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Analyzing the impact of constructing a bypass on traffic network in Darbandikhan town, Kurdistan Region, Iraq

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Abstract:

Drabandikhan town, which is located within the main road between Suleimani and south of Iraq, suffers from high through traffic volume. Oil tankers and trucks that use urban streets have a negative impact on infrastructure, traffic flow and quality of life in the town. On the daily bases around 800 heavy trucks use the urban distributer network. It is also worth mentioned that Darbandikhan is a tourist area due to the agricultural and topographically nature of the lands and the picturesque views but lack of accessibility created long term impact on tourism market. In order to improve traffic and its negative consequences in the city in terms of environmental, social and economic sustainability, a bypass was proposed to be built to divert traffic (Traffic that does not have a destination in a town) from built-up area and separate it from local traffic. To predict the outcome for the proposed scenario for the decision makers, modeling of the traffic situation is needed. There is several traffic modeling software to do that but The MOVE Meter was used as a modeling tool to analyses the current urban transport in Darbandikhan and to forecast the impact of future change. Move Meter is a tool developed in the Netherlands for urban areas and it is used by almost all Dutch municipalities. Based on the outcome of the research, this bypass is essential as backbone for the traffic system in and around Darbandikhan. By building it more than 50% of the through traffic will divert to it, not only the trucks but also private cars which has no origin and destination in the town and it leads to ease traffic circulation in the town. The public sector has been informed about the outcome of this research and positive impact of realization of this project as well as the challenges.

Keywords: Bypass, accessibility, Heavy trucks, Traffic modelling, Move-Meter, traffic planning.

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الملخص:

تعاني بلدة دربنديخان، الواقعة ضمن الطريق الرئيسي بين السليمانية وجنوب العراق، من ارتفاع حجم حركة المرور. تؤثر صهاريج النفط والشاحنات التي تستخدم الشوارع الحضرية سلبًا على البنية التحتية وتدفق حركة المرور ونوعية الحياة في البلدة. يستخدم حوالي 800 شاحنة ثقيلة شبكة التوزيع الحضرية يوميًا. ومن الجدير بالذكر أيضًا أن دربنديخان منطقة سياحية نظرًا للطبيعة الزراعية والطوبوغرافية للأراضي والمناظر الخلابة، إلا أن نقص إمكانية الوصول خلق تأثيرًا طويل المدى على سوق السياحة. من أجل تحسين حركة المرور وعواقبها السلبية في المدينة من حيث الاستدامة البيئية والاجتماعية والاقتصادية، تم اقتراح بناء طريق جانبي لتحويل حركة المرور (حركة المرور التي ليس لها وجهة في المدينة) من المنطقة المبنية وفصلها عن حركة المرور المحلية. للتنبؤ بنتيجة السيناريو المقترح لصانعي القرار، هناك حاجة إلى نمذجة حالة المرور. هناك العديد من برامج نمذجة حركة المرور للقيام بذلك، ولكن تم استخدام مقياس الحركة (MOVE Meter) كأداة نمذجة لتحليل النقل الحضري الحالي في دربنديخان والتنبؤ بتأثير التغيير المستقبلي. مقياس الحركة (Move Meter) هو أداة تم تطويرها في هولندا للمناطق الحضرية وتستخدمها جميع البلديات الهولندية تقريبًا. بناءً على نتائج البحث، يُعد هذا الطريق الالتفافي ضروريًا باعتباره العمود الفقري لنظام المرور في دربنديخان وما حولها. من خلال بنائه، سيتم تحويل أكثر من 50٪ من حركة المرور المباشرة إليه، ليس فقط الشاحنات ولكن أيضًا السيارات الخاصة التي ليس لها منشأ ووجهة في المدينة، مما يؤدي إلى تسهيل حركة المرور في المدينة. تم إبلاغ القطاع العام بنتائج هذا البحث والأثر الإيجابي لتنفيذ هذا المشروع بالإضافة إلى التحديات.

الكلمات المفتاحية: الطريق الالتفافي، إمكانية الوصول، الشاحنات الثقيلة، نمذجة حركة المرور، مقياس الحركة، تخطيط حركة المرور.

پوختە:

شارۆچکەی دراوەندیخان کە دەکەوێتە ناو ڕێگای سەرەکی نێوان سلێمانی و باشووری عێراق، بەدەست قەبارەی زۆری هاتوچۆوە دەناڵێنێت. تانکەر و بارهەڵگرەکانی نەوت کە شەقامەکانی شار بەکاردەهێنن کاریگەری نەرێنییان لەسەر ژێرخان و ڕۆیشتنی هاتوچۆ و کوالیتی ژیانی شارۆچکەکە هەیە. لە بنکەکانی ڕۆژانەدا نزیکەی ٨٠٠ بارهەڵگری قورس تۆری دابەشکەری شارەکان بەکاردەهێنن. هەروەها شایانی باسە دەربەندیخان ناوچەیەکی گەشتیارییە بەهۆی سروشتی کشتوکاڵی و توێژگرافیای زەویەکان و دیمەنە وێنەکێشەکانی بەڵام نەبوونی دەستڕاگەیشتن کاریگەری درێژخایەنی لەسەر بازاڕی گەشتیاری دروستکرد. بە مەبەستی باشترکردنی هاتوچۆ و لێکەوتە نەرێنییەکانی لە شارەکەدا لە ڕووی بەردەوامیی ژینگەیی و کۆمەڵایەتی و ئابووریەوە، پێشنیار کرا کە بای پاسێک دروست بکرێت بۆ لادانی هاتوچۆی (ترافیک کە شوێنی مەبەستی نییە لە شارۆچکەیەک) لە ناوچەی ئاوەدانکراو و جیاکردنەوەی لە هاتوچۆی ناوخۆیی. بۆ پێشبینیکردنی دەرئەنجام بۆ سیناریۆی پێشنیارکراوی بۆ بڕیاردەران، مۆدێلکردنی دۆخی هاتوچۆ پێویستە. چەندین نەرمەکاڵای مۆدێلکردنی هاتوچۆ هەیە بۆ ئەوەی ئەو کارە بکات بەڵام پێوەرەکەی MOVE وەک ئامرازێکی مۆدێلکردن بەکارهات بۆ شیکردنەوەی گواستنەوەی ئێستای شارەکانی دەربەندیخان و پێشبینیکردنی کاریگەرییەکانی گۆڕانکارییەکانی داهاتوو. ئامێری جوڵە پێوەر ئامرازێکە لە هۆڵەندا بۆ ناوچە شارییەکان پەرەی پێدراوە و نزیکەی هەموو شارەوانییەکانی هۆڵەندا بەکاریدەهێنن. بە پشت بەستن بە دەرئەنجامی توێژینەوەکە، ئەم بای پاسە وەک بڕبڕەی پشت بۆ سیستەمی هاتوچۆی دەربەندیخان و دەوروبەری زۆر پێویستە. بە دروستکردنی زیاتر لە 50%ی هاتوچۆی لەڕێگەیەوە دەگۆڕێت بۆی، نەک تەنها بارهەڵگرەکان بەڵکو ئۆتۆمبێلی تایبەت کە هیچ سەرچاوە و مەبەستێکی لە شارۆچکەکەدا نییە و دەبێتە هۆی ئاسانکردنی سووڕانەوەی هاتوچۆ لە شارۆچکەکەدا. کەرتی گشتی لە دەرئەنجامی ئەم توێژینەوەیە و کاریگەرییە ئەرێنییەکانی بەدیهێنانی ئەم پڕۆژەیە و هەروەها ئاستەنگەکان ئاگادارکراوەتەوە.

کلیلە وشە: بای پاس، دەستگەیشتن، بارهەڵگری قورس، مۆدێلکردنی هاتوچۆ، جووڵە-پێوەر، پلاندانانی هاتوچۆ.

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1-Introduction

Cities are long lasting and extraordinary human products that have been shaped based on their climate, geography (mountains, rivers, and desserts), culture, religion, commerce (trade lines), economy and technology. A common characteristic of life in the city space is the versatility and complexity of activities, aspects that contribute to a climate of innovation, inspiration and, ultimately, business. This special environment increases the attractiveness of the cities and this is reflected in their growth [1]. Nowadays, more people live in urban areas than in rural spaces. According to the UN in 2019, 56 per cent of the world's population was residing in metropolitan zones and it is expected that this urban growth will continue to accelerate in the coming years [2]. Thus, cities will have to make crucial changes in their planning systems (for their existing transitioning areas and for their future developing parts) to be able to adapt to the increasing population in a proper and sustainable way. The transport system within and around of any town or city should comply with the triple bottom line of sustainability [3] and therefore it should: respond to basic transportation needs of people and goods, provide affordable, inclusive and equal access to transportation means for all people, regardless of their race, gender, background, and the social dimension. It also should reduce and limit air polluting emissions and waste, and minimize noise and impact on land use. The technology of Geographic Information Systems (GIS) is used in many aspects of life, such as natural disasters and crises. In Iraqi Kurdistan region, this technology was used in health crises such as the spread of covid-19 in Sulaimaniyah and Darbandikhan [4] and in natural disasters such as forest burning disasters in the mountains of Iraqi Kurdistan region in the province of Sulaimaniyah [5]and [6] as well as in other scientific affairs such as the study of the environment, land use and vegetation cover [7] and [8]. GIS provides a reliable tool for users to interact between different spatial data (layers) [9]. The layers of spatial data can also easily be linked with ranges of attribute tables, including spatial data properties called databases [10] and [11].

This aim of this paper is to find the best scenario to reduce pollution caused by car exhaust in the town, ease the traffic pressure on town road network to improve accessibility, revitalization of the tourism sector of the town as it is a tourist city and enhancing traffic safety in the region.

2-Study Area

Darbandikhan is part of the Sulaimaniyah Governorate in the Kurdistan Region of Iraq (Fig 1). Currently, the town has an urban population of approximately 45.000 inhabitants. There are several regions and areas that have an impact on the travel and mobility patterns and volumes inside and around Darbandikhan, such as Garmian area, including the cities and towns of Kalar, Kifri, Pebaz and Maydan, with a total population of approximately 270.000 inhabitants and Sulaimaniyah city with a population of more than 920.000 inhabitants [12]. as well as Parwiz Khan, border-crossing point with Iran, for visitors and heavy-duty traffic.

The southern part of Darbandikhan, alongside the Sirwan River is one of the main sources for construction materials in the region. The transportation of these materials, is done by heavy duty vehicles, generates pressure on the internal network of the town [13]. It is also well- known due to its proximity to a large dam used for irrigation, flood control, hydroelectric power production and recreation. Hence, the town is also a touristic spot in the region, attracting citizens from different

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surrounding areas [14]. Furthermore, its closeness to Iran makes Darbandikhan a city of high traffic volumes for cross-border trade (especially of crude oil).

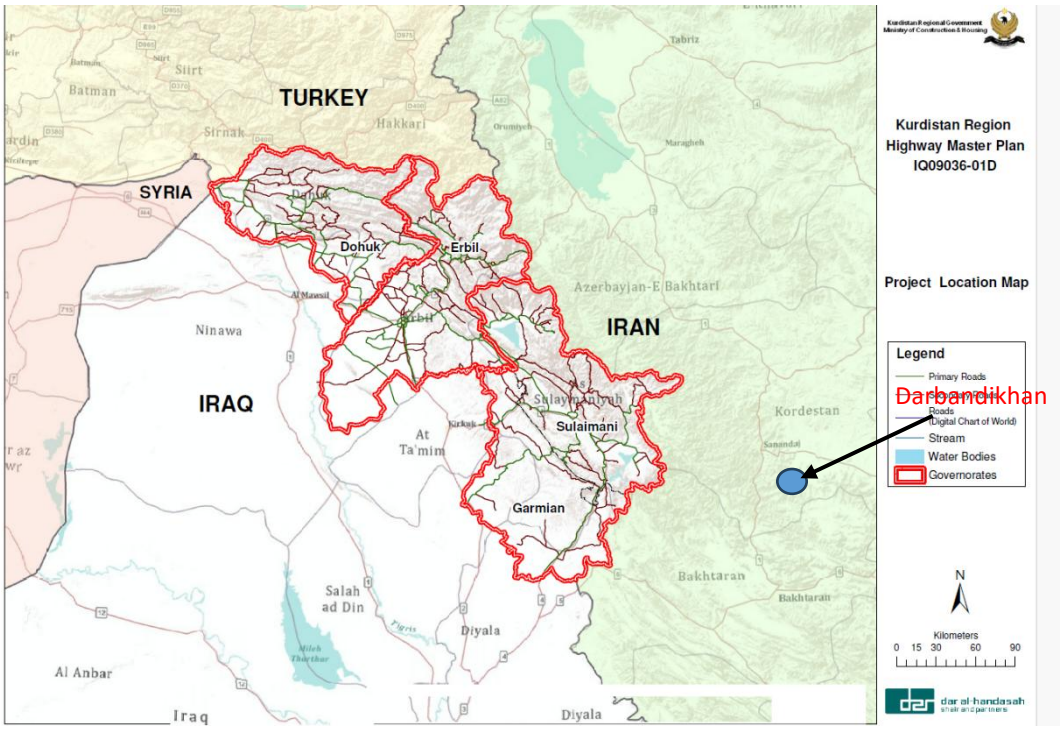

Fig 1: Darbandikhan city, Southeast of KGR, North of Iraq (**Source** Ministry of Housing and Reconstruction KRG)

Through (Figure 2), it is noted that the town of Derbandikhan has a wonderful terrain that may contribute to an increase in users of the new road instead of the urban network road, and this relieves traffic pressure on the city center.

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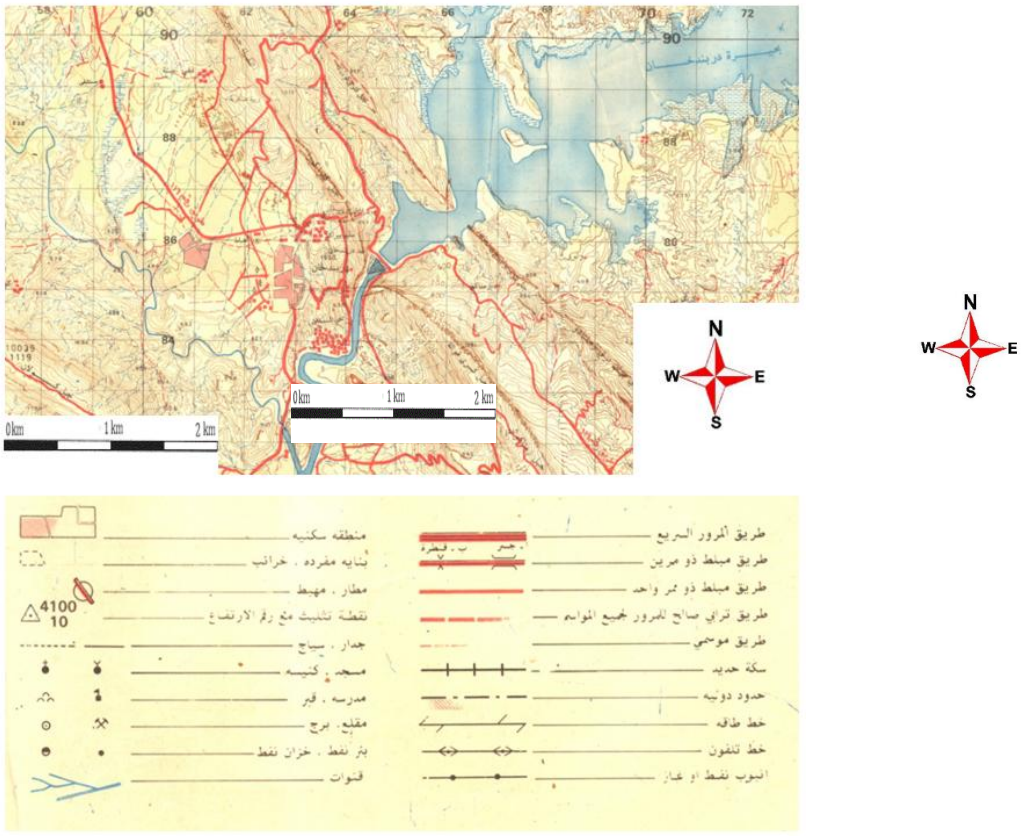

Figure 2: Topographic map of the study area (**Source**: Iraqi Military Surveying Agency)

3- Literature Review

Since the invention of automobiles our cities have changed/advanced tremendously. Cars provide more flexibility to travel longer distance to any destination at any time but meanwhile it has negative consequences of natural and built environment such as insecurity (deaths and injuries), air and noise pollution and unhealthy life style [15].

Road transportation contributes to noise pollution, which has negative impact on public health and interferes with our daily activities. Noise is thought to have an impact on one-third of the population in Europe. Loud exposure can cause pain, hearing fatigue, hearing damage, annoyance and sleep disturbance. [16], [17].

The car poses a significant environmental risk as well; it is estimated that transportation accounts for 20% of the world's current energy-related CO2 emissions. Road transportation accounts majority [18]. One of the main causes of road transport emissions in the industrialized world is automobile travel which has a negative health consequence such as stroke, lung cancers and asthma which leads to premature death. [19], [20].

The dominance of cars has also impact on the society. It affects human health through pollution, auto accidents, injuries, and obesity due to lack of physical activity [21].

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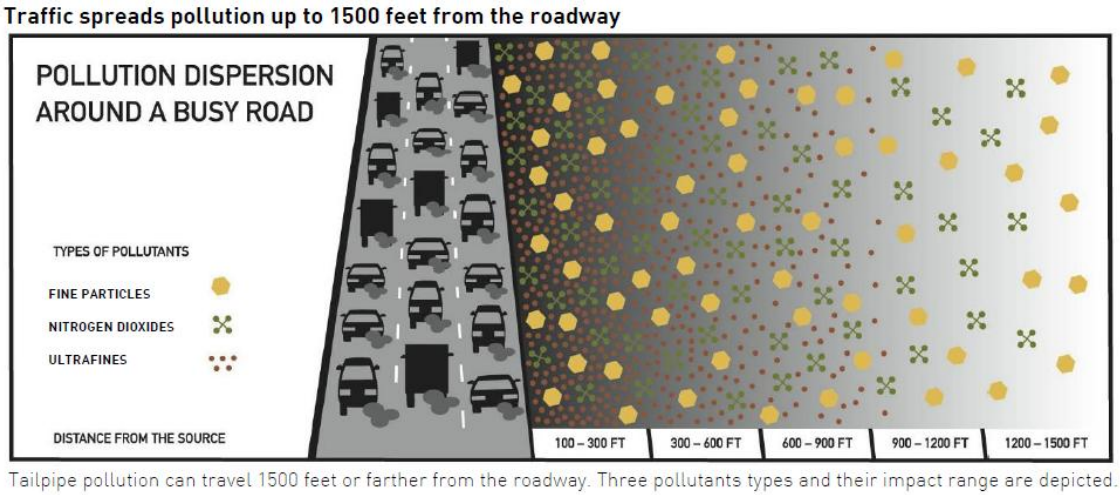

Figure 3: Pollution Dispersion around a busy road (**Source**: www.edf.org)

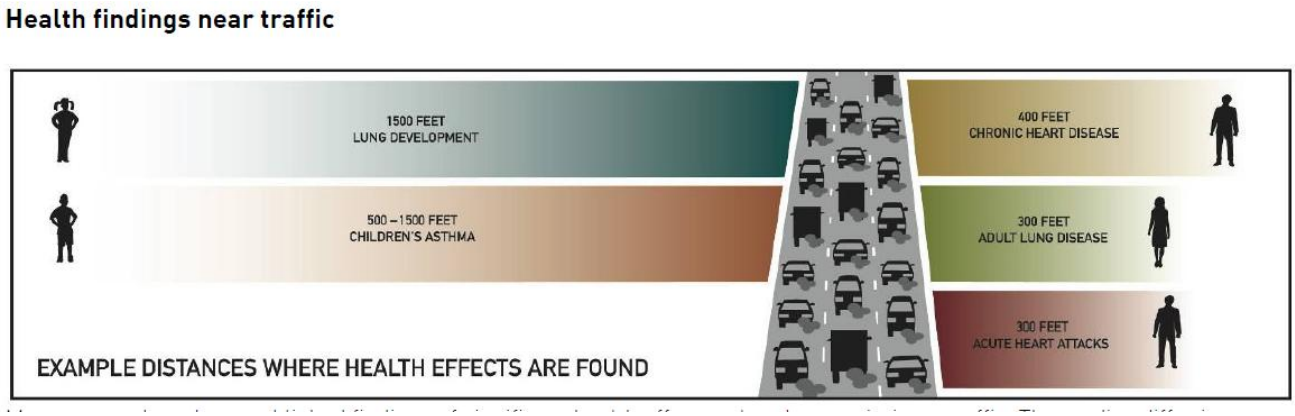

Figure 4: Health Finding near Traffic (Source www.edf.org)

The people might be aware of direct cost of car ownership such as purchasing price, insurance, repair, fuel, registration, and parking. But automobile cities suffer from many indirect economic impacts [22]. Congestion externalities lead people to waste time, and delay and it has economic impact, besides it degrades the environment through less efficient of using fuel. It resulted in two billion hours a year of wasted time and extra infrastructure for sewage, water, and drainage system [23].

It is estimated that around 1.2 million people died in traffic accidents yearly, a third of whom were pedestrians and bicyclists [24]. Whenever extra vehicles on the road increase, the probability of car accidents and road damage costs increase too [25]. The consequences of accidents are material damage, administrative costs, hospital costs, pain and grieving [26]. Road damage costs are the costs which are used to repair and maintenance of the roads due to high traffic volume on the roads [27]. Traffic congestion which resulted from mixing external and internal traffic is an obstacle from economic development and it has also many environmental consequences [28].

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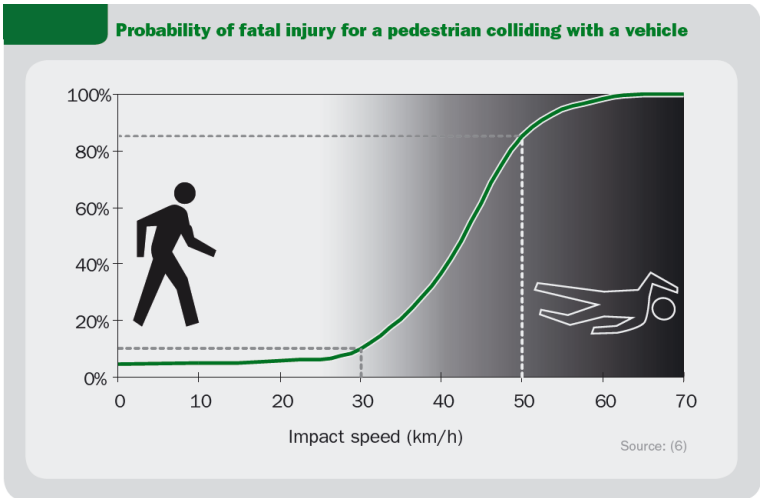

Figure 5: Probability of Fatal Injury for a Pedestrian Hit by a Vehicle (**Source** www.ssatp.org)

Heavy vehicles which use the internal network of any urban area have big negative impact on the infrastructure and traffic flow [29], [30]. The tankers which transport Liquefied Petroleum Gas (LPG) are a serious problem. It might burn the entire adjacent properties alongside the route [31].

4- Data collection and fieldwork

The Sustainable Urban Mobility of Darbandikhan involved the formulation and evaluation of a set of scenarios for the region and the town. After identifying ideas and visions, various development scenarios were discussed during the interviews and meetings with the stakeholders. The process continued with an analysis of the existing situation in order to forecast and evaluate the different mobility and land use proposals for the town. Hence, a data collection study was developed to identify the existing traffic circumstances.

The performed data collection actions were as below:

» Traffic volumes on the main roads of the network
» External traffic (with origin or destination in Darbandikhan), internal traffic (with origin and destination in Darbandikhan) and through traffic where there is no origin or destination in Darbandikhan
» Trip generation and attraction of the distinct neighborhoods in Darbandikhan
» Main destinations within Darbandikhan and the number of trips these locations attract
» Travel times on the road network in Darbandikhan

This note explains the actions that to be taken to collect the necessary data. The data collection provides a sound foundation of facts, conclusions and representative insights to take the right policy decisions.

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Data collection methods

Gaining the necessary data requires a combination of different data collection methods. Hereafter each method will be described.

1. Traffic count

The traffic count is undertaken manually and recorded by camera by the researchers who visually count and record traffic at various locations throughout the road network. The traffic is counted and classified (for each type of vehicle) by direction of traffic flow.

Since traffic flows on the road network changes considerably at each point of time throughout the day, the traffic counting is conducted at regular intervals of 15 minutes between 6:00 am and 19:00 pm for one week. The traffic volume generally varies throughout the week. The pattern during working days is often relatively consistent. The pattern during the weekend may vary considerably though. Considering the day-to-day variation of traffic volumes the counting should comprise both working- and weekend days.

2. Roadside traffic survey

A-Locations

A roadside traffic survey is conducted to provide a detailed picture of the trip patterns and travel choices of the residents of Darbandikhan. The roadside surveys are done by directly interviewing drivers of vehicles at selected survey points. The survey locations are at the two main inbound roads of Darbandikhan. The traffic survey is preferably conducted during the peak hours of the day, in the morning (6:00-9:00), in the midday (12:00 – 14:00) and the evening (16:00-19:00). The manual and camera recording traffic count has taken place on the same time on the same locations.

B-Road site survey

At the locations vehicles and trucks were stopped and the driver was asked if he is willing to participate in a brief survey. The answers are recorded by the investigator.
The following items are recorded:

» Type of vehicle
» Number of passengers in the vehicle
» Origin of the journey
» Stopover in Darbandikhan (yes or no)
» Final destination
» Start time and expected end time of journey
» Frequency of trip

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C- Trip survey

C-1 Purpose and locations

The trip survey is necessary to collect valuable data on the number of trips generated by households and the destinations of these trips. We propose to select a number of distinct places where people will be asked to complete a small survey related to their trip pattern of the day before.

Possible locations are:

City center, Markets, Schools, Local hospital and Parking places

In order to gain insight in the origin and destination of trips, the zone classification is listed below. The origin and destination of trips can be related to each of these zones.

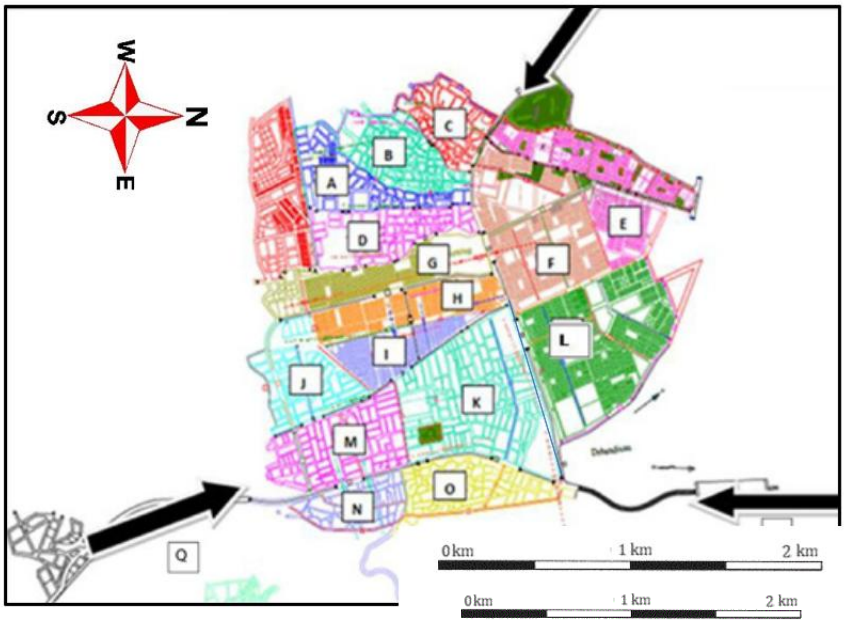

Figure 6: Zoning of Darbandikhan Neighborhoods (**Source**: Municipality of Darbandikhan)

C2-Survey

People are asked to fill in a short survey to record their trips of the day before. The number of trips including the origin, destination and trip time need to be recorded. A total number of around 400 completed forms would be compiled.

3. Travel time measurement

To determine the travel times on specific routes in and through Darbandikhan a specific travel time measurement has been conducted. The routes were divided in a limited number of sections. The distinct travel time of each sector is recorded in seconds. Every route is recorded 10 times during peak hour and 10 times during off peak conditions.

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Figure 7: Truck and Car Route which uses internal network (**Source**: by the researchers based on google map).

The locations of twenty critical places with high potential of accidents have been indicated on the fig 8.

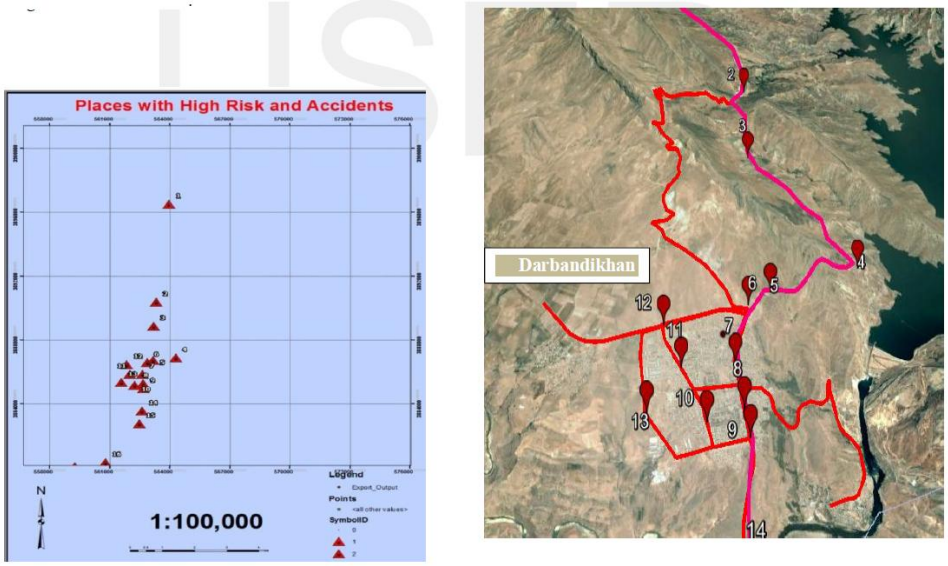

Figure 8: Digital map of the places with high risk and accidents (**Source**: Reference no 23)

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5- Methodology & Result

The current urban transport developments, as well as the new insights in social and economic necessities in cities such as Darbandikhan, may require changes of the existing travel patterns [32]. Innovative modelling and communication tools such as the MOVE Meter are necessary to validate the scenarios and different measures and then decide on possible solutions for the city [33]. A licensed version for educational purpose has been used.

The MOVE Meter, like any other tools for traffic modeling, is an easy-to-use GIS web-based tool developed to support informed decision-making in urban development, in general and in transport, in particular. It assesses the impact of infrastructural, spatial and social-economical changes on mobility, accessibility and the environment, at various scales.

5.1 Car Volumes

Fig 9 shows the private vehicles volumes on the road network of the city. Most of the trips are done in order to reach the city Centre.

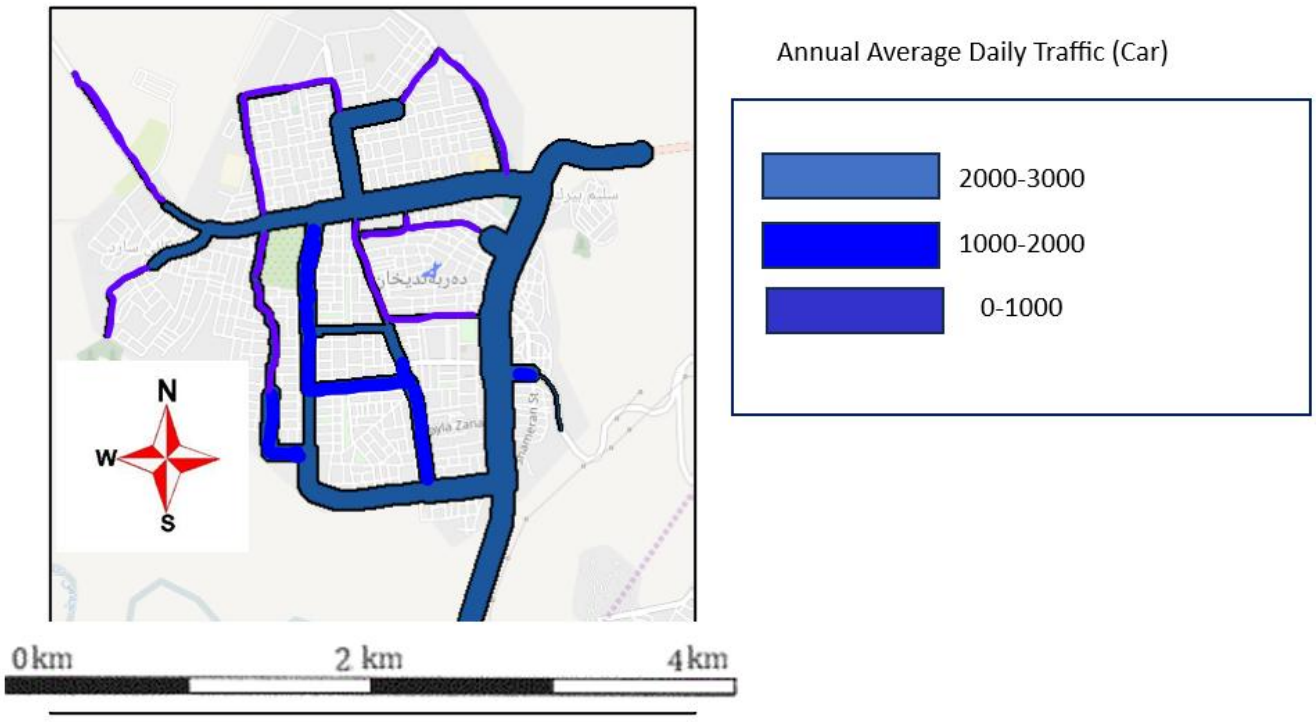

Figure 9: Annual Average Daily Traffic (AADT) for Cars. **Source**: by the researcher using Move Meter based on open street map

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5.2 Truck Volumes

One of the most remarkable results of the computations performed with the MOVE Meter is the visualization on how the network has been structured in relation to the truck traffic. These go through in the town, generating several negative impacts.

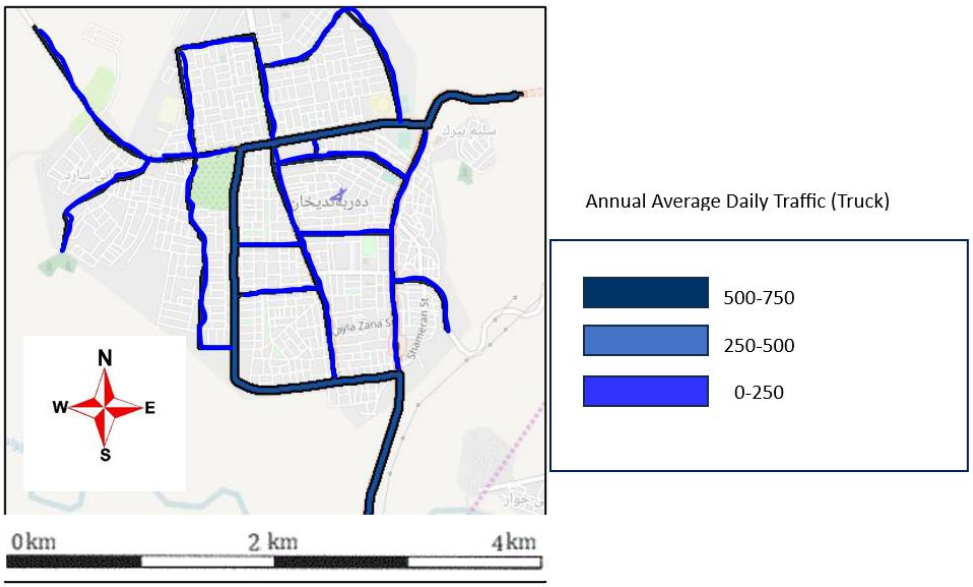

Figure 10: Annual Average Daily Traffic (AADT) trucks. **Source**: by the researcher using Move Meter based on open street map

Based on the scientific literature 150 m was chosen to be more affected by air pollution for areas adjacent to the high traffic volume road. Wind and building heights were excluded for mapping the zones. www.edf.org

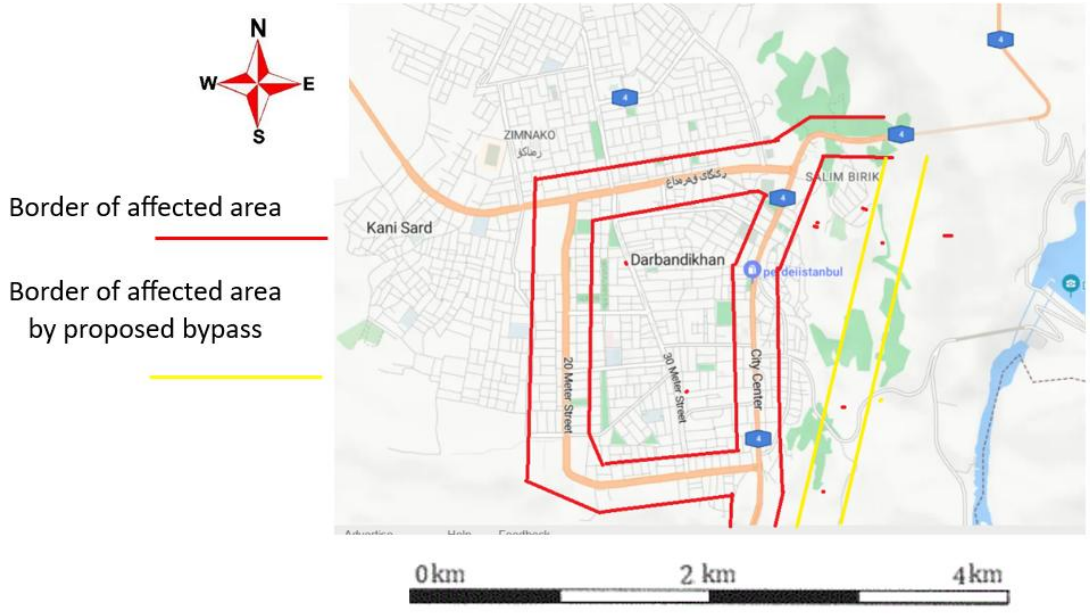

Figure 11: Air pollution border from through traffic. Source: by the researcher based on open street map

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5.3. Speed

Currently, the speed on the main road network of the city varies, depending on the link, and gets up to 60km/hr. The 30 m-wide roads and the lack of appropriate traffic signaling encourage high speed [34].

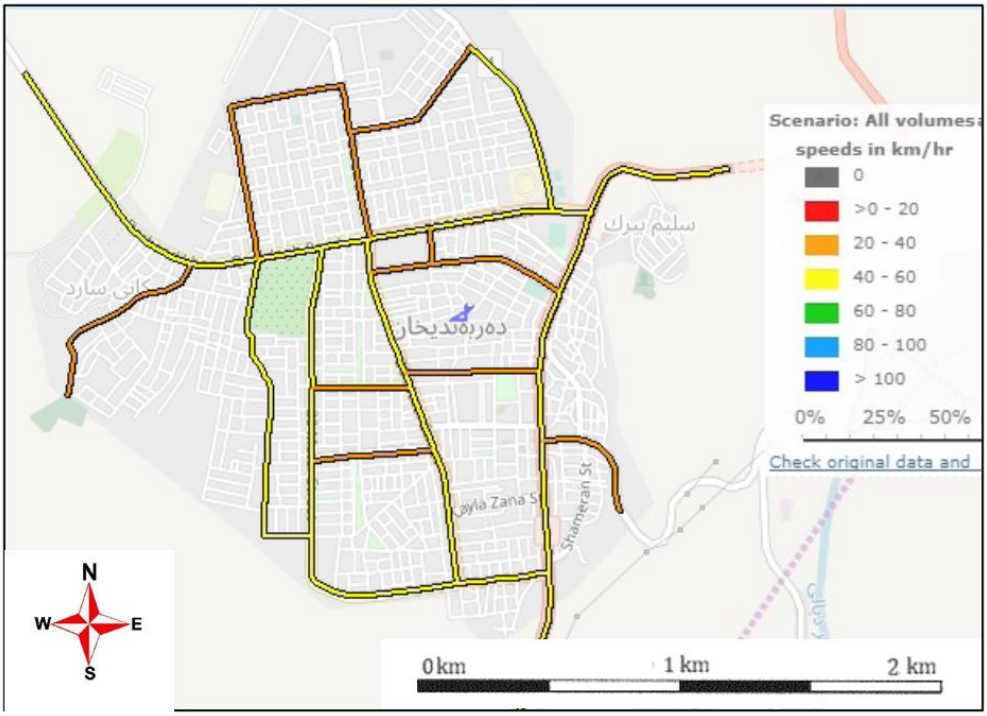

Figure 12: Speed on the network in Darbandikhan. Source: **Source**: by the researcher based on open street map

5.4 Network "spider" map

Internal trips (with both an origin and a destination in Darbandikhan) represent approximately 70% of total numbers of trips and they are distributed between various neighborhoods of Darbandikhan. These internal trips have a distance of maximum 5km. On the other hand, 20% of the trips that do not stop in Darbandikhan (through traffic) are using the internal main road. Finally, the remaining 10% are external trips that have a purpose in the city. Most of this external trip's finish in the city center of Darbandikhan. The distribution of trips can be seen in Figure 13.

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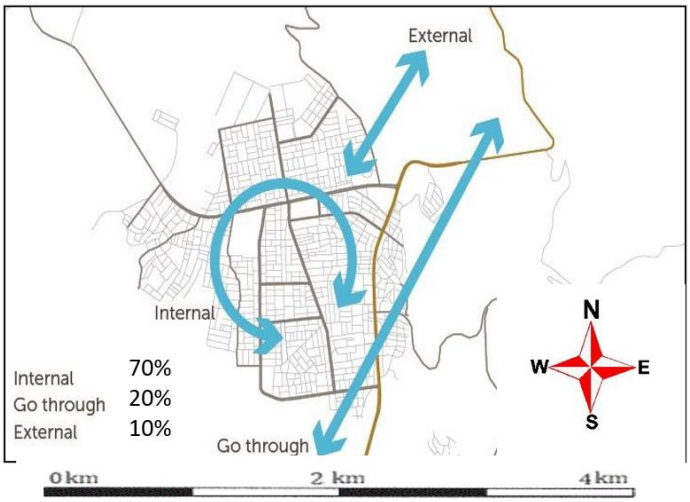

Figure 13: Types of Travel Source: by the researchers based on OpenStreetMap

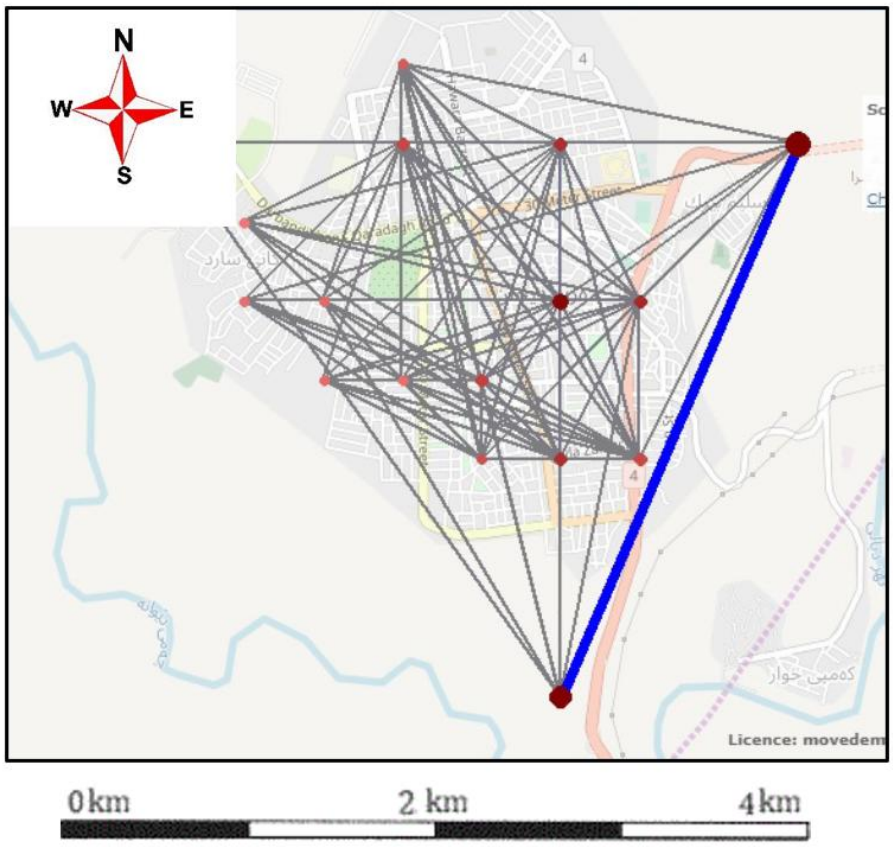

Figure 14: Network "spider" map. Source: Researchers based on fieldwork and OpenStreetMap

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5.5 Bypass

A bypass is a road which divert through traffic (Traffic that does not have a destination in a town) from built-up area in order to separate it from local traffic [35]. The go-through function is the "traditional" way of planning and design of a bypass. There is an integrated function for this bypass if it is used as an additional element of the main car network. This bypass is essential as backbone for the traffic system in and around Darbandikhan[36]. For example, creating a calm traffic area in the city center can be a result of this change in the network. During the study, several places have been visited to find a suitable location for building a bypass. Fig (15) shows the proposed location of the bypass.

The functions of the (possible) bypass for Darbandhikan and Region:

•Go-through heavy traffic

•Go-through private vehicles, taxis and buses

•Distribution for the incoming and outgoing traffic (D1, D2, D3) fig 15

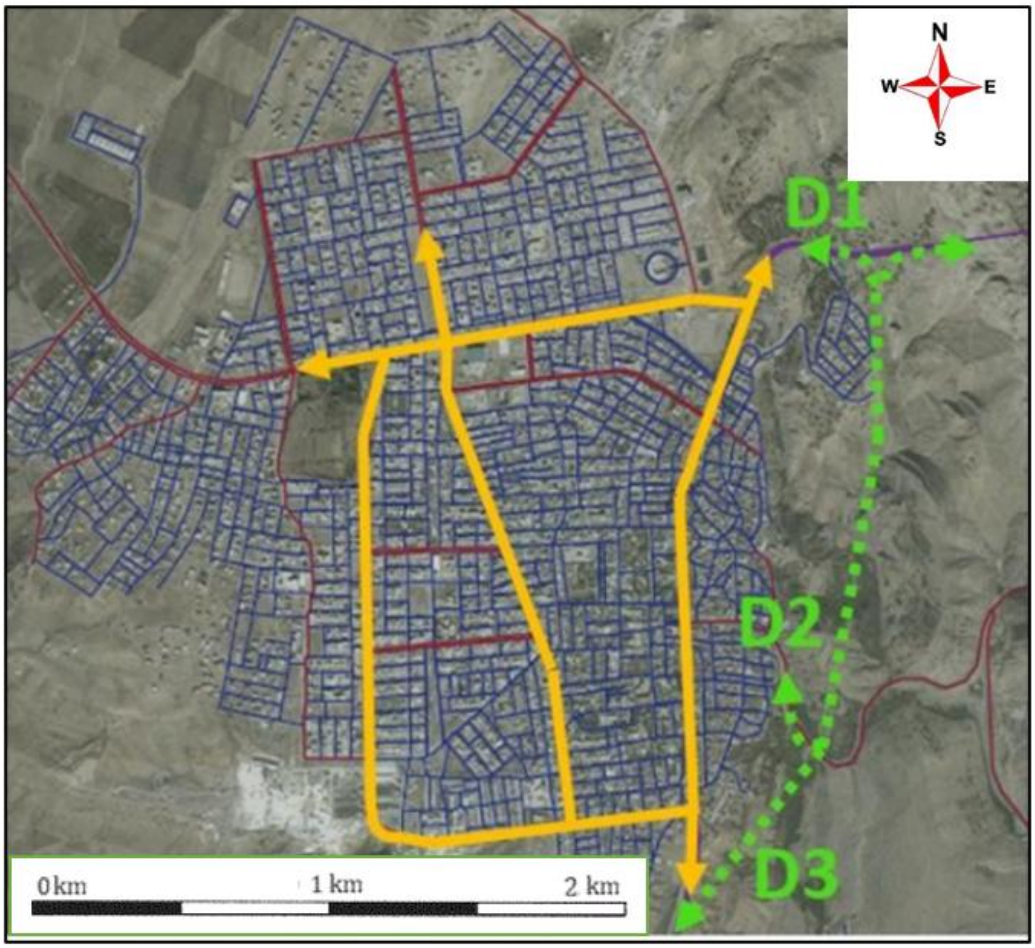

Figure 15: Proposed bypass route location. Source: Researchers based on google map

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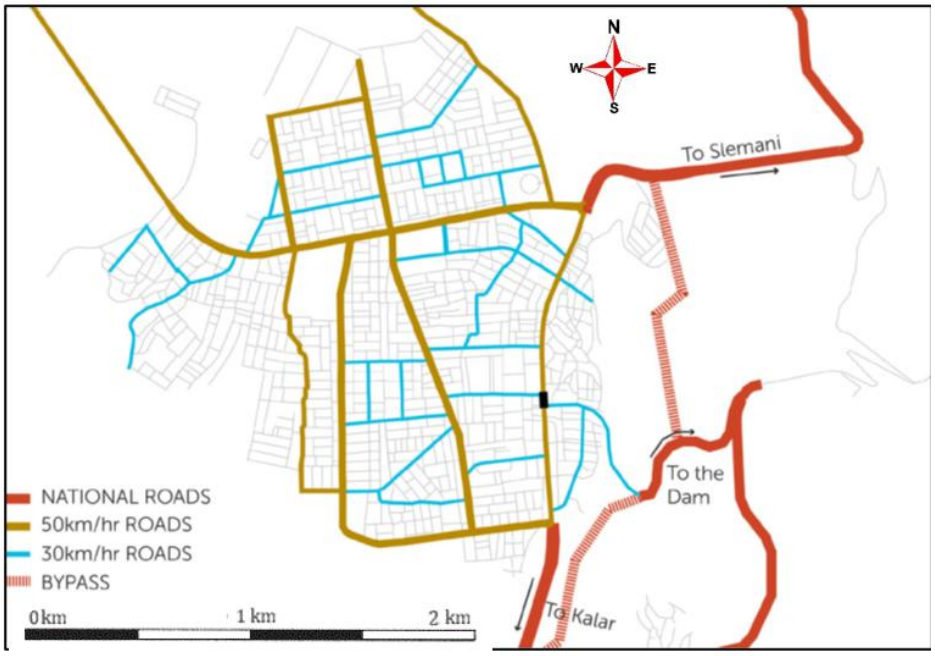

Figure 16: Bypass route location with respect to Darbandikhan network. Source: Source: Researchers based on fieldwork and OpenStreetMap

5.6 Effects of the bypass in trucks volumes

Figure (17) shows the effects of implementing the bypass on the truck volumes. It can be seen that creating the bypass will automatically divert the route of the truck trips from inside the city streets. There will be a reduction of more than 400 trucks (more than 40%). Some trucks stop in the town either they are residents or they transport goods to the building material factories or markets. The red color in the bypass does not means congestion. It shows the increase in traffic volumes per hour on the bypass.

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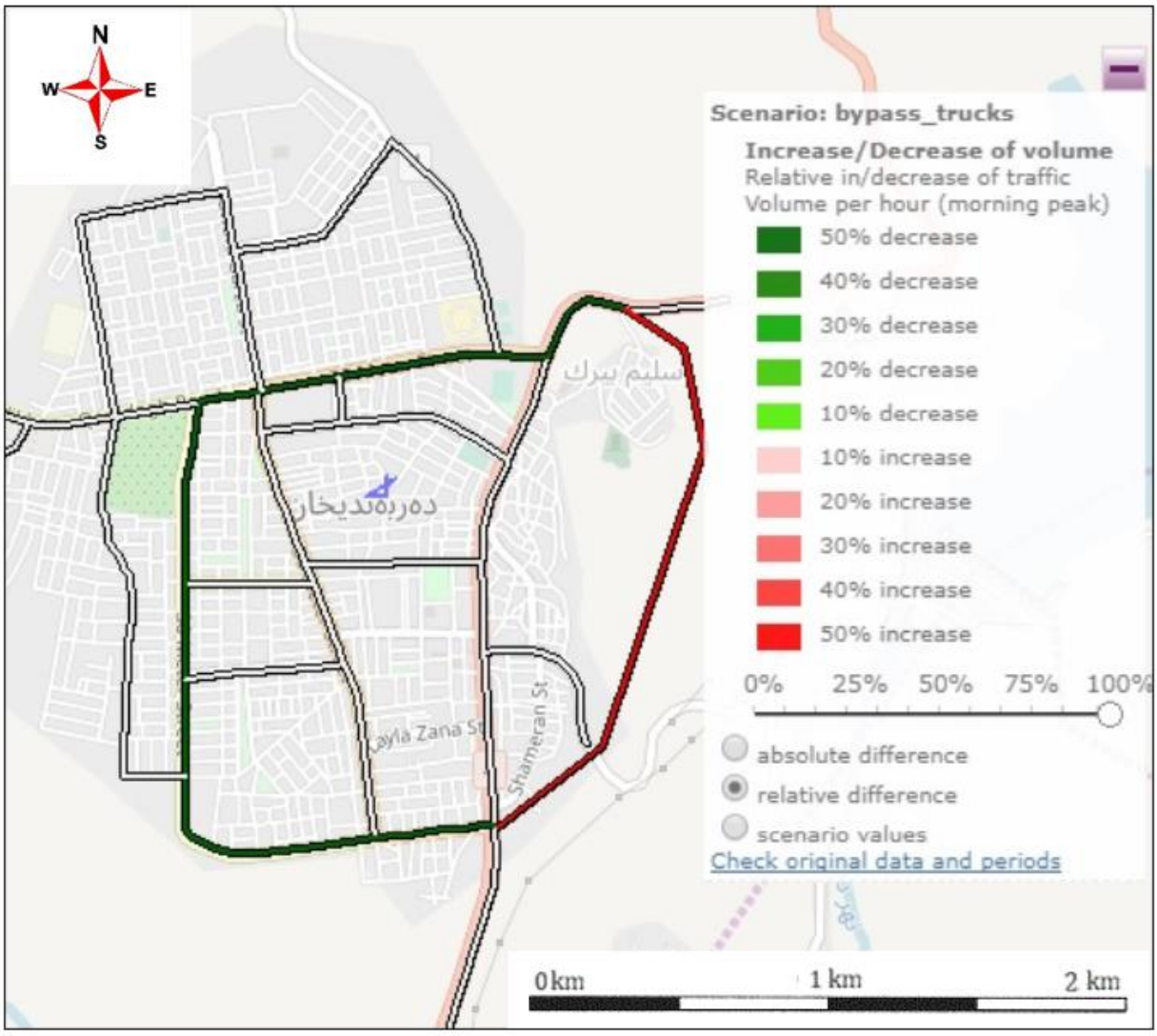

Figure 17: Effects of the bypass on truck volumes. Source: by the researchers based on fieldwork and OpenStreetMap

5.7 Effects of the bypass on car volumes

20% of the trips in Darbandikhan are through traffic. By implementing the bypass, most of this traffic will divert on this new road as shown in fig 18. The bypass will produce an important reduction of car trips (decrease of more than 500 vehicles in absolute terms - more than 50%) on the main road crossing Darbandikhan from north to south and also 30% decrease on city center main street.

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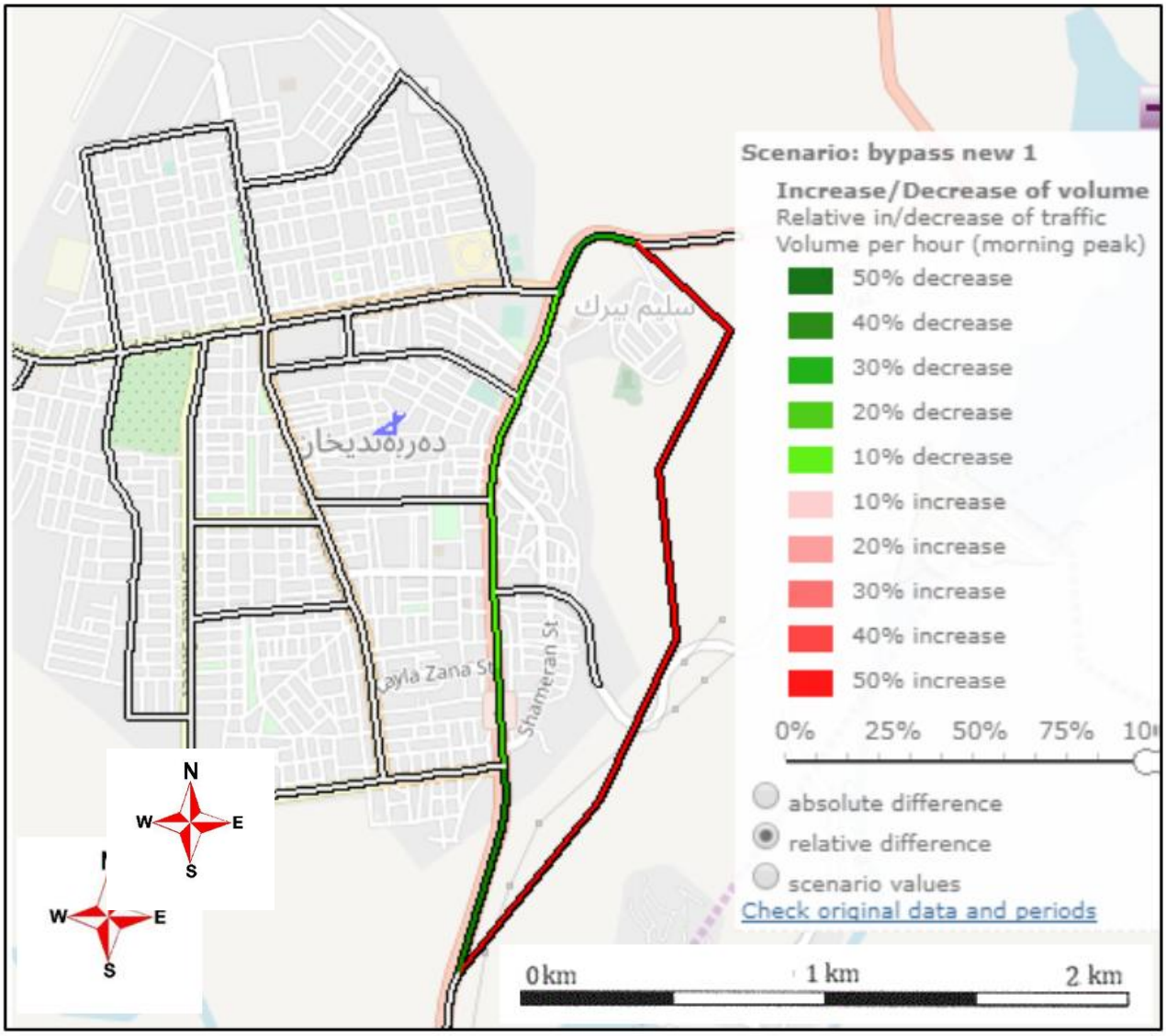

Figure 18: Effects of the bypass on car volumes. Source: by the researchers based on fieldwork and OpenStreetMap

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6- Conclusion & Recommendation

This investigation explores the impacts of building a bypass on environment, society and economy of Darbandikhan town in terms of mobility. Based on the finding, 20% of the traffic that crosses Darbandikhan has no purpose in the city. Of that percentage, 6% are trucks. Implementing the bypass will reduce half of the number of vehicles crossing through the city by diverting to the new road, which improves the internal and external traffic flow, as well as the quality of living in Darbandikhan, by reducing air and noise pollution and decreasing the incidence of traffic accidents. The bypass will minimize another economic damage of the town infrastructure. The pavement deterioration of the truck route street fig (7) is another problem due to frequent loads exerted on the road by heavy vehicles. The bypass will remove half number of these vehicles and prolong the truck route street life.

On the other hand, the bypass project has no influence on a large proportion of movement in Darbandikhan which is internal traffic. It comprises around 70% of the whole trip in the town. This percentage has a significant negative impact on quality of life of the inhabitants in the town. These internal trips have a distance of maximum 5 km which may be replaced by public transport or walking. The research also shows 20 critical points which have more probability for car accidents to occur in urban area and they are mostly located on that part of the network in which the speed exceeds 60km/hr which contributes in traffic fatalities.

However, the project may damage business of restaurants and shops alongside the route but it needs further investigation by the local authority on how to improve the economy of the town via investing in tourism sector or any other sector which booms the town economy. This is because there are some bad examples in the province such as Said Sadiq town. Based on the judgment of the mayor of Said Sadiq (whom was interviewed on April 2022 by the researchers), the economy of the town of Said Sadiq is semi collapsed due to realization of Suleimani -Halabja main road which functions as a bypass and it left the Said Sadiq to be isolated.

Technically there could be some challenges facing the project because of the conflict points between incoming and outgoing traffic before the Darbandikhan tunnel entrance. This is due to steepness (fig 2) and high traffic volume which may cause delay or accident. A suitable solution is required. On the other hand, the location of the proposed bypass project lies in a valley (fig2). It may need extra budget for realization besides Land acquisition which leads to be economically not feasible.

To sum up, the bypass will contribute to enhance environmental sustainability of the town but socio-economic pillars should be addressed and compromised also simultaneously. Further researches are required for mitigating the situation of internal traffic flow as well as the alternative location for the proposed bypass route.

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