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Hamza Bouzid[1*], Abdelmadjid Bouder[*], Bilel Zerouali[**]

** University of Science and Technology Houari Boumediene, Faculty of Earth Sciences, Geography and Territory Planning, Bab Ezzouar, Algeria*
*** Hassiba Benbouali University of Chlef, Faculty of Civil Engineering and Architecture, Department of Hydraulic, Chlef, Algeria*

THE CONTRIBUTION OF THE ROAD TRANSPORT NETWORK TO SUPPORTING DEVELOPMENT: THE CASE OF THE WILAYA OF M'SILA, ALGERIA

Abstract: The paper evaluates the development and the capacities of action of the road network, in particular, its degree of density and accessibility in specific years of 1998 and 2017, in the Wilaya of M'sila, (Algeria). This paper aims to understand the extent of the contribution of this network to support the development in this region. To identify the municipal socio-economic profile, 41 indicators were used, 6 to determine the road density, and 5 to measure the accessibility. After comparing the results in the previously specified years, it was found that there was an improvement in the density, which included 10 municipalities, accompanied by a clear and repeated positive development in 7 of the 41 development indicators in these 10 municipalities, in terms of accessibility, an improvement was noted in 7 municipalities, attached to 8 notable and repeated indicators. The results also showed that the spatial distribution of road networks does not present a clear trend, it does not necessarily tend towards a geographical dependence, where are the grand urban localities, or the lower rank localities. In addition, the contribution of road networks to socio-economic factors are sometimes absent, and when it is present, it varies according to the location or characteristics of the road network (density/accessibility). In the case of density, the support consisted of a decrease in migration rates, and a significant increase in birth rates, in addition to an improvement in economic indicators. However, in the case of accessibility, its contribution is somewhat different, since what distinguishes it is that it helps to attract facilities, to choose the best location.

Key words: road network, transportation, density, accessibility, development, locality of M'Sila

[1] h.bouzid.univ.usthb@gmail.com (corresponding author)

Introduction

Algeria, which is one of the largest countries in North Africa and the Mediterranean basin, since the end of the last decade of the last century, the state, began to pay more attention to the issue of poverty phenomena in the deep regions of the country, especially those characterized by a dry and semi-desert climate (ANAT, 2006). Through the latter study, the "Poverty Map in Algeria" was clarified, which aimed to better know the residents of these poor municipalities, determine their locations, and deepen the knowledge of their geographical, economic and institutional environment in order to clarify sustainable future plans by the public authorities. The specification of these areas has been defined in three points: "Who are these people, where they are, and how are they helped?"

The study was based on certain socio-economic indicators related to education, health, housing and the financial income level of the municipalities, with a total of 18 indicators. The study pointed out that due to the imbalance and inequality in the distribution of services, a large part of society lives in extreme poverty, which endangers the stability of the community, This poverty, which coincides with a declining birth rate, emigration from the countryside and neighbouring regions, is accompanied by the degradation of renewable and non-renewable resources, which are represented in the soil, water, forests, pastures, fragile ecosystems of the coast, steppe and mountains. The study identified 176 poor municipalities, including 47 very poor, representing 11.42% of the total number of municipalities in the country, deprived of the minimum health services, education, housing and equipment, 11 of which are located in the Wilaya of M'Sila, which means that 23% of the total number of municipalities in the Wilaya live in difficult and worrying situations, due to the low level of economic and social indicators. The same results were obtained by Hattab (2012) with regard to the Wilaya of M'Sila, which affirms the problem of territorial disparities.

The Wilaya of M'Sila was created in 1974, being part of the HPC region. This territorial composition has constraints linked not only to the environment characterized by the quality of the soil, the lack of water, and the fragility of the vegetation but also by the tribal structure and the attachment to the ancestral ways of life. In addition, the isolation if one takes into account the absence of transportation infrastructure (highway, airport, and railway); M'sila seems the most deprived state in Algeria. It is a poorly organized steppe state (agro-pastoral economy). However, the local authorities have made great efforts in many fields to improve the development of the state.

The importance of this situation due to these environments unable to have relations (intra and extra), leads us to be interested in knowing the truth of the development, structuring and organization of these areas, where we find ourselves debating what is the socio-economic profile that characterizes each part and how is the coordination, connection and exchange between the different parts of this territory. The ambiguity leads us to ask some questions, in order to know how the population is distributed. What are its economic and social levels, and what is the difference between each part? How the population interacts with the rest, and how they communicate between them? We end up talking about a systemic approach, which considers the space as a "system" whose components are the physical environment, the human environment, the transport networks, the cities. These different elements have relationships with each other, so that a change in one area has repercussions on the whole, as Ghenouchi (2008) explains.

Currently, the most scientific and operational debate concerns the so-called theory of the structuring effect of transportation (Lu et al., 2021; Volpati & Barthelemy, 2020; Hu et al., 2018; Mimeur et al., 2018; Argyroudis et al., 2018), where, it should be noted that this theory, generally linked to economics, is primarily a political approach. In this perspective, Labasse (1966) considers that the simultaneity of the prosperity or decline of the country is only the reflection of the extent of the development of its communication networks (Magnanti & Wong, 1984). In the same context, Hilling (2003) asserts that we cannot see the economic activities of a country develop in a harmonious manner if that country lacks transportation networks. Owen (1970) considered that road density is an indicator of development, so commuting cannot be separated from development, which agrees with Mboukou (2016) who advised a greater focus on the internal road network due to its importance in organizing and structuring the regions and their activities. The latter reported also that the absence or insufficiency of infrastructure, poor network, and poor connectivity would explain the impossibility or difficulties of developing certain regions.

Given the importance of transport infrastructure, the World Bank's World Development Report in 1994 (BM, 1994) notes, "developing countries that wish to find their place in global markets or integrate into multi-source supply must make wise choices to develop their transport infrastructure". Through the study by Brocard (2009), transport networks have always been a tool of power that seeks to consolidate their rule, hold and expand their scope of action in order to organize areas and control people. To support his point, he points out that years of strong economic growth were everywhere marked by the launch of numerous infrastructure projects, as was the case during the so-called 30 glorious years, in Europe and especially in France and Germany (Ellwood, 2014). In any case, it is not possible to imagine a territory without a transportation network; it remains only to understand what degree of its importance in the organization of territories. On the other hand, the denial of the theory of the "effect" of infrastructures on territories and of a direct cause-and-effect relationship between transport and development. It emerged twenty-nine years ago when Offner (1993) discuss the astonishing fate, considered iconoclastic on the relationship between transport and territories-appeared "The 'structuring effects' of transport: political myth, scientific mystification". The author was then able to summarize this idea in a simpler way: "Whether it is the railway in the 19th century or the French motorways, the metros of the 1980s, the first high-speed train lines (TGV), these facilities do not necessarily constitute a 'plus' (more activity areas, head offices, shops, inhabitants, customers, tourists, students, turnover, the real estate added value, e.g.). The analyses indicate a major process: the amplification and acceleration of pre-existing trends, who works well in a city, in a region, benefits from increased accessibility, and who works less well loses. There is nothing mysterious about this: improving transport means expanding market areas, and therefore increasing competition. Both motorways and TGV can be taken in both directions" (Offner, 2014). In the same perspective, (Barre, 1997; Pascal, 1998) emphasizes that the fundamental certainty is that there is no automatic relationship, between the "cause and effect" type, between the presence of a large transport facility and regional development. The investigation by Koning et al. (2013), on French urban units with more than 9,000 inhabitants in 1999 shows that the effect of the TGV on job creation is positive, and of greater magnitude for executives of "higher metropolitan functions", while a negative effect is observed in cities only served by the TGV on a classic line. These results clearly show that there are no systematic effects between infrastructure and local growth.

According to Offner et al. (1996), transportation networks simultaneously constitute the support, conditions, and tangible manifestation of exchanges of any kind that they generate. Rather, it is more than a support to animate the dynamism of these regions; it is also a factor in its development insofar as it gradually creates territorial and social solidarity in the places in which it is organized (López et al., 2008). Brocard (2009) documented the importance of transport networks, as a necessary and sufficient, though not sufficient condition for economic growth and development (Zhou et al., 2022; Banerjee et al., 2020; Deng, 2013). To support of the above, and to enrich the discussion, it is worth noting the contributions of (Steck, 2012; Porter, 2012), which show, for example, varied impacts, both positive and negative, of new transport infrastructure on West African territories, societies and economies, also the contribution of Zeng et al. (2019), who explain that the relationships between road networks and socio-economic factors varied across locations, with multiple relationships (both synergy and trade-off) between them coexisting in the regions studied.

These reviews were gradually enriched, trying to give an idea of the complexity of the subject, emphasizing the impartiality of the opinion. What perhaps justifies our work is that we have approached the problem in a new case study, and the specificity of the network in the study area. There is also a lack of studies on the subject in the study area.

The multiple and permanent interrogations on the contribution of the road network, in particular its degree of density and accessibility, to the accompaniment of the development of the Wilaya of M'sila, justify or confirm the interest of our research. In this work, we will first try to find out how the characterizes of socio-economic profile of the municipalities in the Wilaya of M'sila, and its road network in the specific years of 1998 and 2017. Secondly, we will conduct a qualitative analysis in the municipalities where road accessibility/density was once improved, in order to study to what extent this has contributed to development or not.

Study Area

M'Sila is structured by 114 urban and rural centres including 47 municipal capitals (Figure 1), and 67 secondary agglomerations. The spatial distribution of the centres on the territory seems harmonious. However, this harmony does not reflect the reality of the demographic breakdown, because the centres are differently populated. Moreover, a concentration of the population has been marked in a few centres (8 centres from 114), which together represent more than 42.67% of the total population of all the centres of the Wilaya. The second part is divided between scattered areas estimated at 22.34% of the total and the rest of the centres, whether they are chief towns of municipalities or secondary agglomerations, which represent 35.99% of the total population. This fact marks on the one hand, the imbalance from the quantitative point of view between the large number of centres and the distribution of the population and on the other hand, poses enormous problems of equipment and especially of road service.

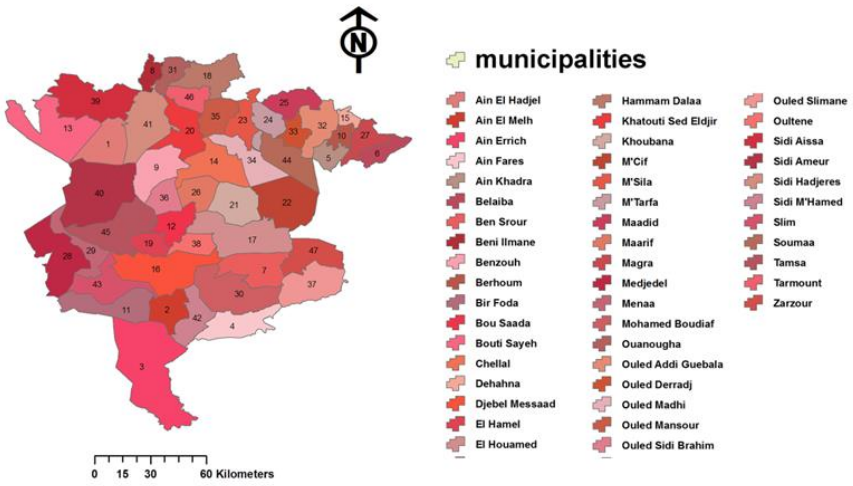

Figure 1. Municipalities of the Wilaya of M'Sila (Northern Algeria)

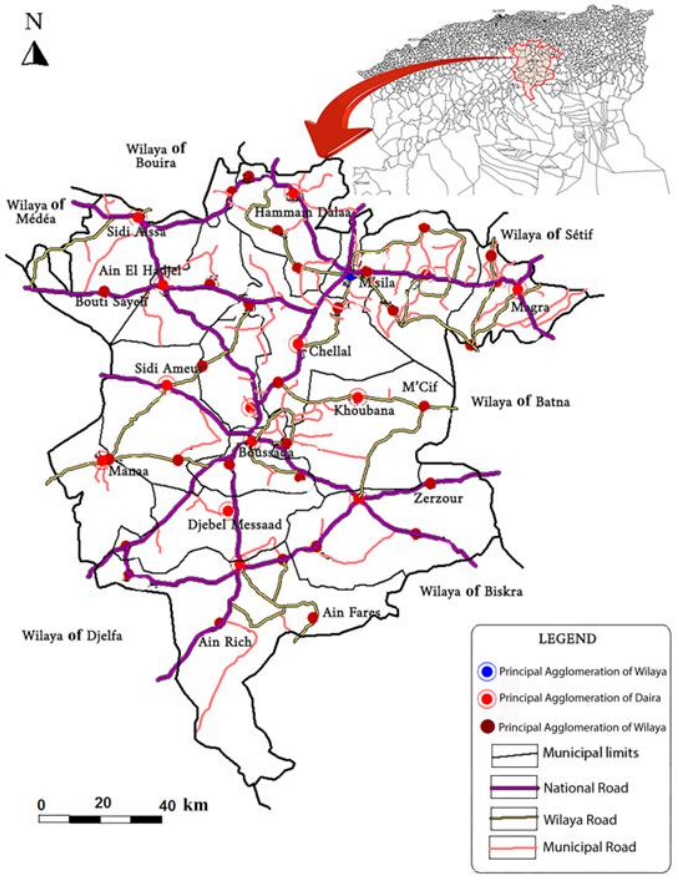

Figure 2. Road network of the Wilaya of M'Sila

Materials and Methods

Due to the complexity of the subject in the Wilaya of M'sila, and in order to respond to the problem, investigations and analyses have been carried out, based on the exploitation of surveys, as follows:

- Identification of the characteristics of the road transport network for the specific years 1998 and 2017;
- Evaluation of the road network's capacities to act in terms of density and accessibility;
- The identification of the socio-economic profile of the municipalities, thus highlighting the problems of municipal disparities, whether economic, social, level of facilities and demographics, on the living conditions of the populations residing there for the same years specified above.

The analytical plan, of the municipalities of the Wilaya of M'Sila is not easy. A large number of municipal components makes their multiple hierarchies and their sectorial weightings difficult. However, the quantitative approach remains an interesting tool for highlighting the disparities that characterize them, in addition to the characteristics of the transport network in terms of density and accessibility. The path that seems to be able to achieve these objectives is the hierarchical classification of each municipality with respect to a certain number of indicators. The main source of the databases is the statistical directory of the Wilaya of M'Sila (Direction of planning and regional development) (DPAT, 2017) as well as some reports recovered from the various directorates and services of the Wilaya. In addition to the good knowledge of the author in the field and study area.

The research was carried out according to the following steps:

- The creation of a dataset for 47 municipalities in the Wilaya of M'Sila, it contains 41 socio-economic indicators, 06 road density indicators, and 05 indicators for accessibility;
- Data processing with the help of Excel and GIS;
- The hierarchical ranking of each municipality relative to each indicator separately;
- The hierarchical classification of each municipality relative to homogeneous type of combined indicators, according to the rank obtained by each municipality for each solo indicator in the previous step;
- The municipality with the minimum accumulation of points will be favourable and relatively more developed compared to the others, depending on the type of homogeneous indicators set;
- To make a judgment (more favoured or marginalized) on the state of development according to the value of each of the 41 development indicators in each municipality, according to:
  - Standards for the theoretical grid of public facilities in Algeria;
  - International and/or national standards and averages;
  - The standards recommended in the national scheme of territory planning;
  - The standards recommended in the regional scheme of territory planning;
- The qualitative census of the judgments relating to each municipality for all the indicators combined, according to the judgment made by each individual indicator

during the previous stage, and the judgment that gathers the majority of votes will give its character to the municipality;

- The same steps were followed to determine the degree of accessibility (very good, good, medium…) and density of the road network (good, medium, poor…) in the municipalities;
- The identification of municipalities where road accessibility/density has been improved in the past, in order to study the extent of its contribution to development;

The Socio-economic Profile: Problems of Municipal Disparities

All of the data collected allowed us to initially draw up four categories totalling forty-one indicators (Tab. 1). The economic, social level, public facilities, and demography seem to be the ways through which they can address the problems of communal disparities.

The choice of economic indicators is not a coincidence. It emanates from a will imposed by the reality on the ground (situation) and by the dominant vocation of the Wilaya. This selection focused mainly on the primary sector and to a lesser extent on the secondary sector in terms of the economic title. Among the eight indicators for assessing the economic level, there are seven indicators related to the agricultural sector in its various forms. This is explained by the search for equity in classification based on the real potential of the communes that are predominantly rural. The relationships linking all municipal useful agricultural areas and irrigation have been taken into consideration. The indicators related to the livestock of all species combined and the collective pastures are related to the total area of the Wilaya were also considered. Yields per hectare of market gardening and tree crops were also parameters based on which the partial ranking was carried out.

The search for balance in the breakdown of the parameters inherent to this heading requires the highlighting of urban municipalities that present, on the economic level, certain advantages in the secondary sector. The rate of industrial employment provided by each municipality, and related to the demographic size of each, makes it possible to weight the classification in favour of the urban municipalities.

For the social level, education seemed to us to be a very good indicator, which translates both quantitatively and qualitatively the level of education of the population of each municipality relative to the whole through seven indicators highlighting the relationships between the different levels of education and the supervision of the school population. The conveniences relating to housing in terms of easement and connection to drinking water and electrical energy as well as the occupancy rate per room and per dwelling complete the social section.

In terms of equipment, the retail trade, crafts, hotels, sports, health, transport, and the telephone were taken as evaluation indicators. It should be noted that the choice of these indicators is not fortuitous, where; two municipalities with the same number of facilities in a given sector are not automatically classified in the same rank. The one that offers a better assignment rate in relation to the number of inhabitants has the one with the best classification.

The demographic section highlights the situation of the communes of the Wilaya of M'Sila in relation to their population dynamics. A crowded population is more manageable than a dispersed population. The birth rate, infant mortality, and the youthful population whose age bracket corresponds to the activity. In addition to the extrapolated ten-year

increase, the supervision of the municipalities related to the population and to the total number of jobs respectively.

Tab. 1. The 41 indicators used for the analysis of municipal disparities

Economic indicators: 08	
01 - Rate irrigated AAU / communal AAU;	05 - Yield in arboriculture per hectare;
02 - Rate irrigated AAU / Wilaya AAU;	06 - Yield of vegetable crops per hectare;
03 - Number of livestock of all species (sheep, goats, cattle, etc.) / total Wilaya;	07 - Current industrial employment rate / 1000 inhabitants;
04 - Communal course / total area;	08 - Cereal area per SAU.
Social level indicators: 13	
09 -Scolarisation rate ;	16 - Occupancy rate per accommodation;
10 -School enrolment rate of the population aged 6 to 14 years;	17 - Occupancy rate per room;
11 -Enrolment in 1st and 2nd cycle compared to the number of teachers;	18 - Percentage of dwellings served by electricity;
12 -Enrolment in 1st and 2nd cycle compared to Classrooms;	19 - Percentage of dwellings served by water supply;
13 -Number of 3rd cycle students compared to the number of teachers;;	20 - Percentage of dwellings served by sewage disposal;
14 -Rate of general secondary education students / 1,000 inhabitants;	21 - Percentage of dwellings served by natural gas.
15-Illiteracy rate of the population aged 10 and over;	
Equipment indicators: 12	
22 - Number of retail traders per 1000 inhabitants;	28 - Number of pharmacies / 1000 inhabitants;
23 - Number of private enterprises per 1000 inhabitants;	29 - Number of taxis / 1000 inhabitants;
24 - Number of hotel beds / 1000 inhabitants;	30 Number of sports facilities (youth centres, multipurpose halls, municipal stadiums and playgrounds) / 1000 inhabitants;
25 - Number of restaurants and artisans per 1000 inhabitants;	31 - Number of cultural facilities (cultural centres, libraries, theatres, museums) per 1000 inhabitants;
26 - Number of hospital beds / 1000 inhabitants;	32 - Percentage of households served by Internet access;
27 - Number of doctors / 1000 inhabitants;	33 - Number of telephone subscribers / 1000 inhabitants.
Demographic indicators: 08	
34. Growth rate % (1998-2008);	38 - Birth rate per 1000 inhabitants;
35- Population density (inhab/km^2);	39 - Mortality rate per 1000 inhabitants
36 - Agglomerated population/total population ratio;	40 - Unemployment rate;
37 - Infant mortality rate (under 1 year);	41- Supervision of municipalities in relation to total employment.

Source: AAU: agricultural area utilized

Accessibility and Related Concepts

The notion of accessibility goes hand in hand with the notion of centrality because the most central places are often the most accessible and which offer the most ease. The method consists in determining the most accessible points in relation to others or in relation to the whole and according to the extent of the territory (Raham, 2001). Mboukou (2016) reported that accessibility is the greatest ease with which a place or an attractive economic function (jobs, trade, services, etc.) can be reached from one or more other places, using all or part of the means of transport existing". This agrees with Gleyze (2001) that concludes: Accessibility, therefore, expresses the offer of travel possibilities given by the transport/communication system to reach one (or more) location(s) in order to realize an opportunity." What has convinced us to retain within the framework of our work? As for the importance and necessity of accessibility in development, Audrey (2012) wrote: "Ensuring good accessibility, to different types of activities, is an integral part of the current vision of sustainable development."

Many mathematical indicators are thus defined to better describe the accessibility or provide information on the continuity of a network (connectivity), the density and variety of possible relations between the vertices, and the quantity, and quality of the relations between each point of the network, and all the other points. Thus, indicators based on matrices and more generally on descriptive algebraic objects of graphs - allow a finer vision of the characteristics of vertices and edges at the local level. In this work, we examined the degree of accessibility for each locality, based on the indices and matrices defined below. One of these indices are The Connectivity matrix, the Shimbel matrix, the Shimbel the König indexes.

The connectivity matrix

The connectivity matrix is a binary and symmetric matrix, which indicates the presence or the absence of a direct connection (edge) between any two nodes (vertices). The existence of an edge is denoted one (1), its absence is denoted zero (0). The total number of direct links for a given number of vertices V varies from a minimum of 2*(V-1) in the case of an arborescence to a maximum of V*(V-1) in the case of a related network. They measure the degree of connectivity of a network by relating the sum of the observed links to the minimum number of links 2*(V-1) (Ghenouchi, 2008). In addition, it can calculate a centrality index (CI) by relating the total of the lines to the sum of a line. It expresses the position of the vertex (or node) in the network, the higher index; the vertex occupies a peripheral position. Therefore, the centre of the network is the node with the lowest index. It is calculated by the following formula:

$$IC = \frac{\sum of\ lines}{\sum of\ a\ line} \quad (1)$$

The Shimbel matrix and the Shimbel index

The method is very simple and resides in the fact of putting in a double-entry table the shortest paths in km from each place to all the others (Shimbel 1951), this matrix, usually called a table of kilometre distances, makes it possible to determine the places more accessible by using the real distances that separate all the vertices taken into consideration. The second step consists in making the sum in lines of each place towards all the others in order to obtain the sums of each line, the total of the distances, which separate each geographical place from all the others. Let her be the total of each row of the matrix (Raham, 2001).

$$I_i^{Shimbel} = \sum_{j=1}^{n} d_{ij} \quad (2)$$

The König matrix and the König index "the centre notion"

The calculation of this matrix has based on the principles of iterative multiplication that are the same as those evoked previously in the matrix of Shimbel. However, the accessibility between vertices in the sense of the Shimbel matrix and now defined as the power of the matrix at which a path between the two vertices appears for the first time (it is the length of the shortest path between the two vertices considered).

The König index for a vertex then corresponds to the length of the shortest path separating it from the most distant vertex (Gleyze, 2001). In other words, this index is equal to the maximum element of the row associated with the vertex considered in the Shimbel matrix. Naturally, the lower the König index, the better the accessibility is judged.

$$I_i^{König} = \max d_{ij}{}_{1 \le j \le n} \quad (3)$$

where d_{ij} represents the distance between vertices i and j.

This indicator seeks to give a value to the accessibility of a locality when it is connected to a locality of higher rank. It is calculated by the following formula:

$$ACC_1 = \sum E * Pl \quad (4)$$

where E represents the number of edges.
Pl =1, If the locality of the measure is connected to a locality of lower rank.
Pl =1.5, If the locality of the measurement is connected to a locality of the same rank.
Pl =2, If the locality of the measure is connected to a locality of higher rank

It gives a value of accessibility in a locality according to the rank of the road it crosses. It is calculated by the following formula:

$$ACC_2 = \sum E * Pn \quad (5)$$

where E represents the number of edges. Pn =1, the case of E represents a communal road. Pn =1.5, the case of E represents the wilaya path. Pn =2, the case of E represents the national road.

The Notion of Road Density

According to the road density approach, the most significant density is that which relates the total length of the network (in km) to the area of the territory (in km²). It makes it possible to determine the average distance of the network per km². The second concept of density, which is also interesting, is that it relates the population of the territory according to the length of its network. The number of kilometres per 1000 inhabitants or more can express it when the network is sparse. As this index does not take into consideration the distribution of the network on the territory as well as its area, the results could sometimes appear as contradictory with respect to spatial realities (Raham, 2001).

The calculation of the density of each municipality was made from the six ways defined below:

- The density of national roads and Wilaya paths is expressed as follows;

$$D = \frac{L_{\text{national roads and wilaya paths}}}{S} \quad (6)$$

- The density of paved municipal roads is expressed as follows:

$$D = \frac{L_{\text{paved municipal roads}}}{S} \quad (7)$$

- The rate (%) of municipal roads paved compared to unpaved (Gherabi, 2009);
- The density of national roads and Wilaya paths, per 1,000 inhabitants (Raham, 2001);
- The average distance: this is the average distance between adjacent roads within the network, it is expressed as follows;

$$D = \frac{S}{L} \quad (8)$$

where the value of this index is small, it expresses a higher number of meshes, compared to the network and the territory (Gherabi, 2009).

- The rate (%) of the area served by the edge of the road: It is the area between the road and the width of 10 km, which is the extent of the impact of the road on its sides. in the desert, this distance can exceed 500 km without reaching the population, and it is calculated by multiplying the length (national roads, and roads of Wilaya) of the network by the distance of 02 km, then dividing the result on the surface of the municipality, the result obtained multiplied by 100, and we thus obtain the percentage of the impact of the road on the regions adjacent to it (Gherabi, 2009), it is expressed as follows:

$$D = \frac{2 * L_{\text{national roads and wilaya path}}}{S} \quad (9)$$

where S corresponds to the area of the territory and L, the length of the corresponding network.

Results

Development and Communal Disparities

The cross-referencing and prioritization of the indicators of the four levels (equipment, demographic, socio-economic) revealed very large municipal disparities. Where it was found that the Wilaya of M'sila suffered from a low level of development in 1998, while 94% of the communes of the Wilaya suffered from marginalization, but the situation improved in 2017, where the latter distinguished 6 distinct groups that characterize this last 2017 (Figures 3a, 4 and Table 2).

The first group, made up of three municipalities (M'Sila, Boussaada, and Sidi Aissa), seems to be the most favoured compared to the others, not in terms of absolute number, but also in terms of equipment rate per inhabitant. Within this group, M'Sila emerges with 437 points, characterized by good road density, and also very good accessibility, followed by Boussaada with 518 points, with medium road density and good accessibility (Figure 5).

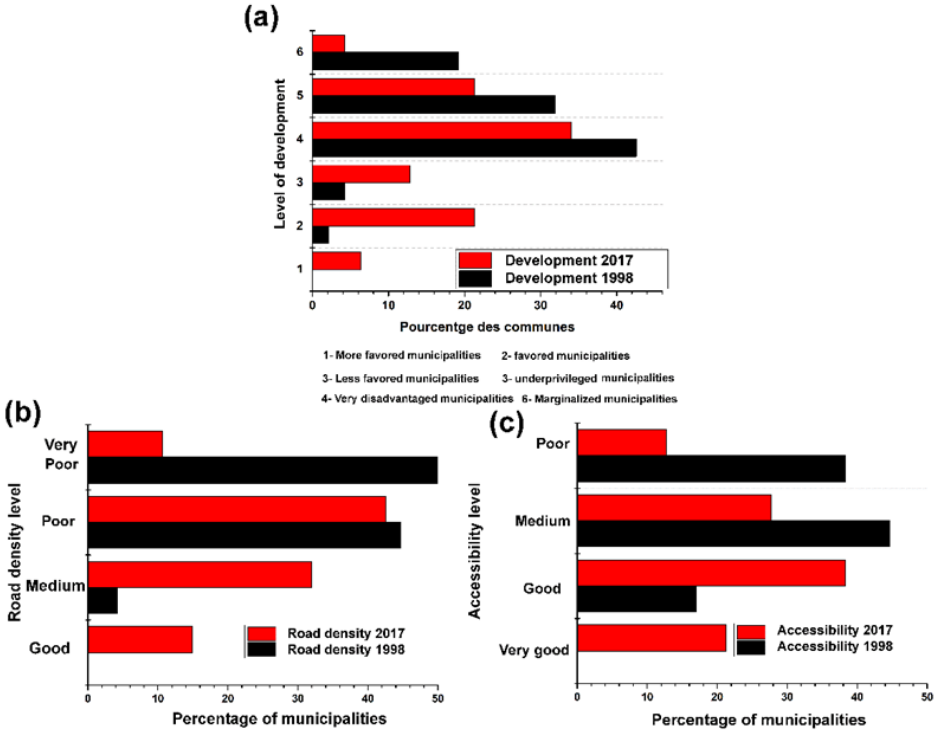

Fig. 3. The Development, accessibility and road density in 1998 and 2017.

A second group is also favoured over the others, but less than the first. It is made up of 10 municipalities, led by Aïn El Hadjel with 587 points and ending with the municipality of Bensrour with 666 points. These municipalities are characterized by a good level of demography and equipment but are weak in terms of economic indicators. As far as the network is concerned, the municipalities in this group are characterized by a road density that varies between average and very low, and very good accessibility in the majority of the municipalities in this group. A third group, less favoured, is made up of 6 municipalities with between 712 and 796 points. These are Ouled Sidi Brahim, Magra and Aïn El Khadra, who lead this group, which ends with Maadid (775), Metarfa (782) and Tarmount (796). This group is made up of municipalities with an average level of equipment, a road density varying between average and very low, and average accessibility. Three municipalities in this group have high economic potential.

The fourth group consisting of 16 disadvantaged municipalities, which characterized generally by a very low road density, in contrast, it characterized by very good accessibility. It should be noted here that half of the municipalities in this group have significant economic capacities. The big gap is in the fifth group, which seems to be marginalized given the number of points it has, which exceeds 900. This last group is made up of 10 municipalities, which suffer at different levels. They are Aïn Fares, Menaa, Mohamed Boudiaf, Benzouh, Souamaa, Temsa, Sidi M'Hamed, K. Ced El Djir, Ouled Slimane and Bir Fodda. Also in this group, as in the previous one, it became clear to us that all the municipalities suffer from very low road density, as well as poor accessibility. The sixth group, very marginalized, is included in two municipalities. Bouti Sayah emerges with 1066 points. Is one of the most disadvantaged

municipalities in terms of demography, equipment, and social level, although it has a very significant economic potential, characterized by a good density of roads, unlike poor accessibility, is followed by Zerzour with 1157 points, which is disadvantaged at all levels.

Tab. 2. Classification of municipalities according to the synthetic level.

A: Economic indicators; B: Social level indicators; C: Equipment indicators; D: Demographic indicators; T: total points; R: synthetic rank.													
Synoptic table													
Centre	A	B	C	D	T	R	Centre	A	B	C	D	T	R
M'Sila	162	88	63	124	437	6	Ouled Maddi	163	254	221	186	824	3
Boussaada	164	166	77	111	518		Maarif	165	264	248	158	835	
Sidi Aissa	209	174	85	87	555		Belaiba	185	315	222	120	842	
Aïn El Hadjel	180	205	123	79	587	5	Medjdel	176	242	225	202	845	
Hammam Dhalaa	115	200	153	128	596		Djebel Messaad	233	238	206	174	851	
Barhoum	182	232	95	97	606		Sidi Ameur	153	315	206	177	851	
Ouanougha	166	144	142	176	628		Houamed	169	328	207	156	860	
Ouled Derradj	210	169	133	116	628		Sidi Hadjres	194	294	178	211	877	
El Hamel	241	162	137	97	637		M'Cif	208	280	188	203	879	
Aïn El Melh	191	244	110	107	652		Dehahna	213	273	234	163	883	
Chellal	169	177	124	183	653		Oultem	218	283	224	167	892	
Ouled Addi Guebala	151	244	135	126	656		Aïn Fares	154	256	303	205	918	2
Bensrour	207	228	117	114	666		Menaa	181	297	253	190	921	
Ouled Sidi Brahim	204	200	148	160	712	4	Mohamed Boudiaf	176	349	253	144	922	
Magra	156	297	133	155	741		Benzouh	234	278	217	194	923	
Aïn El Khadra	165	282	177	146	770		Souamaa	221	236	272	194	923	
Maadid	197	247	176	155	775		Temsa	185	262	287	194	928	
Metarfa	199	235	215	133	782		Sidi M'Hamed	190	253	298	195	936	
Tarmount	159	274	201	162	796		K. Ced El Djir	132	315	259	231	937	
Ouled Mansour	155	222	250	171	798	3	Ouled Slimane	196	353	263	223	1035	
Khoubana	177	262	186	175	800		Bir Fodda	232	277	290	236	1035	
Slim	162	258	153	227	800		Bouti Sayah	177	329	325	235	1066	1
Aïn Rich	114	305	256	127	802		Zerzour	224	393	the 310	230	1157	
Beni Ilmane	245	212	158	200	815								

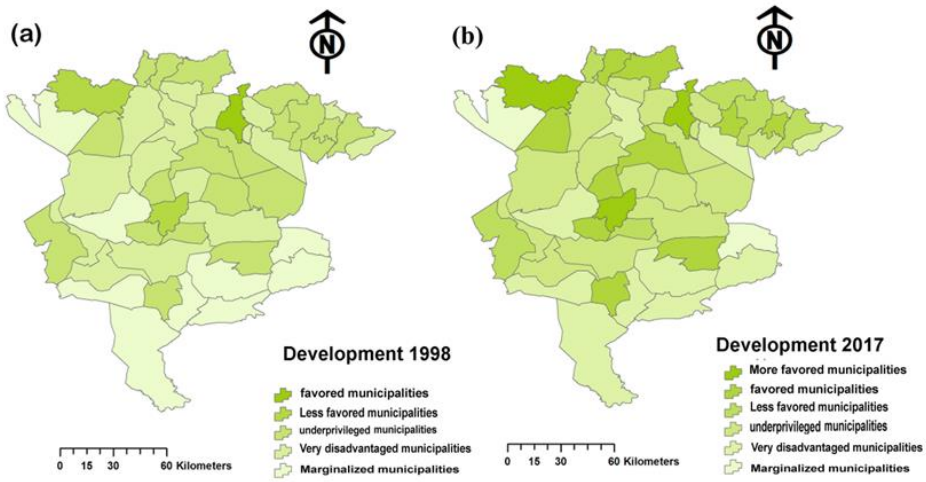

Fig. 4. Development in 1998 and 2017

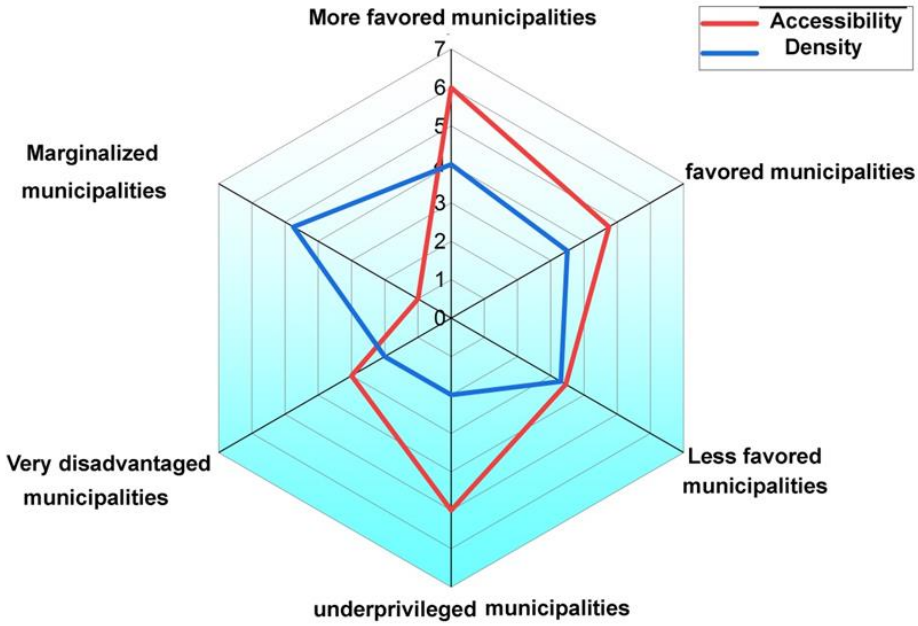

Fig. 5. Accessibility and road density according to the level of development.

The Road Transport Network

In order to study the characteristics evolution of the transport network in the study area, accessibility and road density were calculated separately, and then the contribution of each to supporting development at the level of the municipalities of the M'sila Wilayat was determined. For accessibility in 1998, all municipalities were ranked hierarchically according to each of the five accessibility indicators separately (the connectivity matrix, the Shimbel matrix, the Shimbel matrix, and the König index. e.g), then reordered again according to the five combined indicators, according to the rank obtained by each municipality for each

solo indicator in the previous step. The same steps were followed to determine accessibility in 2017 and road density, except that in density six particular indicators were used.

After studying the evolution of the road network in the Wilaya of M'sila during the period 1998-2017, it was found that there is an improvement in many municipalities, but especially for 10 municipalities for road density and 7 for accessibility. In addition, after perceiving the state of development of the municipalities concerned, it was found that there is a set of indicators that have improved during this period (Figures 3b, c, 6, 7 and 8).

Density

The results (Figures 6, 8a and Table 3) showed a significant positive evolution of 7 development indicators in the communes where the road density was improved, classified sequentially according to their recurrence as follows:

- Net migration: encountered in 8 out of 10 municipalities, where the migration rate has decreased in certain marginalized municipalities, such as Bouti Sayah, Oultem and Aïn Fares, etc.)
- Birth rate: a significant increase in birth rates has been recorded, particularly in the communes of M'Sila and Sidi M'Hamed, and this could be due to the improvement of sanitary conditions, or to encouraging economic conditions. This was found in 7 out of 10 municipalities.
- Irrigated AAU / communal AAU rate: The economy of the communes of the Wilaya of M'Sila is essentially based on the primary sector and particularly on the great potential that characterizes the latter. The useful irrigated agricultural area in relation to the communal area highlights the capacities of 3 communes namely Aïn Fares, Oultem and Bouti Sayah with respectively 73.99%, 51.35% and 40.93%.
- Communal AAU / Wilaya AAU rate: Communal useful agricultural area in relation to the area of the Wilaya, found in 5 out of 10 communes.
- Cereal area in relation to UAA: found in 5 municipalities out of 10.
- Yield in arboriculture in relation to the hectare: found in 4 municipalities out of 10.
- Rate of pupils in general secondary education / 1000 inhabitants: found in 4 municipalities out of 10.

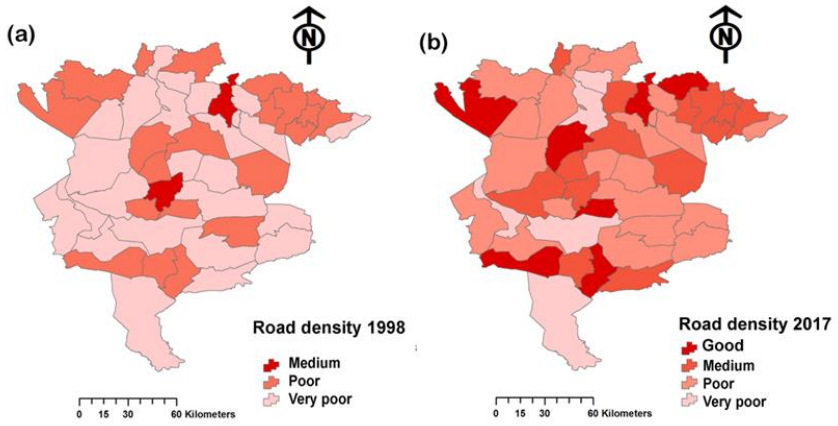

Figure 6. The road density in 1998 / 2017.

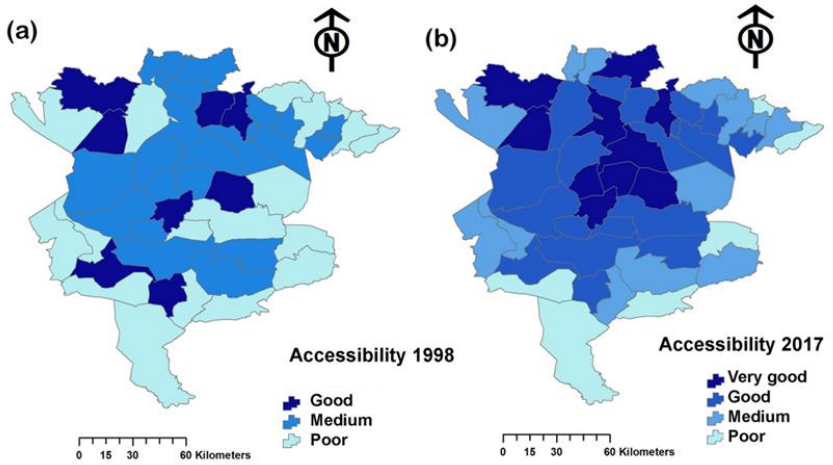

Fig. 7. The accessibility in 1998 / 2017.

Tab. 3. Apparent indicators after density improvement

Indicator ID	1	2	5	8	14	37	38	Total
Bouti Sayah	x	x		x		x	x	5
M'Sila					x	x	x	3
Oultem	x	x	x	x		x	x	6
Maadid			x		x	x	x	4
Benzouh	x	x	x	x				4
Sidi M'Hamed			x	x	x		x	4
Aïn Fares	x	x			x	x	x	5
Boussaada						x	x	2
Aïn El Khadra				x		x		2
M'Cif	x	x				x		3
Total	5	5	4	5	4	8	7	38

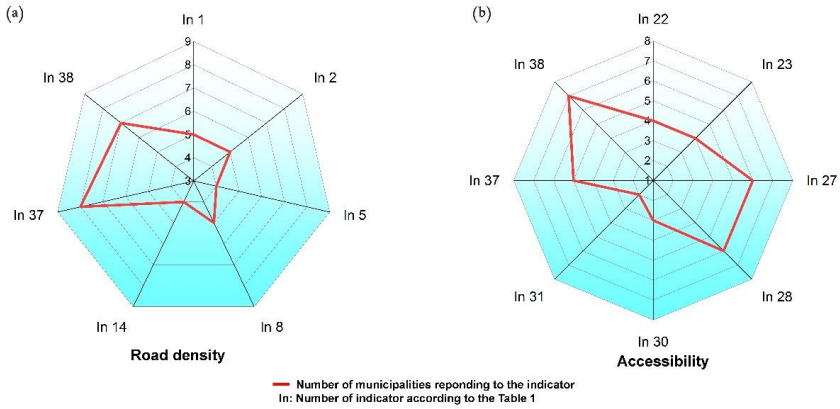

Fig. 8. Apparent indicators after improving density/accessibility.

Accessibility

The results presented below (Figures 7, 8b and Table 4) show the communes in which accessibility was improved, as well as the 8 development indicators that were tracked as having been improved in these communes, ranked sequentially by their recurrence as follows:

- Birth rate: found in 7 municipalities out of 7.
- The number of doctors / 1000 inhabitants: found in 6 municipalities out of 7.
- The number of pharmacists / 1000 inhabitants: found in 6 municipalities out of 7.
- Net migration: encountered in 5 out of 7 municipalities, where the migration rate has decreased in certain marginalized municipalities, such as Bouti Sayah, Oultem and Aïn Fares, e.g.)
- The number of retail businesses per 1000 inhabitants: found in 04 municipalities out of 7.
- The number of private companies per 1000 inhabitants: found in 04 municipalities out of 7.
- The number of sports facilities (youth centres, multipurpose halls, municipal stadiums and playgrounds) / 1000 inhabitants: found in 3 municipalities out of 7.
- The number of cultural facilities (cultural centres, libraries, theatres, museums) per 1000 inhabitants: found in 2 municipalities out of 7.

Tab. 4. Apparent indicators after accessibility improvement

Indicators ID	22	23	27	28	30	31	37	38	To-
Khoubana			x	x				x	3
M'Sila	x	x	x	x	x	x	x	x	8
Chellal	x	x	x	x			x	x	6
Ouled Sidi Brahim	x	x	x	x	x		x	x	7
Maarif			x	x			x	x	4
K. Ced El Djir								x	1
Boussaada	x	x	x	x	x	x	x	x	8
total	4	4	6	6	3	2	5	7	37

Discussion and Conclusion

The state of insecurity experienced by Algeria as a whole during the period 1989-2000 had a negative impact on development (Noudri et al., 2016), particularly in the interior regions, including the study area, which suffered from marginalization at the end of 1998 which resulted in a significant decline in development affecting 94% of the municipalities of the Wilaya. After the return of stability and security, efforts were intensified to develop the areas concerned, with the maintenance of national roads and deteriorated Wilaya paths, and the creation of new communal paths, all within the framework of the development, where an improvement in road density was recorded in 10 municipalities of the Wilaya, as well as accessibility in 7 municipalities. The results showed that the improvement of 7 development indicators was observed in communes where road density improved, as well as a decrease in migration rates, and a significant increase in birth rates, in addition to an improvement in economic indicators. These observations agree with results obtained by (Fithra et al., 2019; Tarigan et al., 2018; Jedlička et al., 2018). As for the 7 municipalities in which accessibility has improved, 8 indicators were noticed, the first of which is the increase in birth rates, accompanied by a decrease in migration rates, as well as a significant increase in indicators of equipment. Like the municipalities affected by the improvement in road density,

the accessible municipalities were not the only ones to improve some of their own indicators, but what sets them apart is the combination of several equipment indicators, which may be due to the fact that the equipment chooses the accessible places. In addition, it has been found that the relationship between road density and accessibility is not very coordinative sound. where it turns out that 8 municipalities with very good accessibility, but they suffer from a very low density in terms of municipal roads, despite significant economic potential. This requires a solution from the local authorities, in order to work for the densification of the road network in the accessible municipalities. The results also showed that the spatial distribution of road networks does not have a clear trend, it does not necessarily tend towards a geographical dependence, where are the large urban localities, or the localities of lower rank, on the contrary, we have found that sometimes the network is good both ways. Furthermore, the contribution of road networks to socio-economic factors is sometimes absent, and when it is present, it varies according to the location or the characteristics of the road network (density/accessibility). In the case of density, the support consisted of a decrease in migration rates, and a significant increase in birth rates, in addition to an improvement in economic indicators. As for accessibility, its contribution was a little different, since it was it that attracted the equipment indicators to choose them in order to better locate them.

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References

Argyroudis, S., Mitoulis, S., Kaynia, A. M., & Winter, M. G. (2018). Fragility assessment of transportation infrastructure systems subjected to earthquakes. Geotechnical Earthquake Engineering and Soil Dynamics V: Numerical Modeling and Soil Structure Interaction.

Audrey, G. (2012). *L'accessibilité en transport - méthodes et indicateurs* [mémoire de maîtrise]. École polytechnique de Montréal, Université de Montréal.

Banerjee, A., Duflo, E., & Qian, N. (2020). On the road: Access to transportation infrastructure and economic growth in China. *Journal of Development Economics, 145*. https://doi.org/10.1016/j.jdeveco.2020.102442

Barre, A. (1997). Le réseau autoroutier français: un outil rapidement valorisé, des effets controversés. *Annales de Géographie, 106* (593-594), 81-106.

Banque Mondiale. (1994). *Banque Mondiale Rapport Annuel 1994. Banque Mondiale*. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/190771468328848588/banque-mondiale-rapport-annuel-1994

Brocard, M. (2009). Transports et territoires. Enjeux et débats, Territoire en Mouvement Revue de géographie, 10 (2011). https://doi.org/10.4000/tem.1156
Delaplace M., Koning, M., & Blanquart, C. (2013). Dessertes ferroviaires à Grande Vitesse et dynamisme économique local: Une analyse exploratoire sur les unités urbaines françaises. 50ème colloque de l'Association des sciences régionales de langue française.
Deng, T. (2013). Impacts of transport infrastructure on productivity and economic growth: Recent advances and research challenges. *Transport Reviews, 33*(6), 686-699. https://doi.org/10.1080/01441647.2013.851745
DPAT (2017). *Rapport des statistiques de Direction of planning and regional development*. (Accessed: 03/01/2022).
Ellwood, D. W. (2014). *Rebuilding Europe: Western Europe, America and Postwar Reconstruction*. Routledge.
Fithra, H., Hasyim, S., Saleh, S. M., & Saputra, J. (2019). Road network connectivity and freight transportation for supporting the development of the northern zone of Aceh. *Journal of Southwest Jiaotong University, 54*(3). https://doi.org/10.35741/issn.0258-2724.54.3.28
Ghenouchi, A. (2008). *Réseaux de transport et organisation spatiale dans le Nord-Est Algérien (Cas des réseaux ferroviaire et routier)* [thèse de doctorat]. Faculté des Sciences de la Terre, de la Géographie et de l'Aménagement du Territoire, Université Mentouri Constantine, Algérie.
Gherabi, N. (2009). *Le transport semi-urbain dans la Wilaya de Annaba réalité et horizons* [thèse de magister]. Faculté des Sciences de la Terre, de la Géographie et de l'Aménagement du Territoire, Université Mentouri Constantine, Algérie.
Gleyze, J-F. (2001). *Réseaux, Territoires et accessibilité*. Institut géographique National, Paris.
Hilling, D. (2003). *Transport and developing countries*. Routledge.
Hu, X. Wu, C. Wang, J., & Qiu, R. (2018). Identification of spatial variation in road network and its driving patterns: Economy and population. *Regional Science and Urban Economics, 71*, 37-45. https://doi.org/10.1016/j.regsciurbeco.2018.04.014
Jedlička, J., Havlíček, M., Dostál, I., Huzlík, J., & Skokanová, H. (2019). Assessing relationships between land use changes and the development of a road network in the Hodonín region (Czech Republic). *Quaestiones Geographicae, 38*(1), 145-159. https://doi.org/10.2478/quageo-2019-0003
Labasse, J. (1967). L'organisation de l'espace, éléments de géographie volontaire. *Revue de Géographie Alpine, 55*(1), 232-235.
López, E., Gutiérrez, J., & Gómez, G. (2008). Measuring regional cohesion effects of large-scale transport infrastructure investments: an accessibility approach. *European Planning Studies, 16*(2), 277-301. https://doi.org/10.1080/09654310701814629
Lu, X., Wang, M., & Tang, Y. (2021). The spatial changes of transportation infrastructure and its threshold effects on urban land use efficiency: Evidence from China. *Land, 10*(4), 346. https://doi.org/10.3390/land10040346
Magnanti, T. L., & Wong, R. T. (1984). Network design and transportation planning: Models and algorithms. *Transportation science, 18*(1), 1-55. https://doi.org/10.1287/trsc.18.1.1
Mboukou, M. (2016). Mal-développement territorial au Congo: une lecture à travers la connectivité et l'accessibilité du réseau de transport routier. *Organisations and territoires 25*(3), 55-66. https://doi.org/10.1522/revueot.v25n3.303.
Mimeur, C., Queyroi, F., Banos, A., & Thévenin, T. (2018). Revisiting the structuring effect of transportation infrastructure: an empirical approach with the French Railway Network

from 1860 to 1910. *Historical Methods: A Journal of Quantitative and Interdisciplinary History, 51*(2), 65-81. https://doi.org/10.1080/01615440.2017.1393358

Ministère de la Solidarité Nationale (2006). *Etude d'affinement de la carte de la pauvreté de 2000 communes pauvres: territoires, populations et capacités d'action. Rapport de synthèse.* Sous la tutelle de la Ministère de la Solidarité Nationale, en coopération avec le Programme des Nations Unies pour le Développement.

Noudri, H., Mehdi, W., Hamouta, D., & Fatima, F. (2016). *L'impact de l'insécurité sur le développement économique en Algérie 1989-2014.* Faculté des Science Politique, Université Larbi Ben M'hidi, Oum el Bouaghi, Algérie.

Offner J.-M. & Pumain, D. (1996). Au croisement des chemins: rencontres interdisciplinaires à propos des réseaux et des territoires. *Réseaux et territoires, 106*(597), 549-551.

Offner, J.-M. (1993). Les effets structurants du transport: mythe politique, mystification scientifique. *Espace géographique, 22*(3), 233-242.

Offner, J.-M. (2014). Les effets structurants du transport. *L'Espace géographique, 43*(1), 52-54.

Pascal, B. (1998). Analyser les mobilités et le rayonnement des villes pour révéler les effets territoriaux des grandes infrastructures de transport. *Les Cahiers Scientifiques du Transport, 33*, 109-127.

Porter, G. (2012). Reflections on a century of road transport developments in West Africa and their (gendered) impacts on the rural poor. *EchoGéo, 20*(2012), 14. https://doi.org/10.4000/echogeo.13116

Raham, D. (2001). *Les structures spatiales de l'Est algérien. Les maillages territoriaux, urbains et routiers* [thèse de doctorat]. Faculté des Sciences de la Terre, de la Géographie et de l'Aménagement du Territoire, Université Mentouri Constantine, Algérie.

Shimbel, A. (1951). Applications of matrix algebra to communication nets. *Bulletin of Mathematical Biophysics, 13*, 165–178. https://doi.org/10.1007/BF02478225

Steck, B. (2012). West Africa facing the lack of traffic lanes. A study case: The Nouakchott-Nouadhibou road (Mauritania). *EchoGéo, 20*(2012), 18. https://doi.org/10.4000/echogeo.13101

Tarigan, H., Matondang, A. R., & Lubis, S. (2021). The Effect of Road Transportation Infrastructure on Freight Transport Mobility and Regional Economy in Indonesia. *The Journal of Asian Finance, Economics and Business, 8*(3), 645-654. https://doi.org/10.13106/jafeb.2021.vol8.no3.0645

Volpati, V., & Barthelemy, M. (2020). Revisiting the coupling between accessibility and population growth. *Journal of Physics: Complexity, 1*(2). https://doi.org/10.1088/2632-072X/ab97a7

Zeng, C., Song, Y., Cai, D., Hu, P., Cui, H., Yang, J., & Zhang, H. (2019). Exploration on the spatial spill over effect of infrastructure network on urbanization: A case study in Wuhan urban agglomeration. *Sustainable Cities and Society, 47.* https://doi.org/10.1016/j.scs.2019.101476

Zhou, Y., Tong, C., & Wang, Y. (2022). Road construction, economic growth, and poverty alleviation in China. *Growth and Change, 12*(9). https://doi.org/10.1111/grow.12617