covid-19 spread in the Iskenderun area can be seen in terms of colours of the heat map, now transformed into a bar graph over the days. Each colour represents the percentage of incidence of Covid-19 in specific date.

The situation is in harmony with the general outline of Turkey's case progress as given in (Covid.msb.gov.tr). In the figure, the densities of the cases and contacts can be tracked by zones of colour as described. This figure gives the fundamentals for Covid-19 progress in the city.

The 2nd peak of the pandemic starting from late November dominantly covers the figure where the increase in the red and orange colours represents the fact that the total PI index reaches up to 200s.

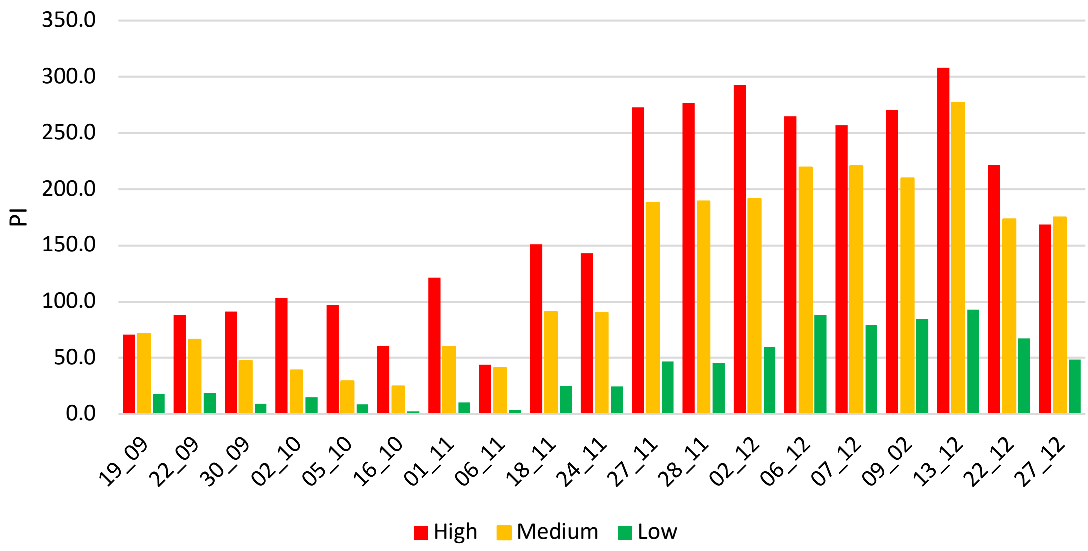

Fig.10 The course of Pandemic thorough Pandemic Index

After evaluating the Covid-19 pandemic status for Iskenderun in the given time interval, the evaluation of the 3 density zones in the case area was visualized by PI values in Fig.10. The figure shows that for all the dates for the high-density zone, the PI is higher than both that of the medium and low-density zones', but the gap is much more relevant in peak periods that start late November. Furthermore, when the rates of increment are evaluated it's once again seen that the increase rate (differential) of the PI in the high-density zone is higher, compared to its medium and low counterparts. The levels are similar between the high and medium density zones as of the 6th of December, as the medium density zone seems to follow the high-density zone with a delay. The predominant difference of the low-density zone with other areas can be seen for all dates.

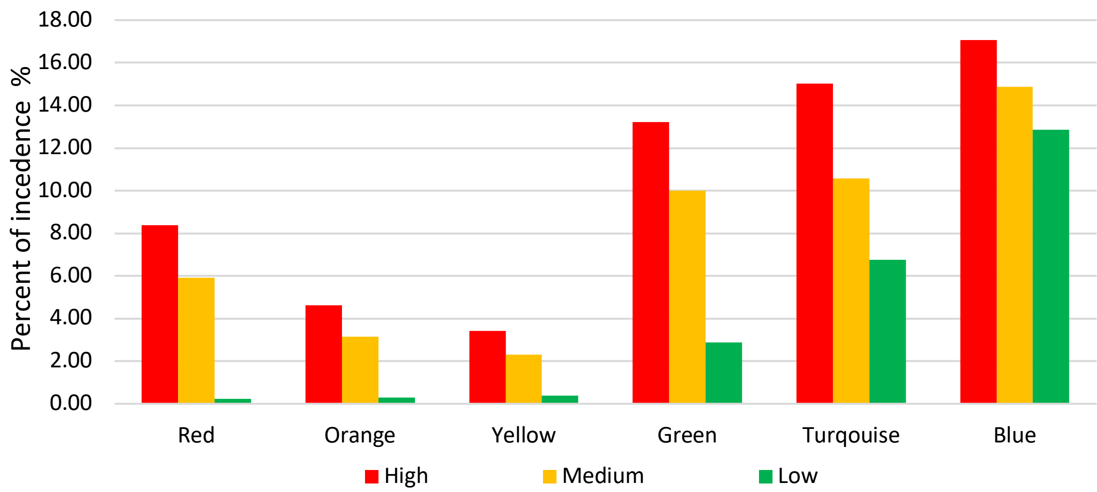

Fig.11 The average percentages of 6 PI levels for the three density areas

In Fig.12, the average values for all dates for each of the three density zones are given as a percentage of coverage and PI index. It is evident that the high-density zone has the highest percentage and PI values with 61 and 173, respectively, whereas these values are 23 and 39 respectively for the low-density zone. The tendency of the numbers is as expected which holds true for Fig.11 as well, where the six categories for three density zones are shown. Interestingly, the high-density zone has the highest value in all categories in Figure 8, even in the blue rating.

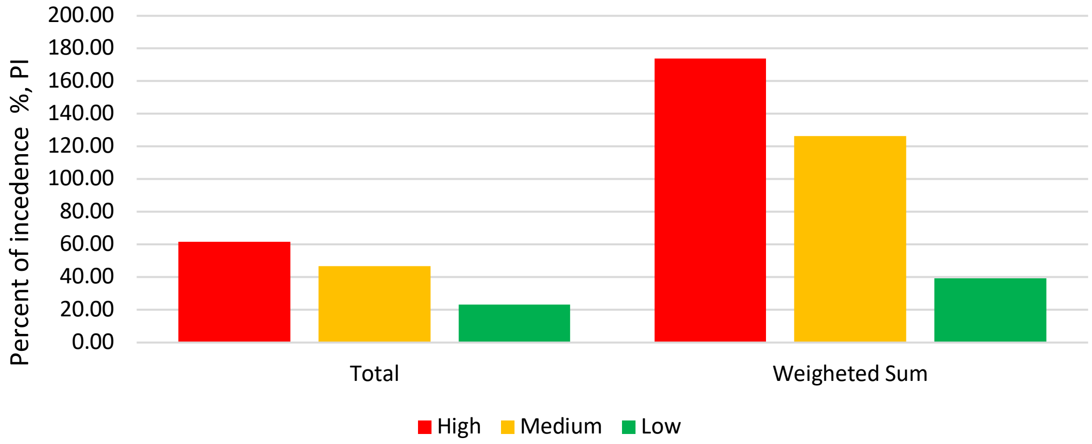

Fig.12 The average of total percentages and PI as the weighted sum for three areas.

A close look-up to the dates 19th of September and 13th of December are provided in Fig.13 and Fig.14, respectively. These dates are chosen to reflect the times where the first wave of Covid-19 was finally suppressed, and only a small number of cases were being reported at the beginning of the summer. As opposed to this, the December period is the peak of the second wave of Covid-19 pandemic that occurs in Turkey. The difference is clear from the density of the values, as in December the majority of the area is in Red and Orange ratings.

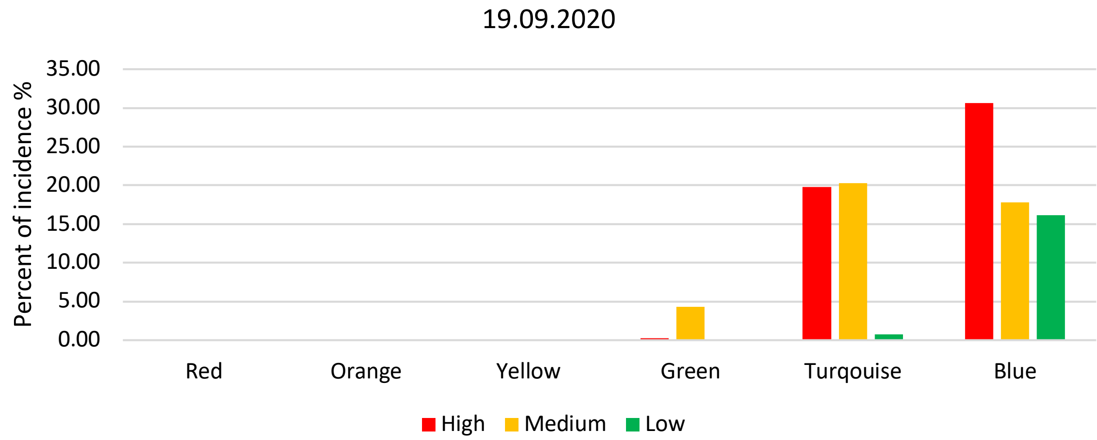

Fig.13 The percent values of 6 levels on the 19th of September

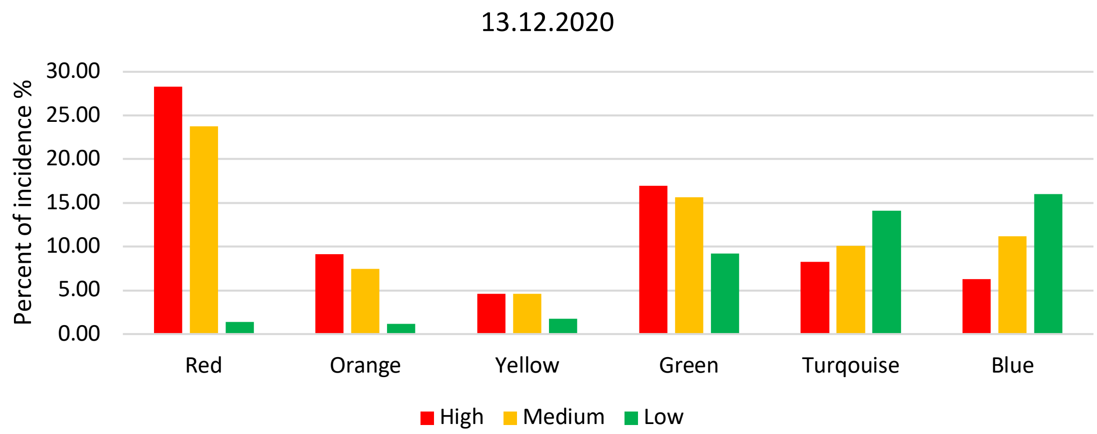

Fig.14 The percent values of 6 levels on the 13th of December

On the other hand, there are no Red or Orange areas in September. When the urban density is considered it can be seen that the ratings for the density of cases and contacts, as well as the PI index, is higher in the high-density areas, for all the dates. Only the Turquoise and Blue rating levels on the 13th of December are "high" in the low-density area, which is an indication of the benefits of low-density housing in terms of pandemics.

5. Conclusion

Urban density is considered to be one of the most important parameters of urban planning. It is for this reason that the course of the Covid-19 pandemic was evaluated in this study in terms of the effects of the urban density parameter on the spreading mechanics of the pandemic. Density arrangements are crucial parameters when the land-use decisions are taken, as they influence the decisions and actual use cases regarding the function, transportation, and formation of a locale. All of these are then reflected in other, emergent parameters like the overall urban density, transportation density, access to public transportation, and temporary proximity to other individuals during actual use. The Covid-19 pandemic has shown that proximity to others is the primary means for the spread of the disease, resulting in the link that starts from the decisions made during the planning phase to the spread of contagious diseases. For all these reasons, it seems now that for a given location, resilience to pandemics is becoming another important criterion when trying to achieve sustainable urbanization.

The data obtained from the HES application developed by the Ministry of Health of the Republic of Turkey to monitor the Covid-19 pandemic were used as the key elements in the study. Heat maps that displayed contacted individuals (actual cases, and contacts with cases) were gathered as screenshots and were processed by an image processing software developed in-house. Although there are some limitations regarding the image data such as the time-frequency, resolution, mixed representations of actual cases, and contacted individuals, the data is still the most accurate location-based publicly available data available for Covid-19 in Turkey, and probably in the world. Other similar examples around the world only provide the city-based data for Covid-19 cases.

This study brings a different perspective regarding the investigation of pandemics by comparing the spread mechanics of the disease in different density zones. The results clearly show that the high-density zone has higher values for Covid-19 "cases and contacts percentage" and "PI rating" (61 and 173 respectively), whereas for the low-density zone these values drop significantly (23 and 39, respectively). A similar trend is observed when the increment rates are evaluated, where it's once again seen that the increase rate (differential) of the PI in the high-density zone is higher than that of others, particularly during the start of the second peak period. The gap between high and low-density zones in terms of the spread of the disease is much more relevant in peak times, starting in late November. The high-density zone has the highest value in all categories, including the lowest rating of blue.

The results are indicative that the lack of urban land production and high population concentration, which have become important problems of developing countries and regions due to rapid population growth, are indeed strong factors for the spread of diseases, such as the Covid-19 pandemic. Also for controlling and appeasing the disease the urban density is also crucial especially in lock-down periods. It is much easier to control human traffic for sustaining imperative need with out avoiding social distance within lower denser urban areas.

For future studies, it is suggested that the evaluation of the relationship between urban density and the spread of the Covid-19 where the data for such research is available. Even when the exact number of cases is not provided and the information is not revealed to the public, heat maps or other similar infographics can be used as shown in this study to create an arbitrary but accurate scale, if they are available. Further studies should also be performed regarding other disease outbreaks if possible, to determine if the urban density affects all diseases in similar manners. As for this study, it is humbly hoped it will provide a new perspective for land use decisions when considering the relationship between urban density and spread of diseases, along with the introduction of a new approach and a methodology when trying to evaluate existing areas in terms of public health.

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Image Sources

Fig.1 Screenshot of HES application at 22.12.2020, SOURCE: https://play.google.com/store/apps/details?id=tr.gov.saglik.hayatevesigar&gl=TR;

Fig.2 The processed image of the case area, SOURCE: Original;

Fig.3 The percent of risk categories in 22.12.2020, SOURCE: Original;

Fig.4 Iskenderun in Turkey, SOURCE: Created by the author using google earth image;

Fig.5 Density zone in the case area, SOURCE: Created by the author using google earth image;

Fig.6 Study areas, SOURCE: author archive;

Fig.7 Figure-ground analysis maps of three density zones high, medium, and low respectively, SOURCE: Created by the author using google earth image

Fig.8 Traffic Density through in the case area, SOURCE: http://maps.google.com/;

Fig.9 The course of Pandemic in overall Iskenderun, SOURCE: Original;

Fig.10 The course of Pandemic thorough Pandemic Index, SOURCE: Original;

Fig.11 The average percentages of 6 PI levels for the three density areas, SOURCE: Original;

Fig.12 The average of total percentages and PI as the weighted sum for three areas., SOURCE: Original;

Fig.13 The percent values of 6 levels on the 19th of September, SOURCE: Original;

Fig.14 The percent values of 6 levels on the 13th of December, SOURCE: Original.

Author’s profile

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