Network System and Accessibility in Erbil Governorate

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Abstract

The notion of transportation network refers to a network of roads, streets, railways or nearly any structure which permits either vehicular movement or flow of some commodity (Ahuja et al. 1995). It is quite broadly known that transit systems can impact cities in many different aspects, from their economy and land-use activity to their liveability. Network analysis remains one of the most important and persistent type of research and application areas in the area of geography of transportation (Curtin 2007). Network analysis has a strong theoretical basis in the mathematical disciplines of graph theory and topology. The application of graph theory to road transportation systems emerged in the late 1950s and lasted through the 1970s (Rodrigue, Comtois, and Slack 2017). Measures such as the Beta, Alpha, and Gamma indices (Karl Kansky and Danscoine 1989) are used to measure the relative connectivity of a network by comparing the number of edges to the number of vertices (in the case of the Beta Index). In addition, the accessibility of the GIS network system is another new significant approach developed in recent research studies which has been applied in the discipline of transportation geography. This paper addresses the geographic characteristics of the network system in Erbil governorate in Kurdistan-Iraq based on new approaches which involve quantitative measures and GIS techniques such as the ArcGIS extension network analysis.

Keywords: Network, accessibility, connectivity, GIS, Transportation, Erbil.

1. Introduction

The transportation system plays a significant economic and social role in the life of nations and communities whereby the network system is one of the most important components. Without such a system and without roads for instance, nothing could be transferred (road, settlements, goods and conveyance). Countries and states without a good network system are suffering from isolation. Hence, the study of network systems has become the subject of scientific research for many disciplines such geography, engineering and economics. Transportation geographers focus on the road as one element of spatial organisation through network analysis using excretion spatial dimension and by analysing the geographic attributes of network systems. William Garrison was the first geographer who applied network transport system analysis in 1960 (Garrison and Marble 1961).

Thus, the network is set of roads represented as nodes and links. Network analysis theory ignores the direction and distance but only focuses on tree patterns, which are: (1) routes, (2) nodes and (3) links on infrastructure networks system. In a normal network analysis package four essential operations can be done, all of which are derivatives of route-finding processes. Also, it helps investigate the measurement of a road network structure. Existing measures of connectivity include accessibility while the no connectivity is another application used in this paper investigates Erbil network system. Overall, this involves three purposes: finding a route between point locations, finding the connectivity and non-connectivity across the network. The most common and familiar application of network models are those used to represent the networks through which most of the population relates on a daily basis: transportation. Also, the aim of transit is not only to move people from a

point of origin to their destinations, but also to do it in a way that declines travel time and avoids unnecessary transfers.

Moreover, Network data structures were one of the earliest representations in geographic information systems (GIS) and network analysis remains one of the most significant representations in GIS. Technology including GIS is the most suitable one to analyse network systems and the toolbox extension functions (ArcGIS) has been developed for transportation applications. The ArcGIS network analyst extension allows us to build a network dataset perform analysis on a network and others as well as produce an accessibility map.

2. Geographic frame of Erbil's roads system

Erbil is one of the main provinces in northern Iraq, located in the centre of the Kurdistan region. It consists of sub-districts which Ankawa, Makhmur, koya, Soran, Mergasur, Choman, Rawnaduz and Khabat. Erbil has a population of approximately two million inhabitants.

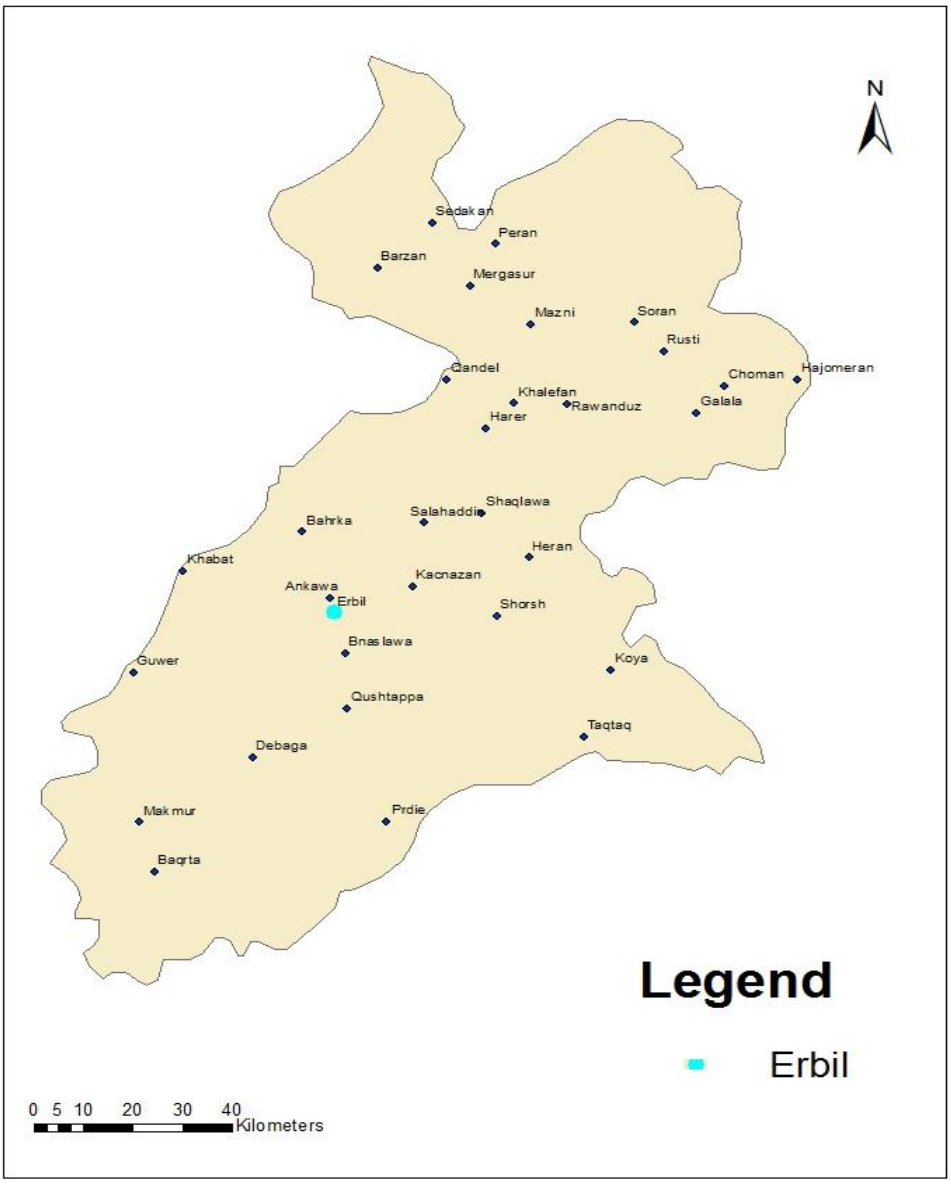

Figure 1: Erbil governorate.

3. Goal of the study

The goal of this study is to point out numerous characteristics of the Erbil transportation system by investigating and measuring the road network structure, connectivity and accessibility. Also, evaluating accessibility can help answer the following basic questions:

1) What is the range of accessibility between settlements?
2) What is the centrality of network?
3) What is the rate of connection of Erbil roads among settlements?
4) What is the Detour index (road)?

4. Methods and data collection

This study investigates a network system which is a complex spatial system, especially if the network consists of a huge number of roads and stations. Therefore, it is essential to simplify the network through an input network. Hence, routers and graphs consist of many lines and points representing the main roads on arc forms. Also, the settlements were represented as nodes, which make it easier to analyse the attributes of networks. There are many types of networks, some that are simple and others more complex. The simplest networks include few links and nodes that establish connections between cities and settlements for accessibility and easy movements. Complex networks contain a great number of links and roads such as circle roads that make enhance the accessibility of the cities that are on the network. For example, if roads are blocked for utilities, because of snow fall, isolation occurs between cities.

5. Accessibility

"Accessibility is a slippery notion one of those common terms that everyone uses until faced with the problem of defining and measuring it" (Marston 2002,P23). In other words, this notion relates to the possibility of moving between nodes and between a point of origin to a destination easily. Also, accessibility refers to how easy it is to go to a site. In ArcGIS network analysis, accessibility can be measured in terms of travel time, distance, or any other impedance on the network ("Types of Network Analysis Layers—Help | ArcGIS Desktop" 2017). The Shum index is a significant index used to evaluate accessibility among nodes. In this paper, a table was designed containing 32 nodes, representing 32 cities where roads intersect vertically and horizontally. After calculating the number of links between nodes, that shows the lowest value, node 12 (Shaqllawa), represents the highest accessibility. If compared with others in same time, the highest value, node 20 (Hajomran) and node 11 (Taqtaq) are considered the least accessible with rest of nodes (See figure 2).

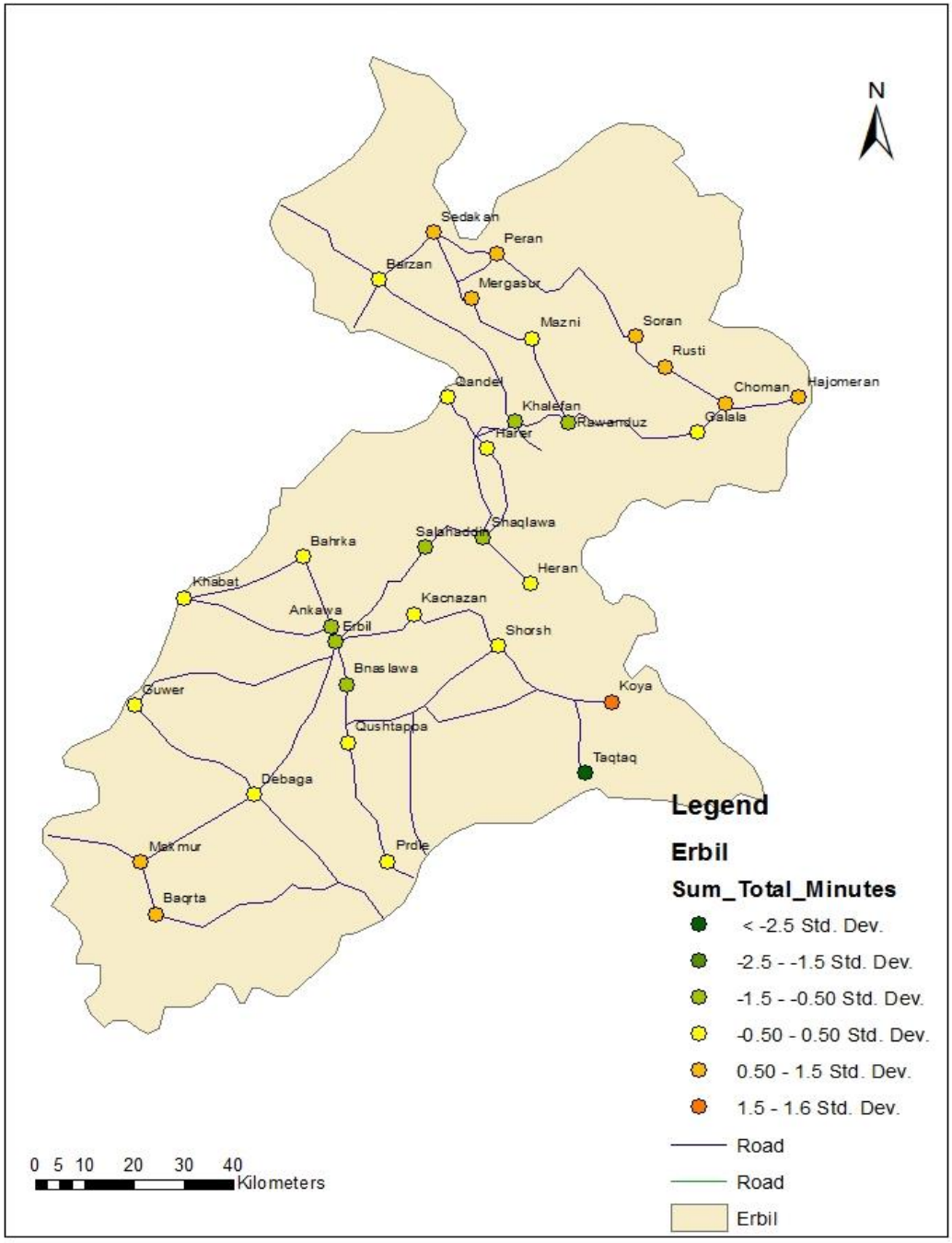

Figure 2: Accessibility major rods in Erbil

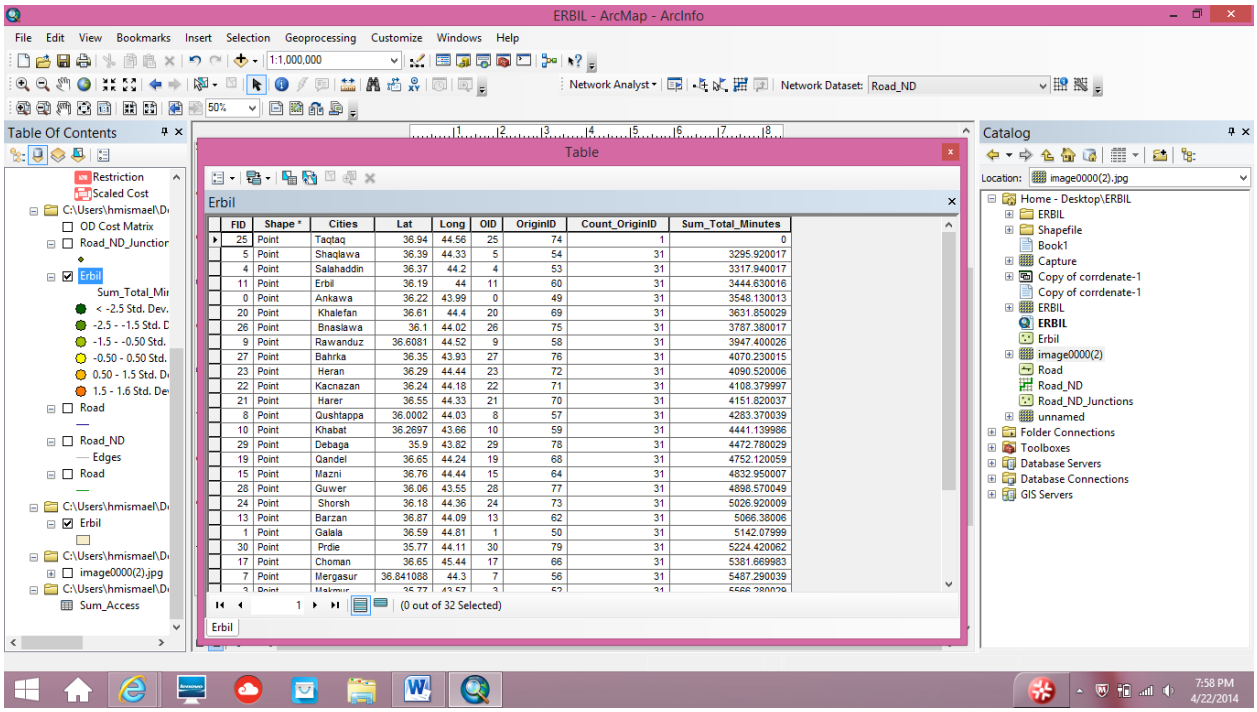

Figure3: Sum of total minutes

6. Connectivity

This refers to the connectivity and mutual relationship between nodes through links that exist. Kensky (1963) provides some evidence and clues to explain these relationships.

6.1 Beta Index

Designed this context so that less than one is when the network attribution is made of branches only. If the indexes reach 1, it means that it is a perfect network. Also, if the index is more than one it means that there is more than one network. When these indexes were applied on Erbil's road network, the beta was 1.25,

Where e = number of edges (links) and v = number of vertices (nodes).

Table 1: Beta, Gamma and Alpha measures of Erbil road

Measure	N.Links	N.Nodes	Link and directories	Neutralization
Beta	40	32	1.25	$\beta = \frac{e}{v}$
Gama	40	32	0.42	$\gamma = \frac{e}{3(v-2)}$
Alpha	40	32	0.17	$\alpha = \frac{u}{2v-5}$

When I applied the sub-district, the high connection was 2 and the low connection was 0.75; others were between 1 and 1.75 see table 2

6.2 Gamma Index

It measures the level of accessibility in general. If the value is 0, it means that there is no accessibility; if the value is 1, it means that the connection is full. according to this table, the gamma index was 0.43.

The index ranges from 0 (no connections between nodes) to 1.0 (the maximum number of connections, with direct links between all the nodes).

Table 2: The level of communication of Erbil's road network

Cities	Choman	Erbil	Makhmur	Koya	Shaqlawa	Soran	Mergasur	Bnaslawa
N.links	3	4	8	4	6	5	6	7
N.nodes	4	4	4	4	4	5	5	4
Connectivity	0.75	1	2	1	1.5	1.2	1.2	1.75

6.3 Alpha index

This index measures the Circulation in networks. It includes the percentage of circle roads in the network Compared to the maximum number of circle roads. This index ranges between 0-1. When the index was applied to the road network in Erbil, it Less than 15%.

The values range from 0%, which means no circuits, to 100% which refers to a completely interconnected network.

6.4 Mediate

It shows the pointed central point in the network. It is possible to calculate the number of lines that separate each from the central point. Kolej, for instance, was the first one used with the formula. This index represents each node to a number of links that span the length to the furthest point through the shortest path on the network system. Less number represents more nodes in the center of the network. Nodes 13 were the central point in the center of the network (See table4).

7. Concentration of the network

It means that the network is separate from one point to various centers or connection parts in networks without a central point. It is possible to calculate the central during variance that node 1 was the first one in direct road with percentage of Variance equal to 1,401. When the formula was applied, the value of the index was 32.902 connections.

Table 3: The level of communication network of roads Erbil

Nodes	Direct nodes	Deviation from the average	Standard Deviation
1	6	3.515+	12.355
2	1	1.485-	2.205
3	2	0.485-	0.235
4	4	1.515+	2.295
5	2	0.485-	0.235
6	2	0.485-	0.235
7	4	1.515+	2.295
8	1	1.485-	2.205
9	4	1.515+	2.295
10	4	1.515+	2.295
11	1	1.485-	2.205
12	3	0.515+	0.265
13	3	0.515+	0.265
14	1	1.485-	2.205
15	3	0.515+	0.265
16	1	1.485-	2.205
17	4	1.515+	2.295
18	2	0.485-	0.235
19	2	0.485-	0.235
20	3	0.515+	0.265
21	3	0.515+	0.265
22	3	0.515+	0.265
23	2	.485-	0.235
24	3	0.515+	0.265
25	2	0.485-	0.235
26	1	1.485-	2.205
27	2	0.485-	0.235
28	4	1.515+	2.295
29	1	1.485-	2.205
30	2	0.485-	2.235
31	2	0.485	2.235
32	2	0.485-	0.235

Table 4: Nodes number of Erbil network system

Cities	
Erbil	N1
Ankawa	N27
Khabat	N2
Guwer	N3
Qusttapa	N28
Makhmur	N 5
Bahrka	N33
Prdie	N8
Heran	N14
Shorsh	N 9
Sallahadn	N12
Shaqllawa	N13
Soran	N18
Rawanduz	N30
Choman	N24
Taqtaq	N11
Mergasur	N20
Mazni	N19
Sherwan mazn	N22
Hajomera	N20
Galala	N31
Debaga	N4
Harer	N15
Khalefan	N17
Rusti	N32
Baqrta	N6
Sedakan	N25
Bnaslawa	N7
Barzan	N23
Qandel	N16
Peran	N21
Koya	N10

7.1 Detour Index

The detour index is the ratio between the shortest actual distances between A two-point degree centrality. Knowing the distance in a network system and the length of roads as a

straight line might help determine the efficiency of the road. Also, it can help to add and eliminate links or replace old roads using new transit system tools. Therefore, by calculating the length of road (1964KM) and the length of roads as a straight line (770 KM the detour

$$DI = \frac{D(S)}{D(T)}$$

index was 255.0.

8. Results and Discussion

This paper investigated the accessibility; the low value was found in the Shaqllawa settlement which represents a high accessibility. In comparison, however, the lowest accessibility was in Taqtap and Hajomeran settlements. These results can be explained by the centrality of Shaqllawa on the one hand, and because Hajomean and Taqtaq on the other hand, are peripheral cities.

8.1 Links and linkages

It appears that based on some index and measures all the cities are linked by one road which means that no cities are isolated from each other. To compare with other cities, Erbil has a high connection unlike Soran which is less connected due the topology of the landscape. Also, through the beta index, it was found that the network system was not perfect and that the connection between cities some times during another cities. Also, there is not Circular road in Hawler, because of the mountains and the climate which are physical obstacles.

8.2 Centring

It appears that Shaqllawa cities represent a central point in the network system of Erbil. Also, the network does not have centrality. Erbil was the first city with a direct connection with most cities while six cities have less than Erbil like: Debags, Bnaslawa, Shorsh, Koya, Qalefan and Qushtappa.

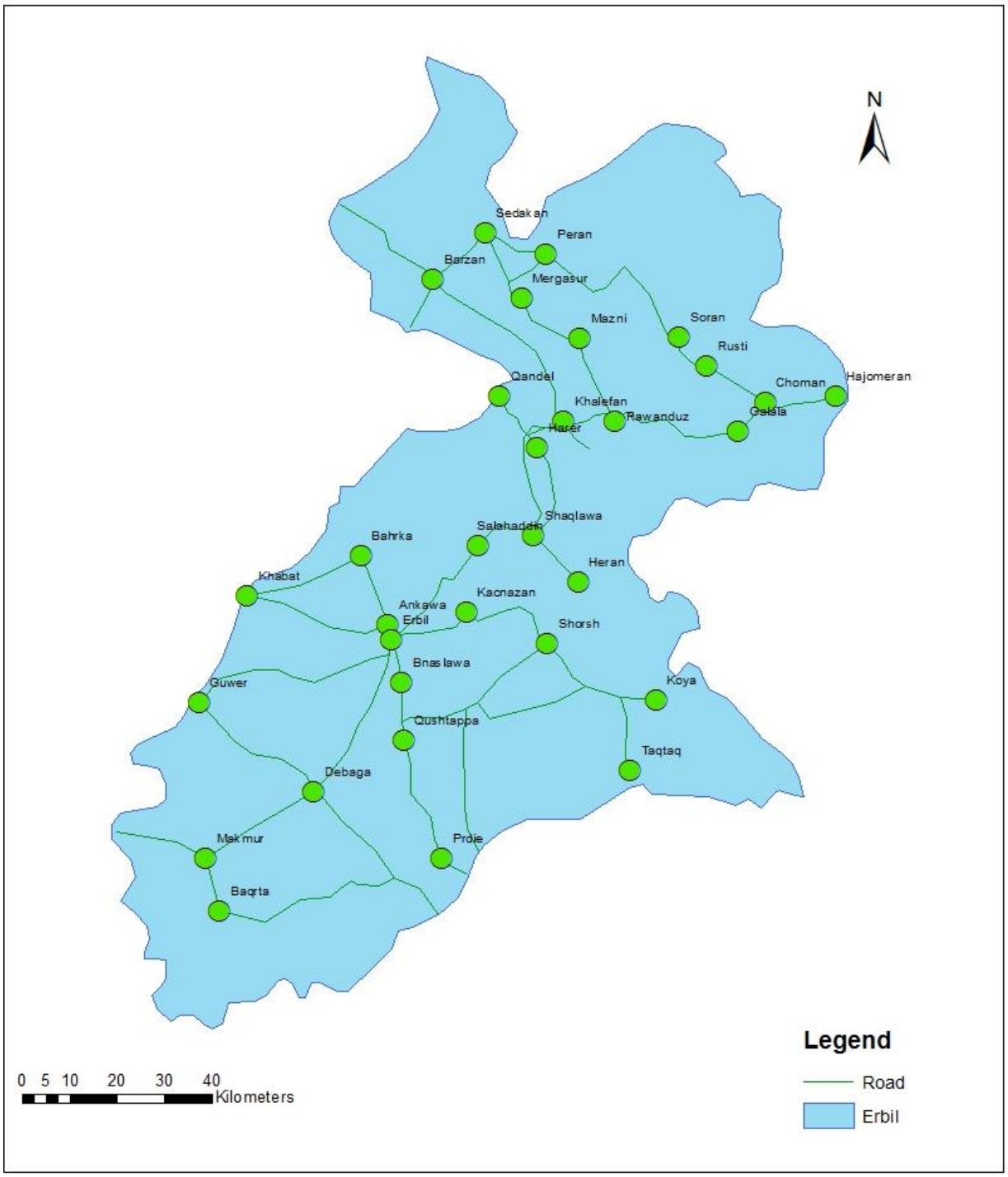

Figure 5: Roads in Erbil

8.3 Detour Index

This is to be expected given that most provincial cities are located in the Central area and that Shaqlawa is located almost at the geometric center of Erbil. The contours of the accessibility gradient broadly correspond to the physical geography and the population distribution of Kurdistan. Other cities located in the central and east-central part of the country, such as TaqTaq and Hajomeran, also rank high in the accessibility score.

9. ArcGIS and the Network System

Accessibility is measured using the ArcGIS network analyst extension. It is necessary to carry out many-to-many path calculations, edit and combine different networks, add impedances and get point data for origins and destinations ("Route Analysis—Help | ArcGIS Desktop" 2017). It is also needed to create a field called *speed for networks*. To assign the speed values for roads links, it is important to first select those whose type = 1, use the field calculator to assign these fields To the correct speed and Create a new field for travel time for roads. The field name must be one that ArcGIS will accept as impedance, so it is called *minutes*, specify a scale of 2 and precision of 5 and use the field calculator to assign travel time values using the length values calculated with the speeds for freeways and for all other roads, using the basic length/speed equation. Then, make a map showing the accessibility of each city. with point of origin or destination, as illustrated in figure4

10. OD cost matrix

With ArcGIS network analyst, it is possible to create an origin-destination (OD) cost matrix from multiple origins to multiple destinations. An OD cost matrix is a table that contains the network impedance from each point of origin to each destination ("OD Cost Matrix Analysis—Help | ArcGIS Desktop" 2017). Additionally, it ranks the destinations to which each origin connects in ascending order based on the minimum network impedance required to travel from that point of origin to each destination.

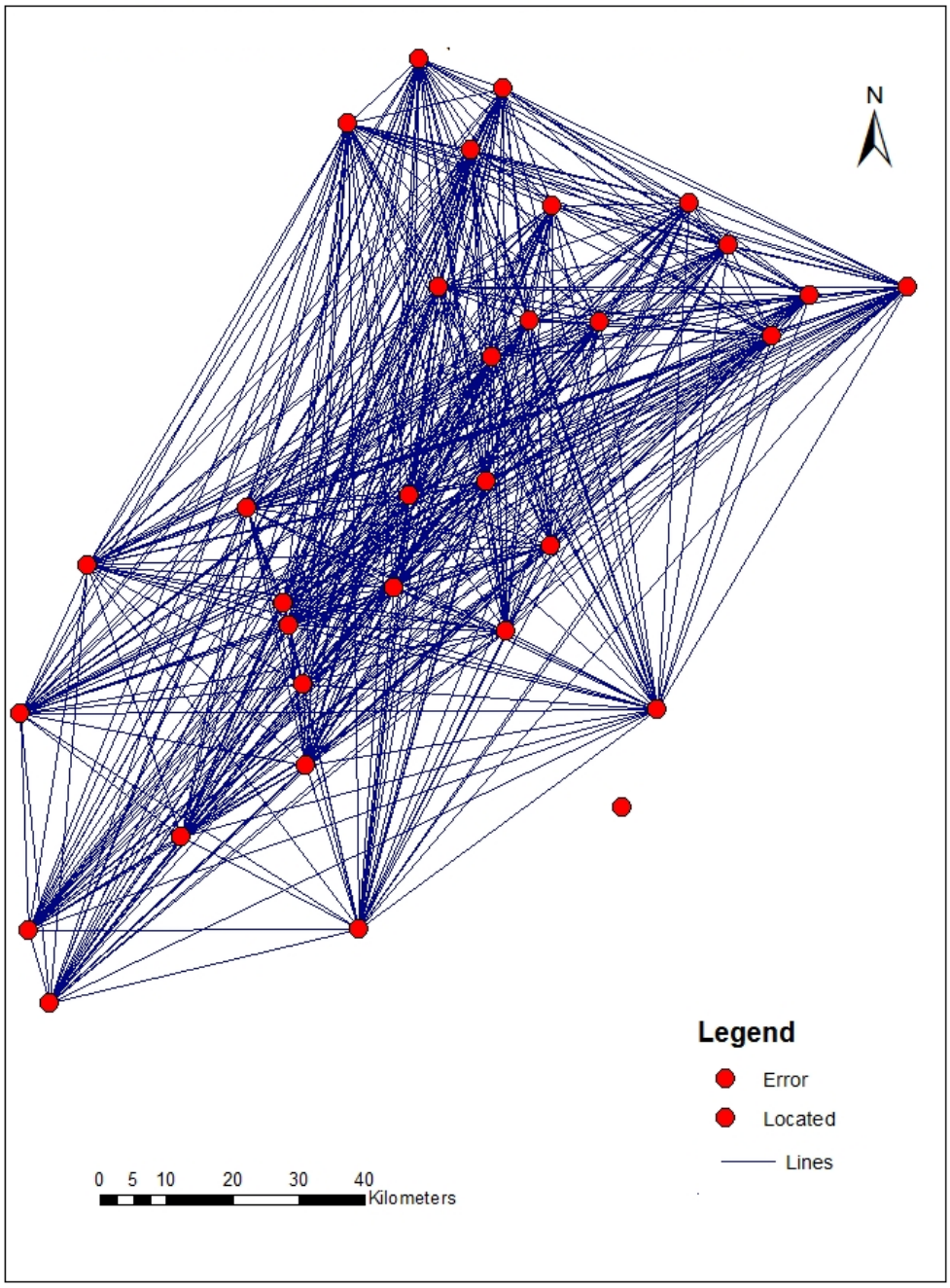

Figure 6: OD matrix of Erbil

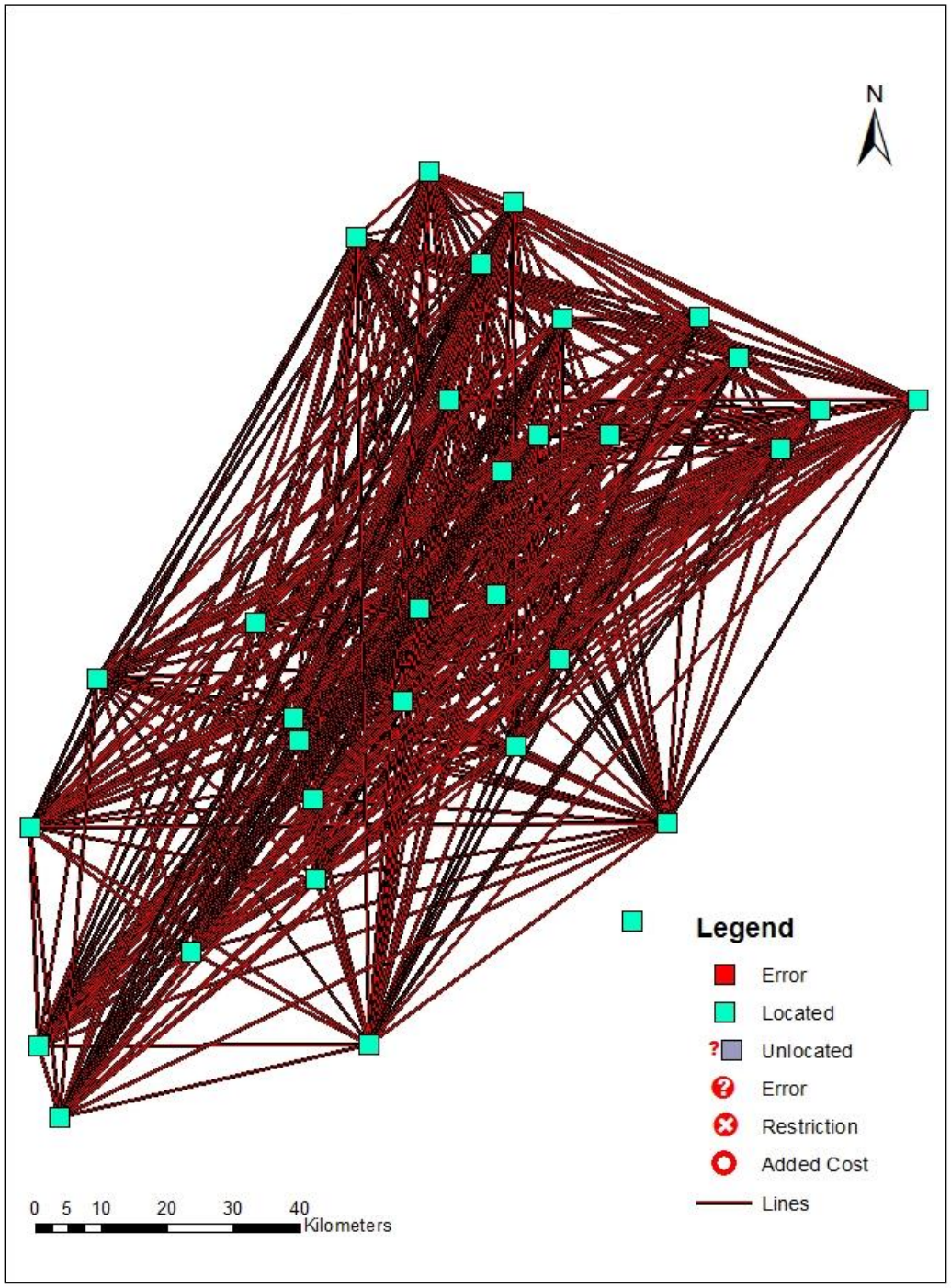

Figure 7: OD matrix destination

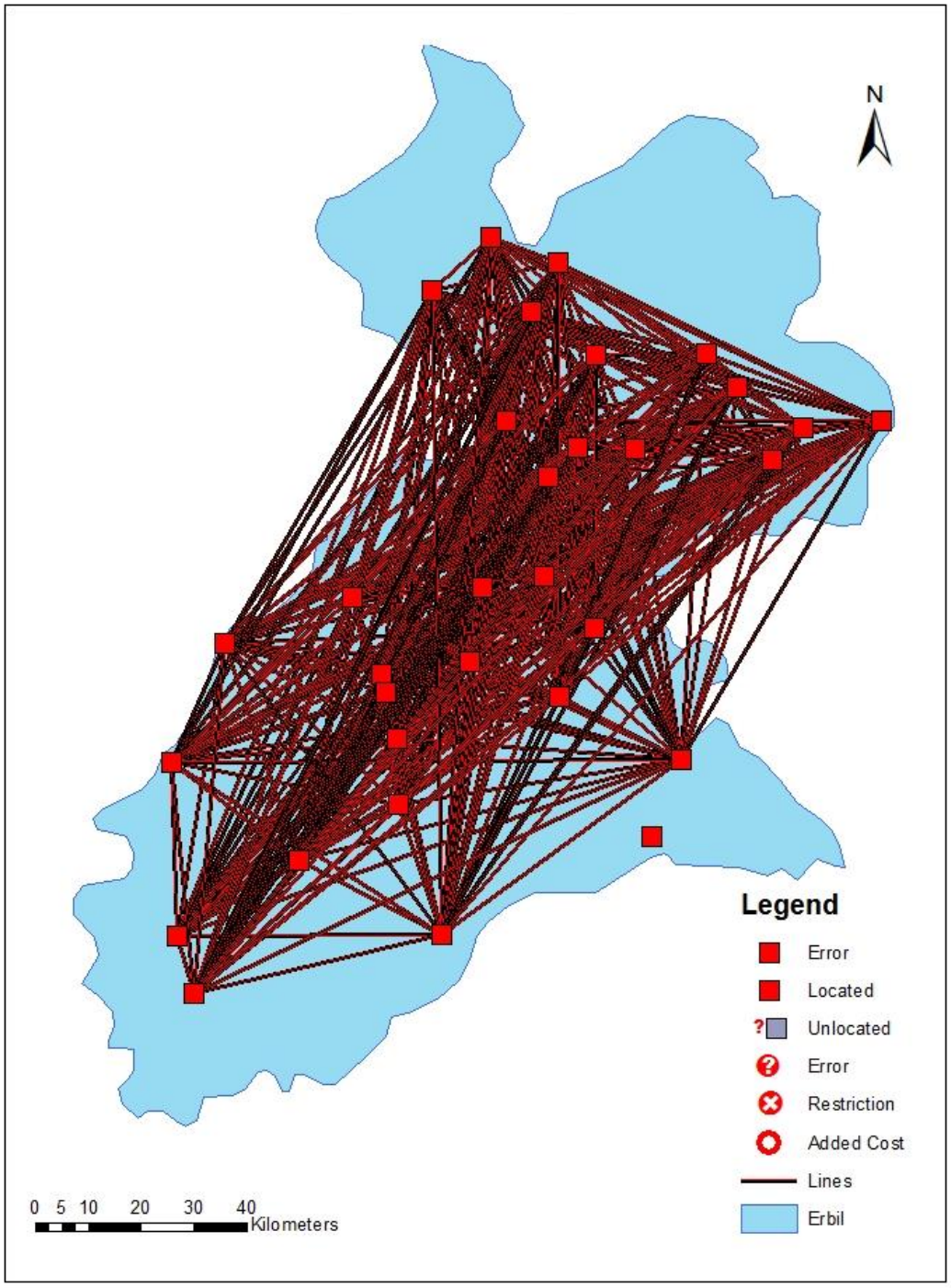

Figure 8: OD matrix destination

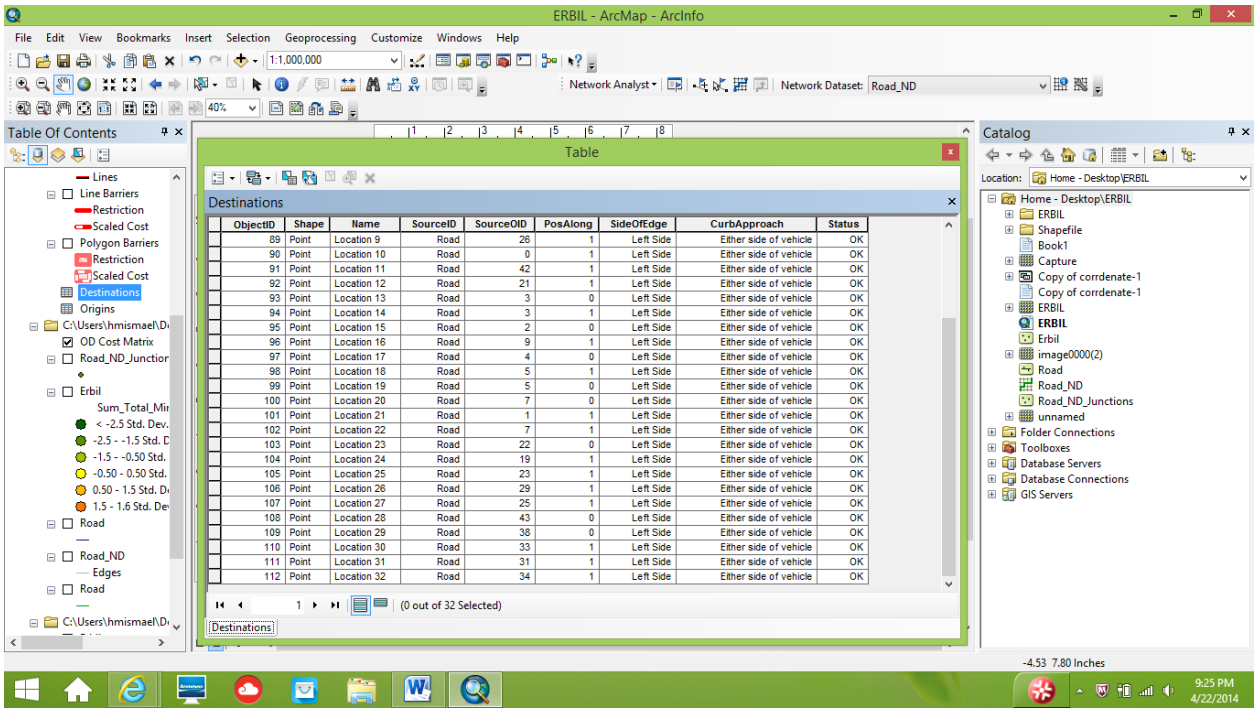

figure 9: OD matrix

11. Conclusion

This paper intended to show the importance of network analysis through graph-theoretic measures and mathematical modelling in geography and measuring the relative connectivity of a network by comparing the number of edges to the number of vertices (in the case of the Beta Index). In this study, certain measuring previously used by Kensky were employed, such as the connectivity and mediate for example. When applied to the Erbil network, node 13 has in centrality and node 1 was most linked. Also, the accessibility of Erbil's networks system was analysed by making some accessibility maps of Erbil's network. The ARCGIS software network analyst extension allows us to build a network dataset perform analysis on a network and measure distances between origins and destinations including measuring the shortest path network distance and make a service area. This is because accessibility is a term that has long been used by planners for descriptions of planning goals. As Taaffe Gauthier (1973) explained, graph theory measures allow us to understand how objects covering the surface interact and what implications they have on spatial organisation. Also, the analysis was split in two groups of graph theory measures: the connectivity measures and the accessibility measures. To compare the structural complexity of the networks, we need measurements that allow us to describe the degree of the network connectivity. Two of the most employed graph-theoretic measurements were used for connectivity: the gamma index (γ), which is the most representative of all, and the beta index, although there are several other indexes measuring network connectivity.

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سیستەمی تۆڕی گواستنەوە و شێوازی گەیاندن لە هەولێر

هێمن محمد اسماعیل

فاکلتی ئاداب- بەشی جوگرافیا/ زانکۆی سۆران-سۆران

پوختە

تۆڕی گواستنەوە، مەبەست لێی ئەوەیە کەوا شێوەی ڕێگاوبان و شەقامەکان لەگەڵ هاموشۆکانی مرۆڤ و گواستنەوەی کەلوپەلی لێوە باس دەکرێت. ئاشکرایە سیستەمی گواستنەوە لە زۆر بواردا کاریگەری گەورەی لەسەر (شار)دا هەیە، جا چ لە ڕووی ئابووری یاخود شێوازی بەکارهێنانی زەویدا بێت. هەر بۆیە لێکدانەوە و هەڵسەنگاندنی تۆڕی ڕێگاوبان، ڕێگەیەکە بۆ لێکۆڵینەوە لە جوگرافیای گواستنەوە.....، . لە دەیەی حەفتاکانی سەدەی ڕابردوو بە بەکارهێنانی شێوەیەکی ماتماتیکی دەست بە بەکارهێنانی میتۆدەکان کرا، ئەمەش زیاتر خۆی لە بەکارهێنانی نیشانەی (بیتا ،الفا و گاما) بو زانینی ڕیژە ی پەیوەندیی نیوان تۆڕی ریگاوبان لە ڕێگەی زانین و بە راوردی هیلەکان و ژمارە ی خاڵە کاندا بینییەوە. هە ڕوە ها بۆ زانینیی شێوە و کاریگەری ڕێگای هاتوچۆ، سیستەمی زانیاری جوگرافی یەکێکە لەو ڕێگە نوێیانە، هەر بۆیە ئیمەش لەم توێژینەوەیەدا بۆ زانینیی تایبەتمەندی تۆڕی ڕێگاوبانی پارێزگای هەولێر و شێوەی گەیاندن وەك یەکێك لە میتۆدەکانی تایبەت بە لێکۆڵینەوە لە گواستنەوەی شار، سیستەمی زانیاریمان لە پارێزگای هەولێر بەکارهێناوە.

وشە ی کلیلە کان: گواستنە وە،هە ولێر،سیستە می زانیاری جوگرافی، ئاسانی ڕێگە یشتن،ڕێک گەیاندن.

نظام الشبكة وسهولة الوصول في أربيل

هيمن محمد اسماعيل

فاكلتي الاداب قسم الجغرافية / جامعة سوران ـ سوران

ملخص

يشير مفهوم شبكة النقل إلى شبكة من الطرق والشوارع والسكك الحديدية أو أي هيكل تقريبًا يسمح بحركة المركبات أو تدفق بعض السلع. من المعروف على نطاق واسع أن أنظمة النقل يمكن أن تؤثر على المدن في العديد من الجوانب المختلفة ، من نشاطها الاقتصادي واستخدام الأراضي إلى قابليتها للعيش. يظل تحليل الشبكات أحد أهم مجالات البحث والتطبيق في مجال جغرافية النقل. تحليل الشبكة لديه أساس نظري قوي في التخصصات الرياضية لنظرية الرسم البياني وطبولوجيا. ظهر تطبيق نظرية الرسوم البيانية على أنظمة النقل على الطرق في أواخر الخمسينيات واستمر حتى السبعينيات في القرن الماضي. يتم استخدام تدابير مثل مؤشرات Gamma, Beta و Alpha لقياس الاتصال النسبي للشبكة من خلال مقارنة عدد الحواف بعدد القمم (في حالة مؤشر Beta). بالإضافة إلى ذلك ، تعد إمكانية الوصول إلى نظام شبكة Gls بمثابة نهج جديد مهم تم تطويره في الدراسات البحثية الحديثة التي تم تطبيقها في مجال جغرافية النقل. تتناول هذه الورقة الخصائص الجغرافية لنظام الشبكة في محافظة أربيل في كردستان العراق بناءً على مناهج جديدة تتضمن مقاييس كمية وتقنيات ونظم معلومات الجغرافيه .

كلمات الرئيسه: نقل, نظم معلومات الجغرافيه, سهوله الوصول, ربط,, اربيل