



# Assessment of the effects of quarrying activities on the road network quality: a case study of Benslimane province, Morocco.

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***Assessment of the effects of quarrying activities on the road network quality: a case study of Benslimane province, Morocco .***

**تقييم آثار أنشطة المقالع على جودة الشبكة الطرقية: دراسة حالة إقليم بنسليمان، المغرب.**

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➤ **Abstract:**

The road network is affected as a result of the passage of the quarry trucks and the transportation of materials in the province of Benslimane. It is natural that the movement of selling the products of these quarries to neighboring cities such as Rabat, Mohammedia, Casablanca, and even Kenitra and El Jadida is active, which will move a huge fleet of trucks of various sizes, especially heavy ones, to transport the products of these quarries of stones, gravels, and marble. Due to the absence of external orbits, this huge fleet is forced to pass within the orbits of the local municipalities of the Benslimane province, which has become a threat to the road network, population, health, properties, and the conduct of their normal activities. The degree of danger and the intensity of impact on the quality of the road network varies according to other determinants such as traffic density, the type of load and trucks used to transport materials, the condition and nature of the roads used, and the duration of transportation periods.

The results show the degree of use of the road network by the local population and quarry trucks that most of these latter use the roads concentrated in the east of the province, where most of the province's quarries are located with about 31 quarries, 19 of which are in the Ain Tizgha communes. While the average use of roads is concentrated in the center of the province, as they cross and depart mainly from the city of Benslimane in the direction of Bouznika, Mohammedia, and the districts. As for the poorly used roads, we find them in the far south of the province, where only a limited number of quarries are concentrated in Ahalaf communes and in the direction of the west.

**Keywords: Environmental impact - Sustainable development - Territory planning - Environmental degradation - Economy.**

### ملخص:

تتأثر شبكة الطرق نتيجة مرور شاحنات المقالع ونقل المواد ضمن مدارات إقليم بنسليمان. إذ أنه من الطبيعي أن تنشط حركة بيع منتوجات هذه المقالع للمدن المجاورة كالرباط، المحمدية، الدار البيضاء وحتى القنيطرة والجديدة، مما سيحرك أسطولا هائلا من الشاحنات بمختلف الأحجام خصوصا الثقيلة منها، لتنتقل منتوج هذه المقالع من الأحجار والحصى والرخام. ونظرا لغياب مدارات خارجية فإن هذا الأسطول الضخم مجبر على المرور داخل مدارات الجماعات المحلية لإقليم بنسليمان، الشيء الذي أصبح يشكل خطرا على الساكنة وصحتهم وممتلكاتهم ومزاولة أنشطتهم الاعتيادية. كما تختلف درجة الخطر وحدة تأثير أحد هذه العوامل على جودة الشبكة الطرقية تبعا لمحددات أخرى ككثافة حركة المرور، نوع الحمولة والشاحنات المستخدمة في نقل المواد، حالة وطبيعة الطرق المستعملة ومدة فترات النقل.

بيّنت النتائج أن درجة استخدام شبكة الطرق من قبل شاحنات المقالع والسكان المحليون تختلف حسب الموقع، فمعظم هذه الشاحنات تستخدم الطرق المتركزة بشرق الإقليم حيث تتموضع أغلب مقالع الإقليم بحوالي 31 مقلعا 19 منها بالجماعة الترابية عين تيزغة. بينما تتركز الطرق ذات الاستعمال المتوسط بمركز الإقليم، إذ تعبر وتنطلق أساسا من مدينة بنسليمان في اتجاه بوزنيقة، المحمدية والنواحي. أما بخصوص الطرق ذات الاستعمال الضعيف فنجدها بأقصى جنوب الإقليم حيث لا يتركز سوى عدد محدود من المقالع بجماعة أحلاف وفي اتجاه الغرب.

**الكلمات المفتاح:** الأثر البيئي - التنمية المستدامة - إعداد التراب - التدهور البيئي - الاقتصاد.

### ➤ Introduction

Among the most prominent areas that know a wide range of quarries, we find the Benslimane province, which has a significant number of them, as this sector occupies a distinguished position within the field of economic development of the province, which makes it vulnerable to many dangers and imbalances that threaten the local environment on the one hand and human health on the other hand.

Benslimane province is also considered as one of the Moroccan provinces that has witnessed a large spread of quarries in recent years with the aim of its development and due to the availability of appropriate geological conditions. However, the pressure on these resources has recently led to the emergence of a set of imbalances in the quarrying sector that concern the methods of exploitation and the growing phenomenon of random quarries, which has resulted in many severe damages to the environment caused by dust, vibrations, noise, excavation, and transportation of materials.

Therefore, we will take the quarries of the Benslimane province as a model for the study, to know the quarries that the province has, as well as their geographical distribution, and thus determine their locations and types of the geographical distribution of population density. All of this is to extract **the pressure on the use of the road network in the area of Benslimane.**

The main objective of this study is to use the geographical information systems to guide the authorities and decision-makers to take the right solutions by rehabilitating these roads, monitoring the number and size of trucks that cross them daily, and punishing violators of these laws, which causes the deterioration of roads and the occurrence of serious traffic accidents.

#### ➤ *The problem*

The subject of quarries is of great importance in recent studies, given the effective role it plays in achieving local development and spatial development strategies, and if this position gives it importance in political and economic studies, its environmental repercussions make it the focus of studies of researchers interested in protecting the environment and encouraging sustainable development.

Therefore, we will take a model for the study of the quarries of Benslimane province, with an attempt to apply the tools of geographic information systems and remote sensing in addressing this environmental problem that revolves around knowing the extent to which the historical development and the large spatial spread of quarries contributed to affecting the quality of the road network in the province of Benslimane.

#### ➤ *Expected Results*

Since we live next to the area of the study. It's safe to expect that it is natural that the movement of selling the products of these quarries to neighboring cities such as Rabat, Mohammedia, Casablanca, and even Kenitra and El Jadida is active, which will move a huge fleet of trucks of various sizes, especially heavy ones, to transport the products of these quarries of stones, gravels, and marble. Due to the absence of external orbits, this huge fleet is forced to pass within the orbits of the local municipalities of the Benslimane province, which has become a threat to the road network, population, their health, properties, and the conduct of their normal activities.

The degree of use of the road network by the quarry's trucks and the local population that most of these trucks use the roads will be concentrated in the east of the province, where most of the province's quarries are located with about 31 quarries. While the average use of roads is concentrated in the center of the province, as they cross and depart mainly from the city of Benslimane in the direction of Bouznika, Mohammedia, and the districts. As for the poorly used roads, we find them in the far south of the area, where only a limited number of quarries are concentrated in Ahalaf commune and the direction of the west.

➤ *Data Sources*

In this analysis we used the next data sources:

- Public data source: We have downloaded the road network of Benslimane province from the open website OpenStreetMap (<https://www.openstreetmap.org>);
- Public data source: We have downloaded the population number in the studied municipalities of the province of Benslimane from the government website of the Ministry of Planning and Statistics (<https://www.hcp.ma>), which provides data for the general census of population, housing, and equipment for the entire Kingdom of Morocco;
- Public data source: We obtained data on the territorial division of the Kingdom of Morocco in a shapefile format that includes the boundaries and areas of regions, regions, and the municipalities of the kingdom;
- Public data source: We have downloaded the Digital elevation model (DEM) for the area of Benslimane province from the website: <https://earthexplorer.usgs.gov>;
- Private data source: We did visit the Regional Directorate of Equipment, Transport and Logistics in the province of Benslimane to obtain data related to the distribution of quarries, the number of trucks transporting materials daily, as well as the types of roads that these trucks cross and their destination.

➤ *Planned Methods*

To extract the pressure on the use of the road network in the area of Benslimane we have used multiple methods:

- We did draw the network of different types of roads in the province of Benslimane, filling a database that includes their names, types, directions...;
- We have downloaded the population number of the municipalities of Benslimane province according to the data of the general census of population and housing in the Kingdom of Morocco;
- We obtained data on the territorial division of the Kingdom of Morocco in a shapefile format that includes the boundaries. Then I will extract the boundaries of municipalities of province Benslimane using special queries (SQL);
- We did give each commune of Benslimane province code number to join and attach the number of populations. After that, I will extract the area of each one using *calculate geometry* inside ArcGIS to calculate the population density of the municipalities;
- We did create a hillshade from the digital elevation model (DEM) for the Benslimane Province to add aesthetics to the map;

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- We filled a database and located the Quarries of Benslimane using their X and Y obtained using a GPS device carried out by the staff of the Regional Directorate of Equipment, Logistics, and Water in Benslimane;
- Then we classified the network roads use of each road in Benslimane province according to the number of trucks and materials that cross daily to extract the amount of pressure these roads are exposed to.

In order to classify the network roads use of each road in Benslimane province, we did use the **reclassify tool** inside ArcGIS by Assigning a score for each characteristic of each of the province's roads, starting with directions, the number of adjacent quarries, the number of quarry trucks that cross daily, then the population density that they exploit and pass through that road.

The grading process will be done as follows:

Directions		Quarries		Trucks		Population Density (people/Km <sup>2</sup> )	
Direction	Score	Number	Score	Number	Score	Number	Score
Inside the Province	0	0	0	0	0	Less than 30	1
To Bsabes	1	2	1	5 to 9	1	30 to 39	2
To Ziaida	2	4	2	10 to 14	2	40 to 49	3
To Fedalat	3	5	3	15 to 19	3	50 to 60	4
To Mansouria	4	6	4	20 to 25	4	More than 60	5
To Benslimane	5	7	5	More than 25	5		
To Bouznika	6	9	6				
To Mohemmadia	7	17	7				
To laayoune	8						
To Rabat	9						
To Casablanca	10						

After that, we used the **Weighted Overlay tool** inside ArcGIS to calculate the final score and reclassify (Reclassify tool) the roads depending on their final score.

**Table: evaluation of the final scores and their interpretation**

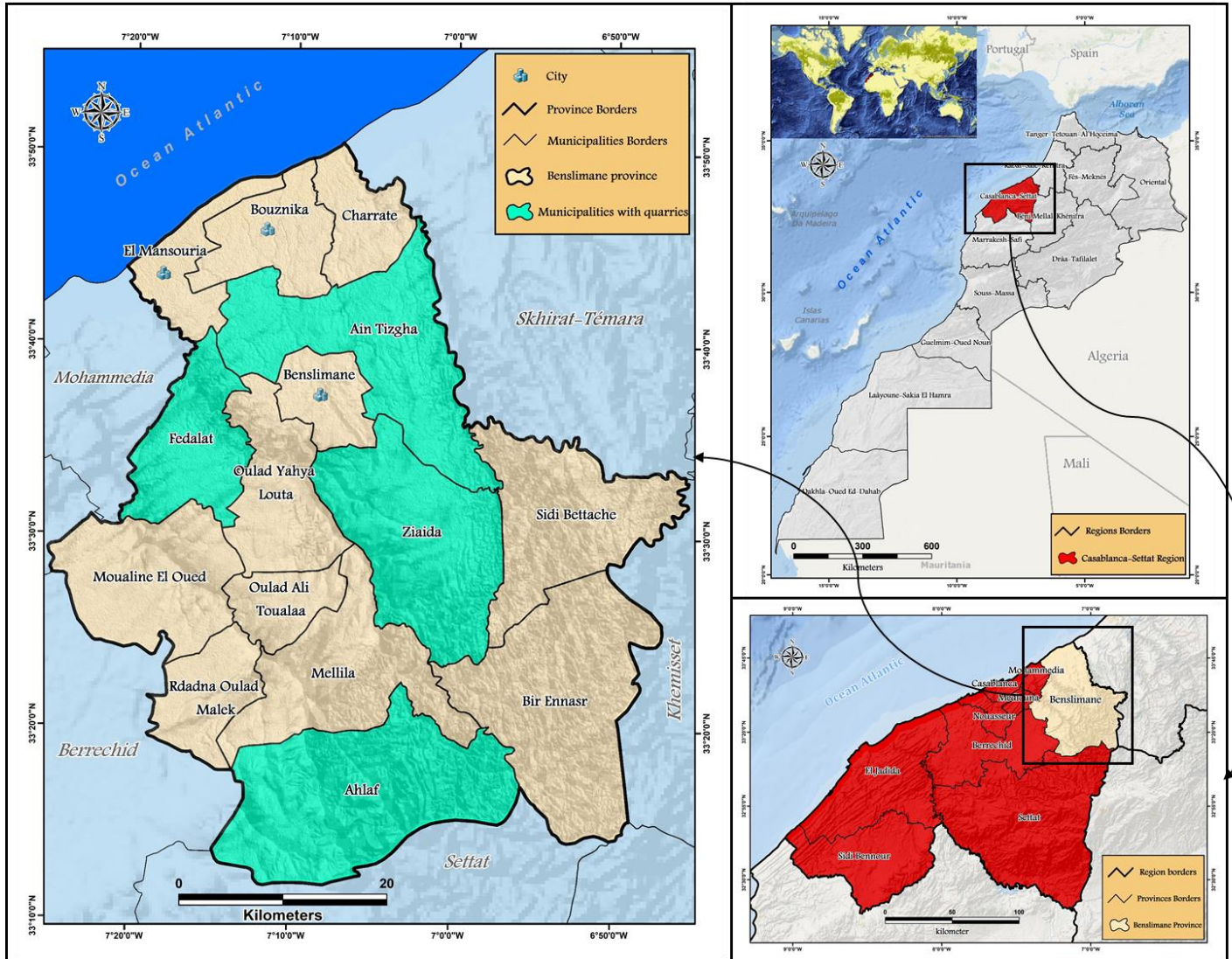
FINALE SCORE	INTERPRETATION
Less than 2	Very poor use
From 2 to 6	Poor use
From 7 to 11	Average use
From 12 to 16	Heavy use
More than 16	Very heavy use



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## ➤ Benslimane province location

**Map: Localizing the studied Area at the national, regional, and local levels.**



**Source: Personal work of Salah Eddine KOTTABI based on: Regional division data for Morocco in 2016, and the SRTM digital elevation model with a resolution of 30 meters.**

The province was created by royal decree n ° 2-77-605 of July 19, 1977, <sup>1</sup> the province of Benslimane is part of the Region of Casablanca-Settat. It extends over a depth of 50 to 60 km from the coast to Sidi Bettache with an opening of 35 km on the Atlantic Ocean along the coastal plain, its area is approximately 240,000 ha (2,400 Km<sup>2</sup>) made up of 55.8% of UAA (133,920 ha), 23.7% of forests (56,988 ha) and 20% of rangelands and uncultivated (49,119 ha).

Between the metropolises of Casablanca and Rabat, in an environment of plateaus crossed by the rivers of the wadi Cherrat and the wadi N'fikh, extends the province of Benslimane.

Oasis of calm and freshness, offering the beauty of its landscapes and its micro-climate, between land and sea.<sup>2</sup>

➤ ***Strengths:***

❖ **Strategic geographic location:**

- The proximity of the two major consumption poles of Morocco: Casablanca and Rabat;
- The proximity to Mohamed V airport;
- The proximity of the port of Casablanca and Mohammedia.

❖ **Important transport network:**

- Highway;
- National, regional, and provincial roads;
- Rail network;
- Motorway being programmed next to the town of Benslimane.

❖ **Structured infrastructure and equipment:**

- Well located airport;
- International complex for young people in Bouznika;
- A regional athletics training center in Benslimane on seven hectares;
- Three golf courses in Benslimane, Bouznika and El Mansouria;
- Studios for filming in Benslimane;
- Regional environmental observatory in Benslimane.

❖ **Unique natural assets:**

- The beauty of its beaches and the quality of the bathing waters that extend over a length of 35 km;
- Important rock stock (41 quarries);
- Very fertile soil with a very high production rate, especially cereals.



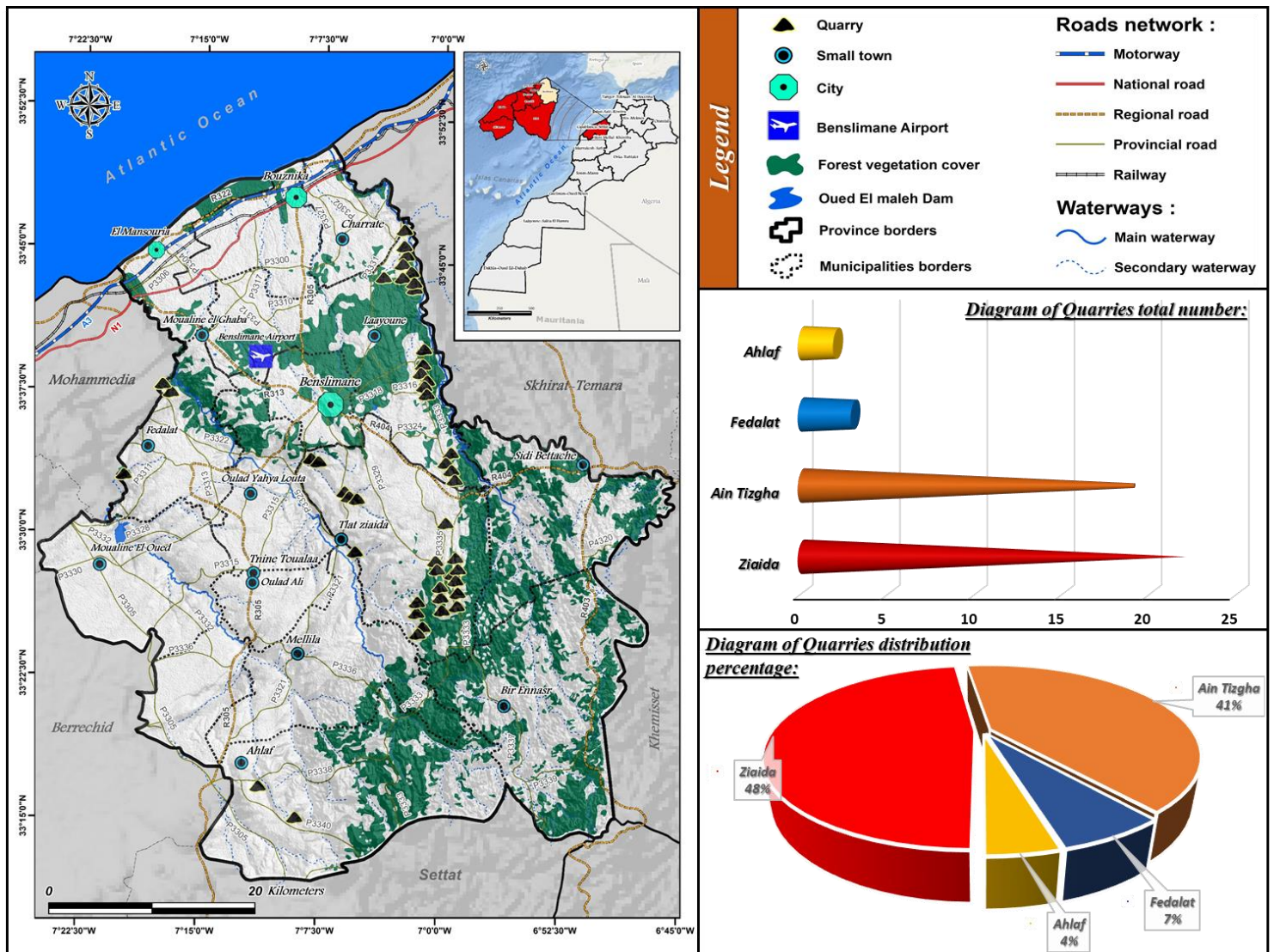
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As for the municipalities that embrace quarries on their soil, they are: Ain Tizgha in the far east of the province, and its headquarters is located 7 kilometers away from Benslimane city in the center of Laayoune. Ziaida south of Benslimane city. Then Fadalat, west of the province of Benslimane, whose center is 25 km far away from Benslimane city, 12 km from the city of Mohammedia, and 12 km from the city of Casablanca. Whereas Ahlaf is located in the far south, 55 km far away from the Benslimane city, 2 km far away from the city of El-Gara, and 30 km far away from the city of Berrechid.<sup>3</sup>

## ➤ Summary of Results

### 1. Benslimane Quarries Location

*Map: Distribution of quarries in the province of Benslimane by municipalities.*



Source: Personal work of Salah Eddine KOTTABI based on the data of the Regional Directorate of Equipment, Transport, Logistics, and Water of Benslimane in 2022, and the digital elevation model SRTM with a resolution of 30 meters.

The province of Benslimane embraces 46 quarries distributed among four municipalities: 41 of them are concentrated in the east of the province.<sup>4</sup> given that the Ziaida has a total of 22 quarries, followed by Ain Tizgha with a total of 19 quarries. While the importance of the rest of the two municipalities declines, as the total of quarries does not exceed 3 in Fadalat in the West, and just two quarries in Ahlaf in the far south of the province.

These quarries are located exactly on the west bank of the river of the wadi Cherrat as 89% of these quarries are spread along the river, 48% of the province's quarries are concentrated in the Ziaida commune, and 41% in the Ain Tizgha commune. While 7% are spread in Fedalat, and only 4% in Ahlaf.

Perhaps the most prominent factor in the spread of quarries in the Benslimane province is the abundance of rocky lands, and the high financial returns of this sector, which contribute to accelerating the development process,<sup>5</sup> in addition to the rapid growth of the urban phenomenon and the comprehensiveness of demographic and urban transformations. The urban explosion of the coastal area and the growth of the cities of Benslimane and Bouznika generated an increased demand for building materials, which led to the growth of stone quarries in the adjacent areas. This activity contributes to the economic development of several municipalities in the study area at the present (especially, the Ain Tizgha municipality, and the Ziaida municipality).

Today, this activity has become a major contributor to the economic and local development of the province, especially the quarries acquired by the major cement companies. which generates large financial incomes related to taxes for the benefit of the various territorial districts that it embraces in the Benslimane Province. In addition to its contribution to the process of paving road axes in all parts of the local area and adjacent to the province.

However, this activity has negative repercussions on the environment, which in turn constitutes an important economic resource for these local municipalities, as it constitutes a space for tourism, leisure, entertainment, and fishing. Thus, managing the effects of the exploitation of quarries on the ecological environment is a big bet for the development of the area.<sup>6</sup>

## ***2. Demographic qualifications are characterized by disparities***

The distribution of the population in the province of Benslimane is witnessing remarkable variations.<sup>7</sup> It is high in urban circles, especially in the city of Benslimane with about 57,101 people, exceeding the rest of the municipalities with about 20,000 people. The Bouznika commune is the closest, with a population of 37,057 while the rest of the municipalities follow closely together, they range from 19,853 people in El Mansouria to 11,451 in Ahlaf. On the other hand, this rate does not exceed 10,000 people in the following municipalities: Cherrate, Oulad Yahya Louta, Moualine El Oued, Sidi Bettache, Oulad Ali Toulalaa, Bir Ennasr, Rdadna Oulad Malek.

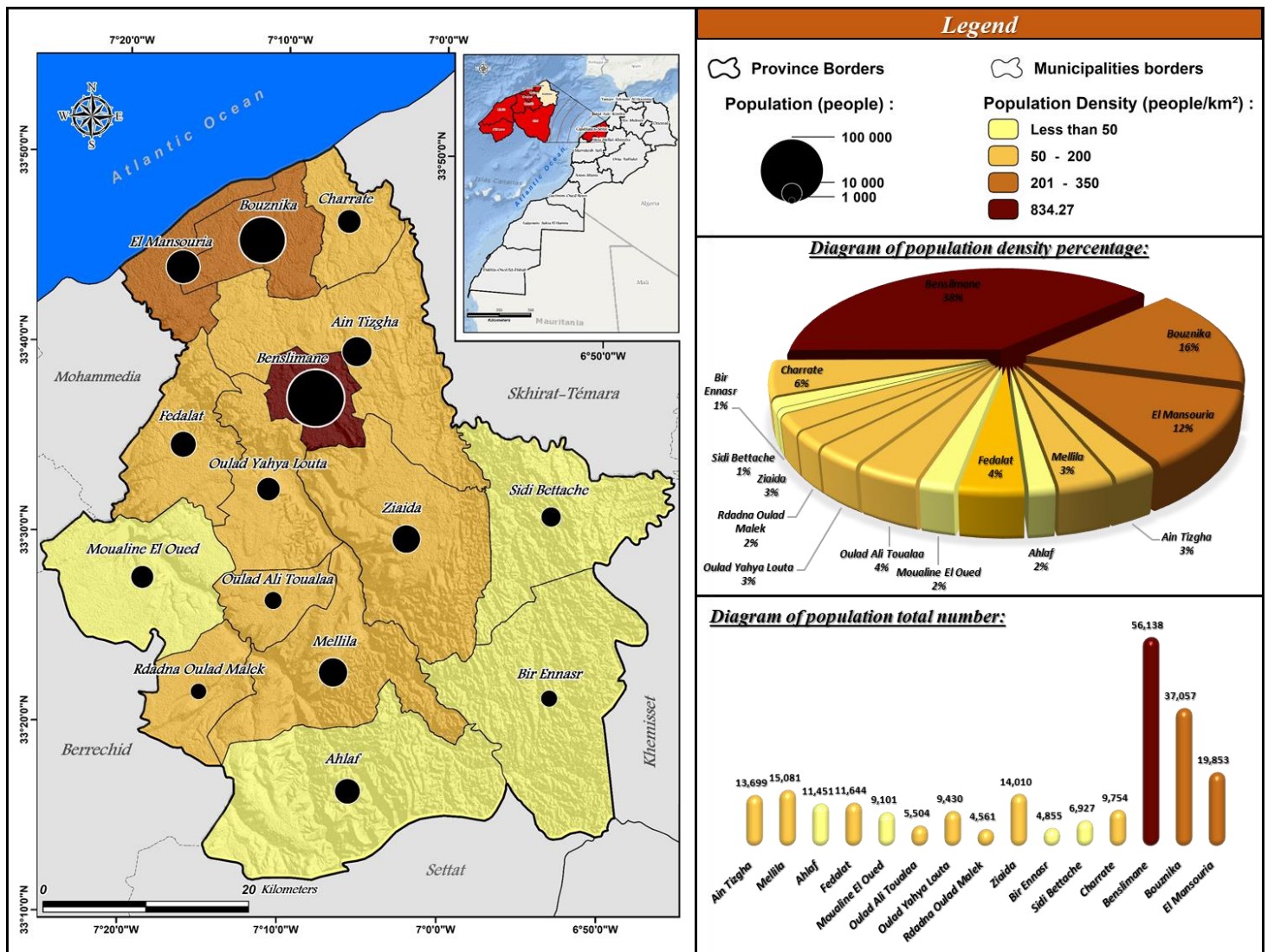
As for the population density rates, they are not very different from the population distribution, as we find them high in urban municipalities, especially Benslimane, at a rate of



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834.27 people/km<sup>2</sup>, followed by Bouznika with about 340.60 people / km<sup>2</sup> and Mansouria with 259.75 people / km<sup>2</sup>. While this rate remains uneven in the rest of the municipalities, starting from 120.74 people/km<sup>2</sup> in the Cherrate communes, up to 50.89 people / km<sup>2</sup> in the communes Rdadna Oulad Malek. On the other hand, some of the municipalities in the province of Benslimane have a population density that does not exceed 50 people/km<sup>2</sup> it concerns four municipalities: Moualine El Oued, Ahlaf, Sidi Bettache, and the Bir Ennasr communes as the lowest with a rate not exceeding 15.76 people/km<sup>2</sup>. This can be explained by the negative natural increase and the spread of the rural migration phenomenon.

**Map: Distribution of the population & population density rate in the Benslimane Province by municipalities.**

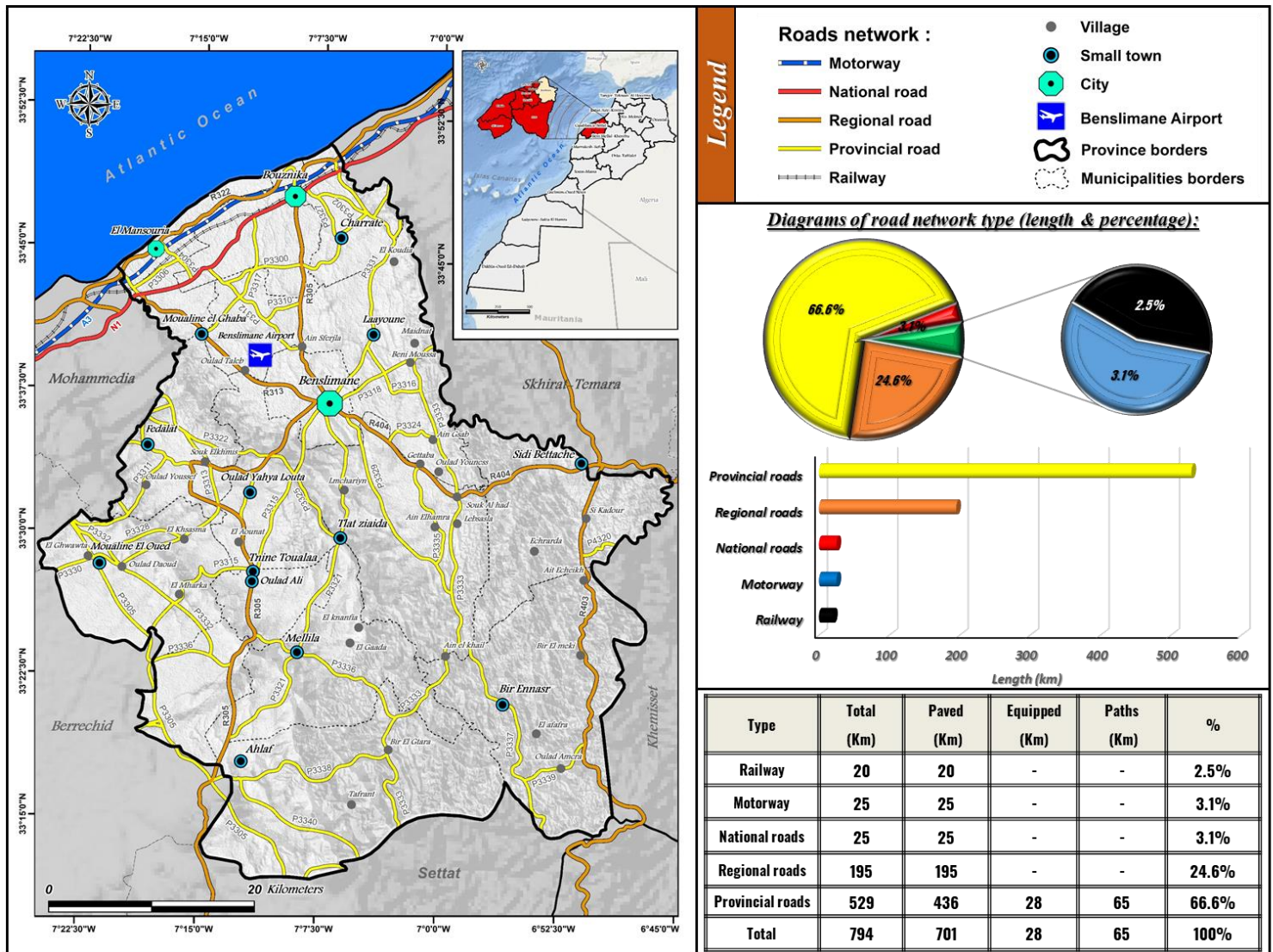


Source: Personal work of Salah Eddine KOTTABI based on the data of the 2014 Population and Housing Census, and the SRTM Digital Elevation Model with a resolution of 30 meters.

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### 3. The infrastructure of the road network is important and concentrated on the coast

Map: Infrastructure of the road network in the province of Benslimane



Source: Personal work of Salah Eddine KOTTABI based on the map of Benslimane of the Roads Directorate from the Ministry of Equipment, & the website: <https://www.openstreetmap.org/> (2022).

Benslimane Province, like the rest of Morocco, is characterized by a spatial concentration of the road network in the coastal area. As we find most of the industrial and economic equipment, as well as infrastructure,<sup>8</sup> especially the road infrastructure, which intensifies and increases in quality the more we head towards the coast, towards the north and northwest, and precisely towards the city of Mohammedia.

Benslimane Province has an important road network due to its density and a total length of 794 km, of which 701 km are paved (88%), Also, 52% of the asphalted road network is in good to an acceptable condition. The road network in the area is represented by a 25 km long coastal



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national road linking both the cities of Rabat in the east and Casablanca in the west. And a motorway stretching for 25 km, in addition to regional roads, the length of which is estimated at 195 km. And other provincial roads linking the municipalities of the province to each other and other areas with a length of 529 km.<sup>9</sup>

Through the map of the distribution of road infrastructure in the province, it is noted that there is a complete concentration of the best types of roads in the coastal part of the area, while the internal areas are witnessing a fragile road network. Knowing that most of the natural tourist areas and quarries are located in the interior, opens the way for forest paths that can harm the forest areas.

In general, the road infrastructure is the most important human element that can contribute to the economic and tourism development of the province. However, consideration must be given to the environmental impacts of road construction at the expense of the outskirts of natural forested areas.

### 4. Road traffic of quarries trucks

Diagrams illustrating the number of trucks crossing the roads (annually):



Source: The Regional Directorate of Equipment, Transport, and Logistics in the province of Benslimane 2022.



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The trucks transporting materials extracted from the quarries are distributed unevenly among the four municipalities within the Benslimane province. Although Ziaida has the largest number of quarries, Ain Tizgha is the leader in terms of the number of trucks crossing the roads due to the large quarries available in them and their economic importance. These tracks cross a group of roads concentrated in the east of the province, some of the most important of which are: The provincial road 3331, the provincial road 3318, the regional road 305, the regional road 404, the regional road 313, and the national road 1. On the other hand, The Ziaida quarry trucks, in turn, cross the following roads: The provincial road 3335, the provincial road 3333, the regional road 305, the regional road 404, the regional road 313, and the national road 1. As for Fedalat, the number of trucks has decreased significantly (does not exceed 1,500 trucks). It is restricted to the following road network: The provincial road 3326, the provincial road 3313, and the regional road 305. While the number weakens even more in Ahlaf, where it does not exceed 70 trucks due to the smallness and poverty of the commune quarries compared to the rest of the other municipalities, and it is related to the following roads: The provincial road 3321, the provincial road 3340, the provincial road 3305 and the regional road 305.

### ➤ Results and Discussion

After we used the *Weighted Overlay tool* inside ArcGIS to calculate the final score and reclassify (Reclassify tool) the roads depending on their final score as shown below:

ROAD NAME	DIRECTIONS SCORE	QUARRIES SCORE	TRUCKS SCORE	POPULATION DENSITY SCORE	FINALE SCORE	INTERPRETATION
National road 1	10	2	4	4	20	Very heavy use
Highway number 3	10	0	0	1	11	Average use
Regional road number 404	5	3	2	4	14	Heavy use
Regional road number 420	0	0	0	2	2	Very poor use
Regional road number 322	4	0	0	2	6	Poor use
Regional road number 305	5	0	0	3	8	Average use
Regional road number 305	5	0	0	4	9	Average use
Regional road number 402	0	0	0	2	2	Very poor use
Regional road number 401	0	0	0	2	2	Very poor use
Regional road number 407	0	0	0	1	1	Very poor use
Regional road number 313	7	0	0	4	11	Average use
Provincial road number 3336	0	0	0	1	1	Very poor use
Provincial road number 3332	0	0	0	1	1	Very poor use

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Provincial road number 3328	3	0	0	3	6	Poor use
Provincial road number 3305	6	0	0	3	9	Average use
Provincial road number 3300	0	0	0	1	1	Very poor use
Provincial road number 3340	1	0	0	3	4	Poor use
Provincial road number 3337	1	0	0	2	3	Poor use
Provincial road number 3339	0	0	0	1	1	Very poor use
Provincial road number 3334	0	0	0	1	1	Very poor use
Provincial road number 3321	2	2	2	3	9	Average use
Provincial road number 3315	2	1	1	3	7	Average use
Provincial road number 3336	2	1	1	2	6	Poor use
Provincial road number 3333	9	7	5	0	21	Very heavy use
Provincial road number 3335	9	5	4	5	23	Very heavy use
Provincial road number 3329	5	4	2	4	15	Heavy use
Provincial road number 3322	3	1	1	4	9	Average use
Provincial road number 3350	0	0	0	1	1	Very poor use
Provincial road number 3313	0	0	0	1	1	Very poor use
Provincial road number 3328	0	0	0	1	1	Very poor use
Provincial road number 3311	3	0	0	2	5	Poor use
Provincial road number 3351	0	0	0	1	1	Very poor use
Provincial road number 3352	0	0	0	1	1	Very poor use
Provincial road number 3314	0	0	0	1	1	Very poor use
Provincial road number 3324	5	3	3	4	15	Heavy use
Provincial road number 3318	5	4	2	4	15	Heavy use
Provincial road number 3316	8	5	3	4	20	Very heavy use
Provincial road number 3331	9	6	4	4	23	Very heavy use
Provincial road number 3302	6	6	4	4	20	Very heavy use

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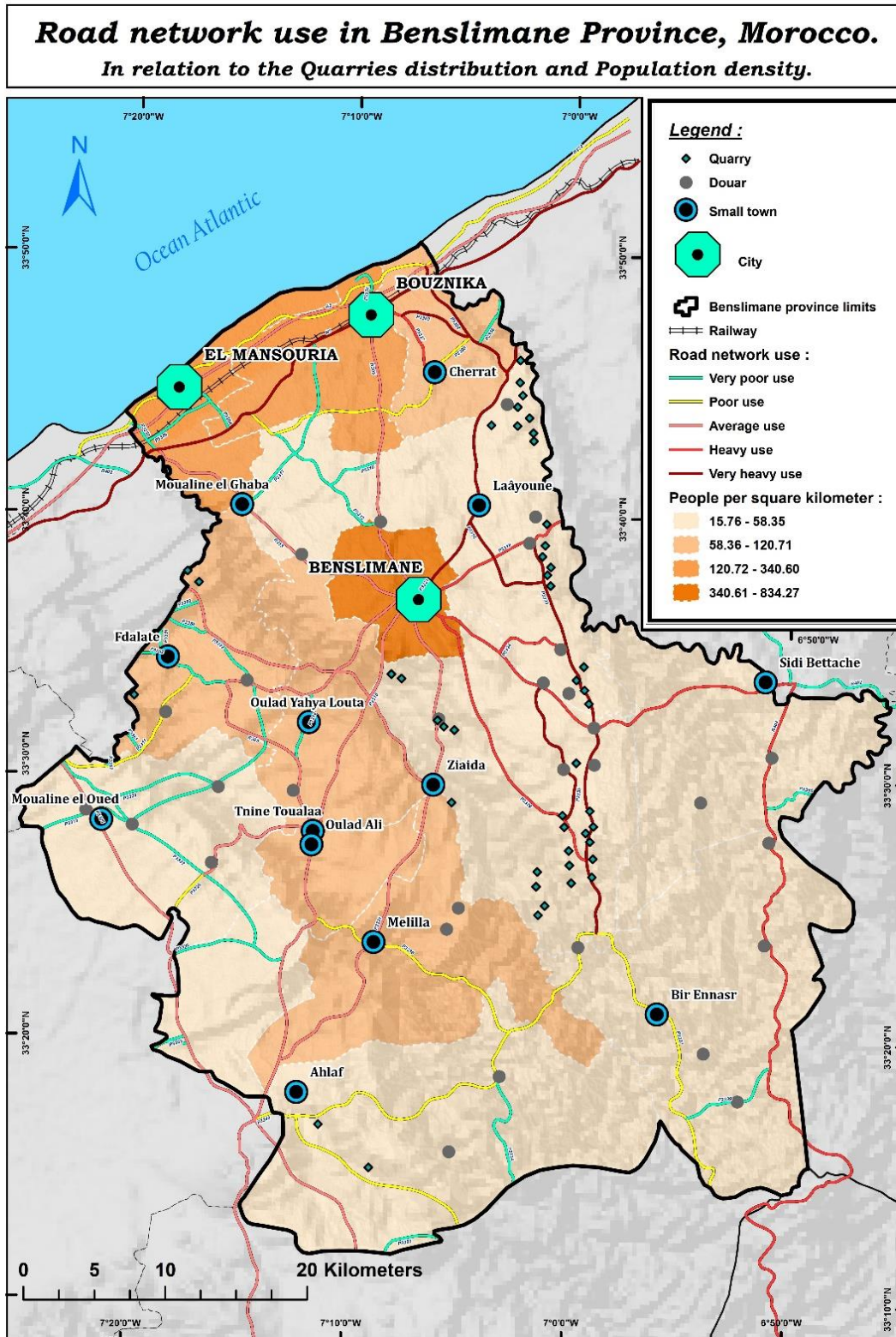
Provincial road number 3355	0	0	0	2	2	Very poor use
Provincial road number 3356	0	0	0	1	1	Very poor use
Provincial road number 3303	6	6	4	5	21	Very heavy use
Provincial road number 3327	5	3	2	5	15	Heavy use
Provincial road number 3300	4	0	0	2	6	Poor use
Provincial road number 3317	0	0	0	1	1	Very poor use
Provincial road number 3312	0	0	0	1	1	Very poor use
Provincial road number 3310	0	0	0	1	1	Very poor use
Provincial road number 3304	0	0	0	1	1	Very poor use
Provincial road number 3306	0	0	0	1	1	Very poor use
Provincial road number 3359	0	0	0	1	1	Very poor use
Provincial road number 3360	0	0	0	1	1	Very poor use
Provincial road number 3361	0	0	0	1	1	Very poor use
Provincial road number 3362	0	0	0	1	1	Very poor use
Provincial road number 3363	0	0	0	1	1	Very poor use
Provincial road number 3364	0	0	0	1	1	Very poor use
Provincial road number 3365	0	0	0	1	1	Very poor use

Since the start of the wave of quarries in the province of Benslimane and the Ain Tizgha commune in particular, and after the quarry that was built in the Koudia village to supply the highway linking Casablanca and Rabat with stones, the quarries began to operate in this area. Then the wave of quarries moved to Welad Younes village, Ziaida and Fadalat.

Naturally, the movement of selling the products of these quarries to neighboring cities such as Rabat, Mohammedia, Casablanca, and even Kenitra and El Jadida will be active. Which moved a huge fleet of trucks of various sizes, especially the heavy ones, to transport the product of these quarries of stones, gravel, and marble.

Due to the absence of external orbits, this huge fleet is forced to pass within the orbits of the local municipalities of the Benslimane Province, which has become a threat to the population, their health, property, and the conduct of their normal activities.

# Assessment of the effects of quarrying activities on the road network quality: a case study of Benslimane province, Morocco.



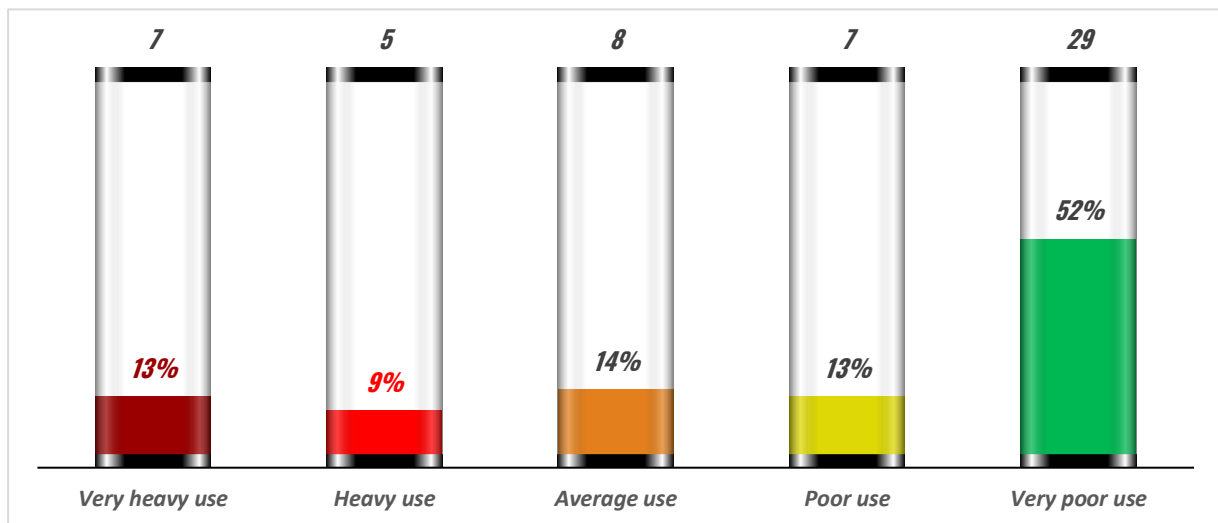
## Assessment of the effects of quarrying activities on the road network quality: a case study of Benslimane province, Morocco.

The most prominent negative repercussions resulting from transporting materials arise mainly from:

- Noise and vibration;
- Deterioration of public roads: risk of accidents or at least feelings of insecurity;
- The heaviness of the transported load and the number of trucks cause inconvenience and imminent danger to other users;
- Energy consumption and air pollution are generated by emissions of carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), and some fine particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>)...<sup>10</sup>

The degree of danger and the severity of the impact of one of these factors on the quality of the road network varies according to other determinants such as traffic density, type of load and trucks used to transport materials, the condition and nature of the roads used and the duration of transportation periods.

*Diagram of the ratio of the number of roads and their degree of use in Benslimane province.*



The graph and the map show that 65% of the roads in the Benslimane province are poorly used due to their distance from the sites of quarries and major cities. While the medium-use of roads does not exceed 14%. On the other hand, 22% of the roads are used extensively, 13% of them are very intensive due to their location around many quarries and their connection to the main cities and vital orbits of the province.

The results show the degree of use of the road network by the local population and quarry trucks that most of these latter use the roads concentrated in the east of the province, where most of the province's quarries are located with about 31 quarries, 19 of which are in the Ain Tizgha communes. We can say that the most used of these roads are the provincial road 3333 and the provincial road 3331, followed by the National Road No. 1 which connects three urban



## Assessment of the effects of quarrying activities on the road network quality: a case study of Benslimane province, Morocco.

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centers: Bouznika, Mansouria, and Mohammedia, and then the regional roads No. 404 and No. 403.

While the average use of roads is concentrated in the center of the province, as they cross and depart mainly from the city of Benslimane in the direction of Bouznika, Mohammedia, and the districts, the most important of which is the regional road No. 313 linking the cities of Benslimane and Mohammedia, the regional road No. 305 and the provincial roads No. 3315 and 3321.

As for the poorly used roads, we find them in the far south of the province, where only a limited number of quarries are concentrated in Ahalaf commune and in the direction of the west, most notably the provincial road No. 3328 and the provincial road No. 3304.



*Photo No. 01: Regional Road No. 404 in Ain Tizgha*



*Photo No. 02: Provincial Road No. 3333 in Ziaida*

The main objective of this study remains the use of geographical information systems to guide the authorities and decision-makers to take the right solutions by rehabilitating these roads, monitoring the number and size of trucks that cross them daily, and punishing violators of these laws, which causes the deterioration of roads and the occurrence of serious traffic accidents.

Some measures have been taken, but their application still knows some flaws with the absence of strictness in their application and respect for laws. Perhaps the most prominent of these solutions remain:

- Monitor the amount of material extracted from the quarries and the amount transported daily;
- Rehabilitation of the local roads in the area to accommodate the pressure of quarry trucks;
- Using water and spraying machines, roads, and extraction areas with water to reduce the volume of dust emitted into the atmosphere;<sup>11</sup>
- Establishing quarries away from the sites of residential municipalities, and areas designated for land and agricultural activities;
- Paving the roads that trucks cross to reduce dust from the surrounding population;

- Applying injunctive laws against violators and trucks carrying more than the authorized and permitted sizes of extracted materials.

➤ *Conclusion:*

It is shown that the characteristic of the quarrying industry is the intensity of the impact on the natural environment, which inevitably leads to its change. Among the most prominent of these imbalances that have become known to the environment in the province of Benslimane, is the deterioration of the road network because of transporting materials extracted from quarries.

It was found that most of the roads that are heavily used are located around the sites of quarries that are available in the Benslimane province and near the main cities, especially in the east of the province, where the transport operations of materials extracted by quarry trucks are active.

The most prominent solution to mitigate the deterioration of the situation remains strictness and application of laws aimed at achieving sustainable development and environmental and economic integration. Since it is established that the integration of environmental and economic interests of business entities dictates the development of new fundamental approaches to the organizational and economic mechanism to support the environmental safety of the road sector.

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