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Stone-Industry in Palestine: Bridging the Gap between Environmental Sustainability and Economical Value

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ABSTRACT

Stone -also referred to locally as 'white gold'- is one of the most important natural resources and one of the main extractive industries in Palestine. It is one of many traditional industries with a long history of production and a growing economic value. Despite its authenticity and high value, this industry and its facilities, such as quarries, crushers, cutting firms and stone workshops, are spreading randomly throughout the West Bank-Palestine, thus posing a threat to both natural and built environments and negatively impacting human health. This paper assessed these negative impacts on the environment caused by the stone industry's facilities in the West Bank by developing a Reality Assessment Model using Geographic Information Systems (GIS) which take into consideration stone industry endemism. The model was also used to categorize the stone industry's facilities based on a comprehensive criteria. As a conclusion, a categorization of four levels (Level 1 to 4) based on their environmental impact and land suitability. It is found that half of the various types of stone industry's facilities have a negative environmental impact that causes damage ranging from medium to very high, while the other half do not cause significant damage. Thus, the first-class facilities must be closed, second-class facilities may be closed or remain if their negative impacts are reduced, while both third-class and fourth-class facilities may be kept in their current state by minimizing their major negative impact.

KEYWORDS

Natural and built environments; reality assessment model; stone-facility diagnostic profile; stone industry; stone industry endemism

Introduction

Stone -also referred to locally as "white gold'- is one of the most important natural resources and one of the main extractive industries in Palestine. It is one of many traditional industries that spread out in places where high-quality stone is available in abundance. The stone industry plays a major role in the Palestinian national economy, with Palestine ranking 12th globally in terms of stone production. Quarries produce about 22 million square meters of stone products annually; worker productivity in this sector being 5 times that of other sectors. The contribution of the stone production sector to the Palestinian GDP is approximately 4.8%, while the productivity of this sector is estimated at about 600 million dollars annually, with 1361 facilities and 25,000 workers working directly in this industrial sector (PIPA (Palestinian Investment Promotion Agency) 2020). The local market consumes 20% of overall stone produced. The regional and international market, and direct export consume the remaining 80% (USMIP (Union of Stone and Marble Industry in Palestine) 2019).

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Nevertheless, despite the economic value and revenues of this industry, it is considered a global phenomenon that has been the cause of concern wherever it exists, even in developed countries. This industry is strongly linked to negative environmental impacts, and many researchers have studied these impacts on both built and natural environments, in terms of biodiversity, dust, noise and human health. The following part of this paper will present an overview of the research conducted on this regard.

Literature

Most researchers who studied the stone industry facilities' environmental impacts on biodiversity, natural and built environments, geomorphology, water, and health focused on the impacts of the dust emitted from the extraction process, the energy used in this industry, the facilities' solid and liquid waste, noise, vibration and the visual aspect.

The effect quarrying activities have on biodiversity was the topic of research of Lameed and Ayodele (2010). Their study of the site of Ogberein-Nigeria showed the vast damage to biodiversity through the complete removal of vegetation, and thus, the full destruction of habitats and species. Furthermore, air pollution caused by quarrying causes a direct threat to the survival of plants and is responsible of vegetation injury and crop yield loss. Pollutants such as dust, gaseous emissions and air-borne particulates effect the physiological activities of plants, such as photosynthesis and respiration.

Titi, Dweirj, and Tarawneh (2015) studied the impact of dust emitted from open cast mining. Mining activities emit air pollutants such as particulate matter (PM) into the air. Airborne particulate matter is cause of great concern to public health, as these particles are small enough to be inhaled into the deepest parts of the lungs of miners, as well as residents living in urban areas near quarries. Moreover, they focused on the impact of dust on vegetation and human health, such as stone dust disposition in surrounding rivers. Its impact on the water quality was further studied by Pal and Mandal (2017). Furthermore, studies show that dust is visible, invasive, and a potentially irritating product associated with quarrying (Umana 2018).

Noise as well was studied among the negative impacts of the stone industry, though it was not a great focus despite its substantiality (Capitano et al. 2017). Energy consumption was also highlighted in the research, especially during the extraction, transportation, squaring and cutting of raw blocks into slabs, as well as edging and polishing tile. Researchers also paid attention to the impact of vibrations resulting from the removal of quarry blocks using explosive or detonating cord, in addition to vibrations generated inside the industrial processing plants and those caused by machinery operations and vehicle traffic.

Vandana et al. (2020) analyzed how mining and quarrying activities can have a negative environmental impact on built and land environments in terms of geomorphology and landscape, and negative impacts on air and water quality. Moreover, he highlights that dust emissions are the major environmental concern of mining activity. Additionally, noise also has a negative impact, its primary source being blasting, crushing, drilling and vehicular movements.

Langer (2001) relates the environmental disturbance created by quarrying to be caused directly by engineering activities that take place during extraction and processing. These activities' impacts are changing the geomorphology and conversion of land use -especially the geomorphic impact-, resulting in the change of the visual scene. This major impact may be accompanied by loss of habitat, noise, dust, vibrations, chemical spills, erosion, sedimentation, and dereliction of the mined site.

Palestinian researchers also tackled the stone industry's environmental impacts. Sayara (2016) explains how the stone industry creates several problems with the environment and the people living in surrounding areas. This is evident in its impact on air quality, water pollution, human health, vibration and noise. After the measurement of air quality in Jammain, Nablus, Sayara found that it showed high concentrations of different particulate matter (dust). The study also demonstrated that there is a high prevalent rate of diseases caused by the stone industry, particularly due to air pollution, such as cough and cold, dyspnea, nasal inflammation, asthma and hearing impairment due to noise pollution. Stress, human discomfort and the effect on the structural stability of houses in that area are also amongst those negative impacts.

Masri (2017); Abu Hanieh, AbdElall, and Hasan (2014) explained that the rock extraction process is accompanied by dust polluting the air and large excavations that leave a severe effect on the landscape and soil. Annually, this industry produces 190,789 m3 of dry, powdery waste, in addition to harmful gasses like CO2 and other exhaust fumes emitted by machinery and different forms of transportation used to distribute products. In addition to the former, noise produced by machinery is also a harmful biproduct of these facilities and a source of auditory illnesses. Gases emitted by machinery and forms of transportation have a role in the spread of the diseases previously mentioned, as well.

Sayara, Hamdan, and Basheer-Salimia (2016) studied the impact of air pollution from quarrying and stone cutting industries on agriculture and plant biodiversity. Both focused on how dust negatively impacts the ecosystem by settling on surface water in addition to land, plants and trees. Furthermore, fertile soil is dislocated and interrupted and after excavation, pits are left unfilled or abandoned, leaving a gap-filled landscape. This poses as a threat to people, livestock and wildlife alike.

Salem (2021) investigates, analyses, and evaluates the status of the Stone and Marble Industry (SMI) in Palestine from different perspectives including geology, culture, socioeconomics, the environment, health, and legislation, with respect to SMI's sustainable development. The SMI's activities have negative impacts on green cover (trees and vegetation), thus producing large amounts of waste generated from its operation, including limestone waste and its impact on soil, water, public health and the environment in terms of air quality and green cover.

Abu Hanieh, AbdElall, and Hasan (2014) in their paper focused on the sustainable development of the stone and marble sector in Palestine, they talked about the challenges and problems encountered by this industry on the economic, social and environmental aspects. They discussed the use of water in the cutting process, which reduces air pollution but causes water pollution. Water in Palestine is a scare commodity and should be used efficiently.

Al-Halaiqa (2010) argues that protection areas, including areas of biodiversity, natural reserves, landscapes, and areas with high agricultural value are affected by the stone industry in Hebron Governorate.

Nevertheless, this paper develops a comprehensive geo-spatial-analysis model of the stone industry sector that assesses both the facilities' endemism and its environmental impacts on the built and natural environments in the West Bank by using GIS. This comprehensive model can be applied, especially in developing countries, to bridge the economic and environmental factors by means of a comprehensive set of spatial criteria.

Stone industry in the West Bank

The stone-industry's facilities are distributed in various parts of 11 governorates in the West Bank, concentrated in the western part of the West Bank in mountainous areas, including about 53 stone dumpsites distributed across the area. Most of the stone-industry's facilities (40.3%) are located in the Hebron Governorate, then comes the Nablus Governorate in second place with 13.6%, followed by Bethlehem Governorate with 12.9% (Figure 1). These governorates are distinguished by the availability of the ingredients and components of the industry, such as abundance of stone, its quality, and the appropriate topography (Research based on geographic information systems data from MoLG (Ministry of Local Government) 2020). Stone-industry's facilities located in the West Bank can be classified into 4 main facilities: Quarry, Crusher, Cutting Firm and Stone Waste Dumpsites.

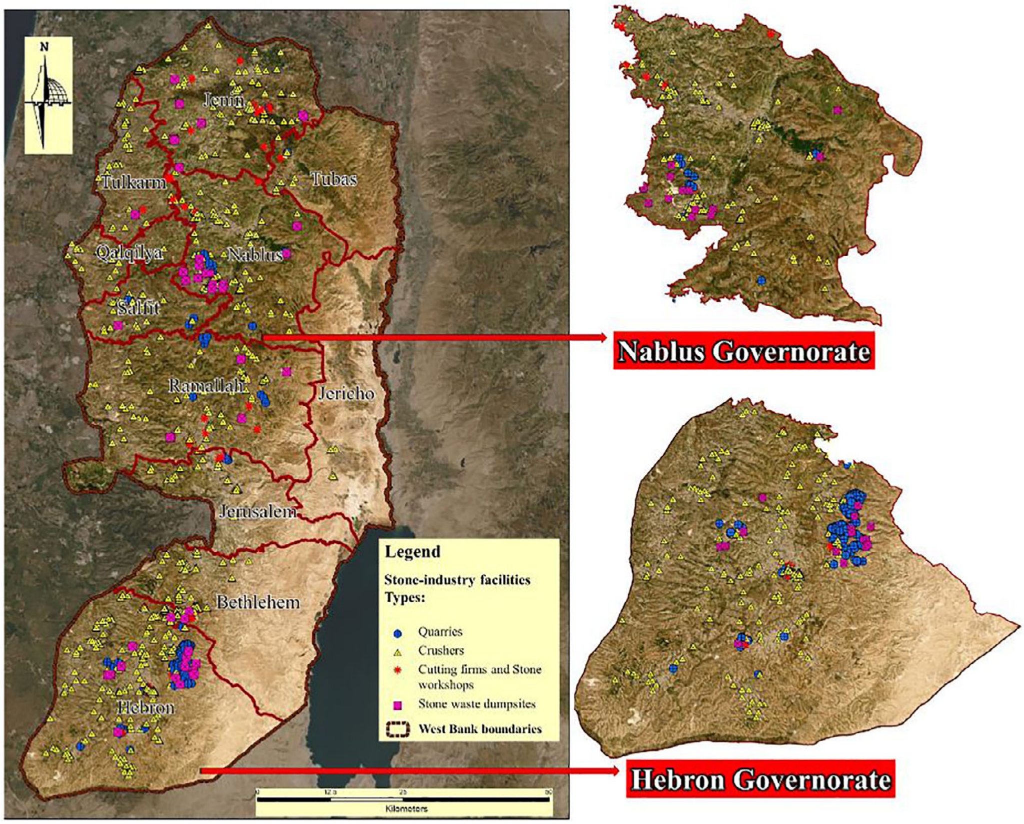

Figure 1. Stone-industry facilities location in the study area (Researchers).

Stone industry endemism

The site where the stone facility is located determines its value, quality of its end product, as well as the availability of the basic elements and components in the site that contribute to its development and ensure its continuity in the future. The stone endemism was diagnosed through an integrated system of factors, including natural factors and infrastructure (Sababhi 2012).

There are essential natural factors that support and influence the stone industry, which include topography, elevation soil, rock type and geology (Szczepańska 2017). In terms of topography and land elevation, it can be noticed that about 95% of stone quarries in the West Bank are located at heights greater than 400 meters above sea level (Figure 2). This is due to the potential of extracting large, adequate quantities of stone of high quality, as the amount of extracted stone increases as the height increases. Crushers, cutting firms and stone workshops are usually distributed in the surrounding areas (Ananza 2003).

It is noted that about 67% of the Palestinian stone-industry's facilities are located in areas of rock originating from rendzina soil, especially Terra Rossas, Brown Rendzinas and Pale Rendzinas. This type of rock is characterized as being covered by a shallow layer of infertile soil. It is also considered to be of a strong species known for its solidity and high quality. In terms of availability, this type is concentrated in the north of the West Bank (IUSS Working Group WRB 2015). In addition to this, about 31% of the Palestinian stone-industry's facilities are located in areas of the Brown Lithosols and Loessial Arid Brown rocks. Soil of this category is considered to be thicker and more fertile. In terms of availability, this type of rock is largely concentrated in the southern region.

Most of the areas where stone-industry's facilities are located contain rocks dating back to the Turonian and Cenomanian periods, which are considered relatively late periods (Research based

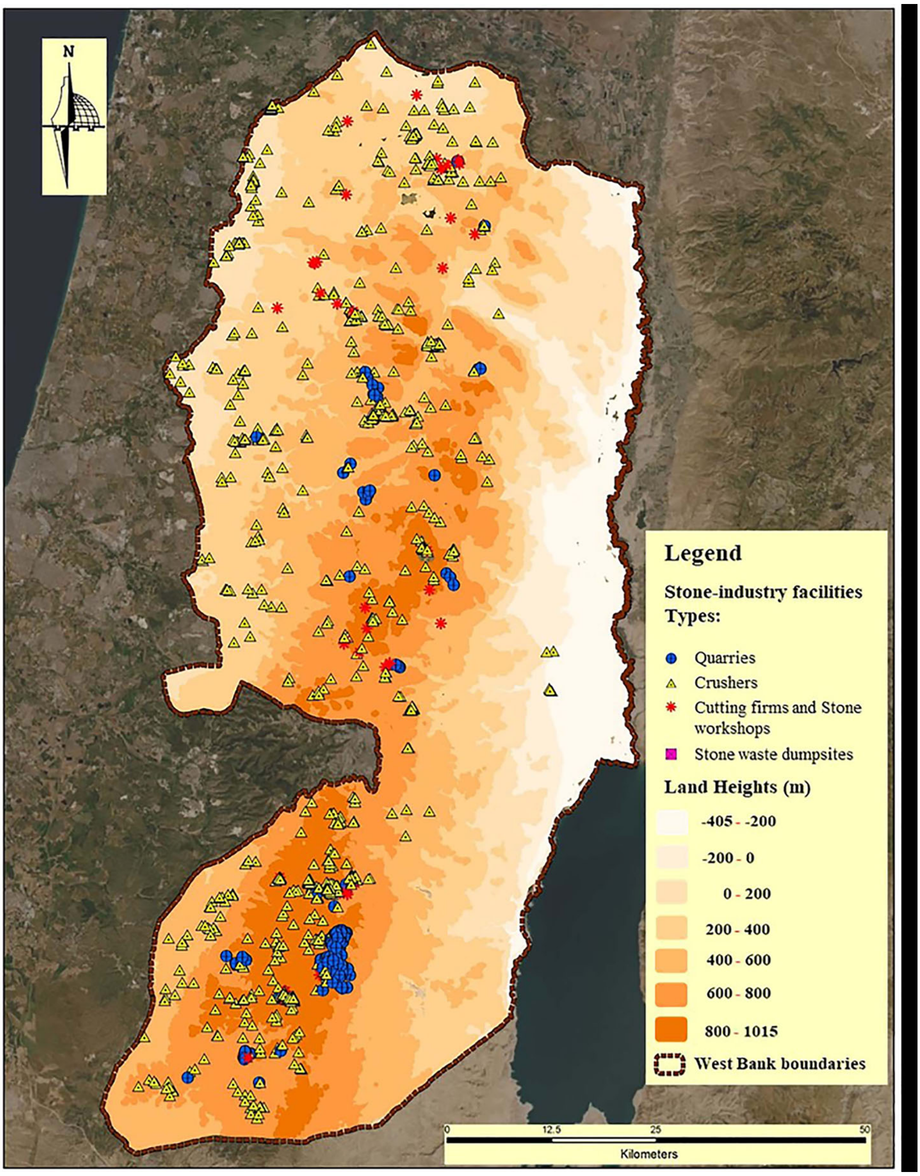

Figure 2. Stone-industry facilities location in term of topography and land elevations in the study area (Researchers).

on geographic information systems data from MoLG (Ministry of Local Government) 2020). Moreover, the stone industry needs good infrastructure, including water and a proper road network in order to function adequately (USMIP (Union of Stone and Marble Industry in Palestine) 2011).

Stone industry environmental impacts in the West Bank

Stone-industry facilities impact both natural and built environments, as well as human health causing different forms of pollution, (solid waste, dust, and noise) in addition to permanent changes to the natural and cultural landscape at the production site.

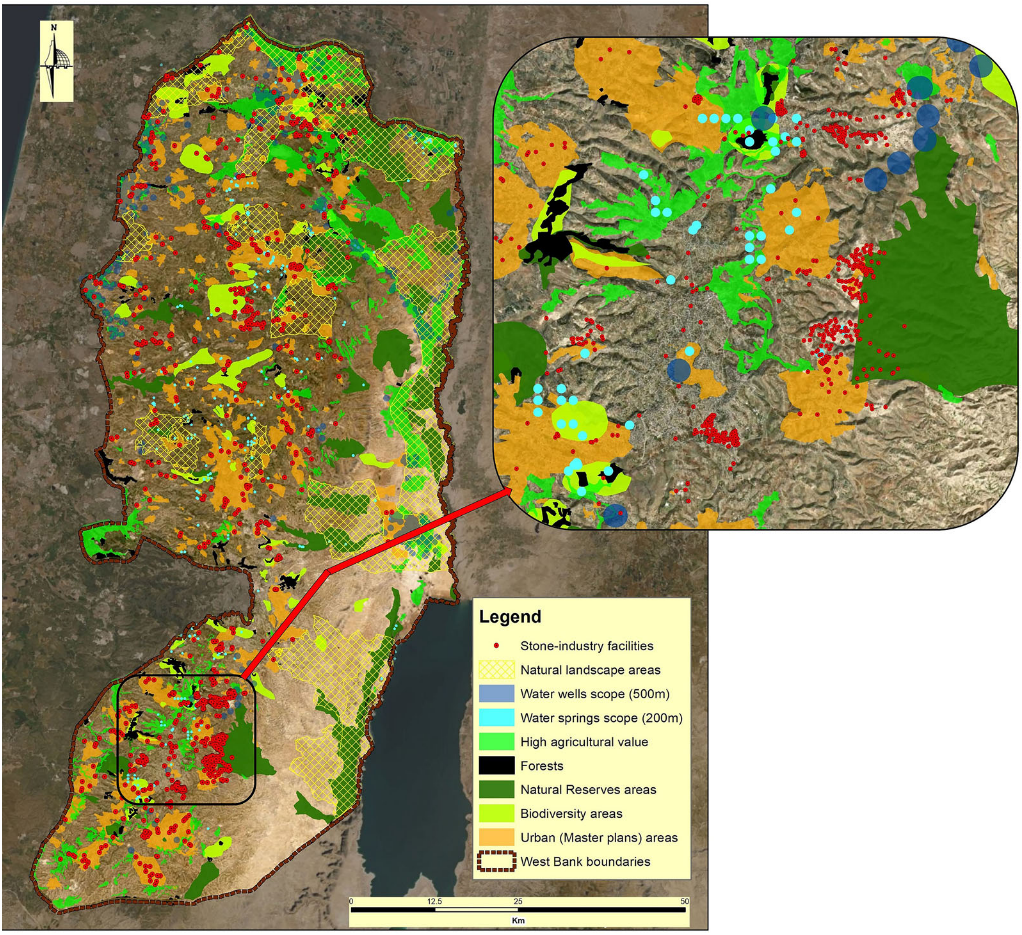

Figure 3. Stone-industry facilities location in term of their impact on sensitive areas (Researchers).

As for the Palestinian stone industry's impact on the natural environment, it is noted that 13% of the stone industry's facilities are located within protection and natural areas, covering about 31647 dunums of areas of natural reserves, 31625 dunums of biodiversity areas and 80154 dunums of natural landscape areas (Figure 3). This causes both air and environmental pollution, negatively impacting the natural environment. It also affects plant diversity and wildlife, thus distorting the esthetic aspect of the land. Quarrying especially carries the potential of destroying habitats and the species they support. Even if the habitats are not directly removed by excavation, they can be indirectly affected and damaged by environmental impacts (Lameed and Ayodele 2010). Moreover, about 5% of the stone industry's facilities are on lands with high agricultural value, destroying about 63783 dunums of high agricultural value, while 29% of these facilities are located in areas of medium agricultural value (Figure 4). It should be noted that the Palestinian Environmental Law (No. 7, 1999, Article 16) permits the establishment of stone industry facilities in areas of medium value if there is no negative impact on the land (Researchers based on geographic information systems data from MoLG (Ministry of Local Government) 2020).

Furthermore, the stone industry has different negative impacts on various types of water sources, such as the pollution of both ground and surface water sources (Masri 2017). It is noted that 40% of stone facilities are causing direct water pollution by dumping gray water (600,498 m3 of slurry water per year) from facilities into valleys and across land layers, eventually reaching

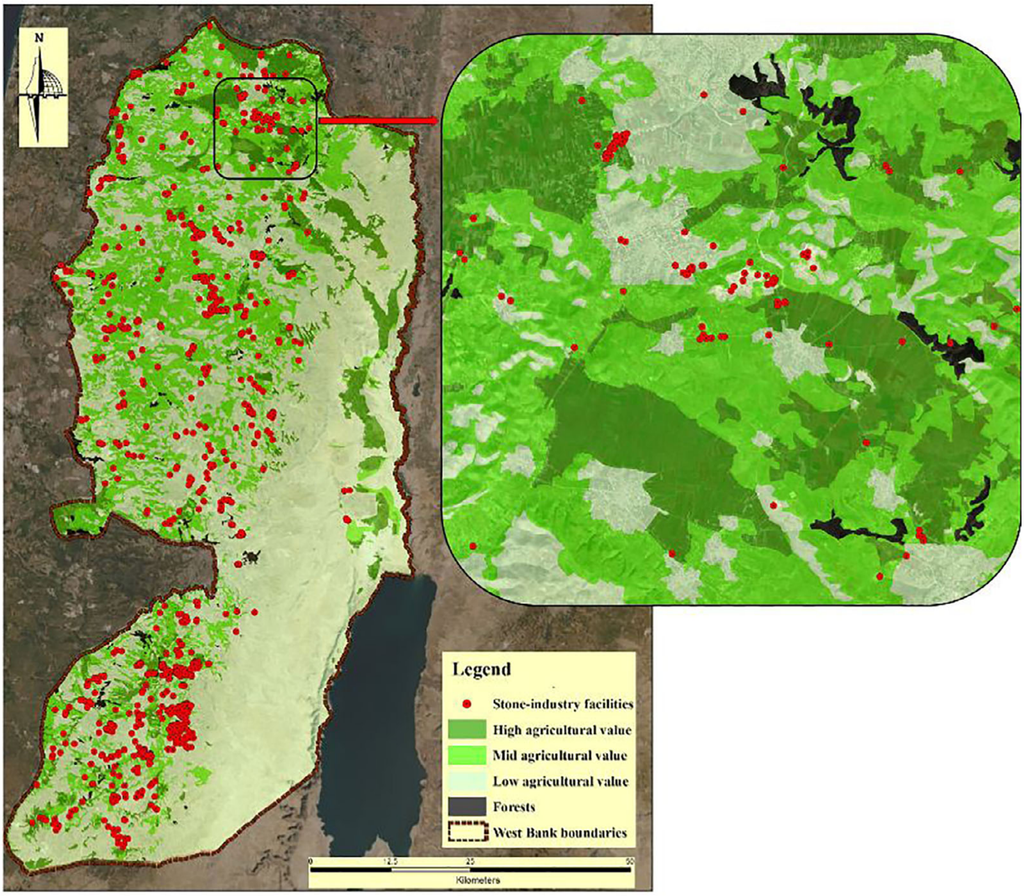

Figure 4. Stone-industry facilities location in term of agricultural value of land in the study area (Researchers).

groundwater. This includes areas with high sensitivity to water pollution and areas of underground wells and springs. It should also be noted that the stone industry consumes 1,006,525 m3 of water annually (USMIP (Union of Stone and Marble Industry in Palestine) 2019; Makhool and Abu-Alrob 1999; Researchers based on geographic information systems data from MoLG (Ministry of Local Government) 2020).

As for the Palestinian stone industry's impact on the built environment, it is noted that the distribution of these facilities and their impact has been studied in urban areas, including built areas in cities and villages where about 69% of stone facilities are found and negatively affect various human activities (Figure 3). These facilities cause air pollution in the region, thus affecting public health, as well as causing noise (Naik, Ushamalini, and Somashekar 2007; Khan et al. 2016). It is noted that most of these facilities are cutting firms and workshops, where the percentage of cutting firms and workshops within the built area reaches about 80%, followed by quarries at 36%, and crushers at 27%. It is additionally noted that 38% of stone industry facilities are located within master plan boundaries, compared to 69% within built-up areas, which extend beyond the master plan's boundary. This urban expansion must also be addressed during the planning process. In the event of an urban expansion on the following ranges of 250 m, 500 m, and 1000 m outside the boundaries of the current master plans, about 58%, 68%, and 79% of the current facilities will be within the boundaries of the proposed or future master plans, the main reason for that is the absence of a national spatial plan that controls urban expansion (Researchers based on geographic information systems data from MoLG (Ministry of Local Government) 2020).

Most of these negative impacts are a result of the existence of unlicensed stone facilities and their random distribution across the West Bank, the lack of law enforcement, lack of national planning, and the insufficiency of legal regulations for this important sector. This has led to an overlap of mandate and responsibilities between the relevant authorities, resulting in the failure to conduct a field inspection of licensed and unlicensed stone industry facilities. The stone industry's facilities play a major role in building and upgrading the economy, therefore rendering it essential to better exploit all resources available to this sector and to develop and implement targeted policies that enhance its role in the national economy. Taking into account the environmental impacts associated with this industry is also of high importance.

This paper focuses on how the stone industry in Palestine can continue to contribute to the economic development as a production sector with good economic potential, while minimizing its environmental impact to an acceptable standard. To be able to draw clear guidance in this regard, the impact of the stone industry's facilities on the natural and built environment, cultural landscape, infrastructure and society will be assessed by developing a methodological model. The land/location suitability for the stone industry's facilities will be evaluated as well, and these facilities will be categorized based on their impact on the environment, in addition to other factors.

In the attempt to provide answers on how to assess the impact of stone industry on the built and natural environment while maintaining its contribution to the national economic development. The developed comprehensive model can be applied to bridge the gap between the economic feasibility and the environmental conditions by means of comprehensive set of spatial criteria. The model and the paper also try to provide answers on how to assess the facilities endemism and to provide solutions for the future uses of the stone industry's facilities that are closed due to their severe environmental impact.

Materials and methods

In the previous section, we reviewed the stone industry endemism and stone industry negative impacts on the environment as a diagnosis for the current situation. However, in order to assess the potentials and negative impacts of the stone industry on both natural and built environments and their land suitability and to ensure economic viability, this paper developed a methodological framework to evaluate stone industry endemism and stone industry impacts based on the descriptive, analytical and deductive approaches through quantitative and qualitative evaluation and classification of different types of stone-industry facilities. This was accomplished using Geographic Information Systems (GIS) and by preparing a Reality Assessment Model (GIS Model). The developed methodological model- GIS modeling system (Reality Assessment Model) follows four successive steps that begin with defining the categories, then defining the criteria with scores for each category, and giving a weight to each of the criteria. The final model result can be found in the following (Figures 5 and 6):

Defining the parameters and establish analytical categories

The point of departure in building the methodology is the identification of the main parameters that guide the modeling process. In this case, the parameters are the economic viability of the industry and creating a sort of balance with the environmental sustainability requirements of stone industry facilities. The methodology suggests 3 categories to classify the stone industry facilities; the first being the availability of the factors supporting the stone industry, which is the stone industry endemism that represents the economic factor. The remaining two categories study

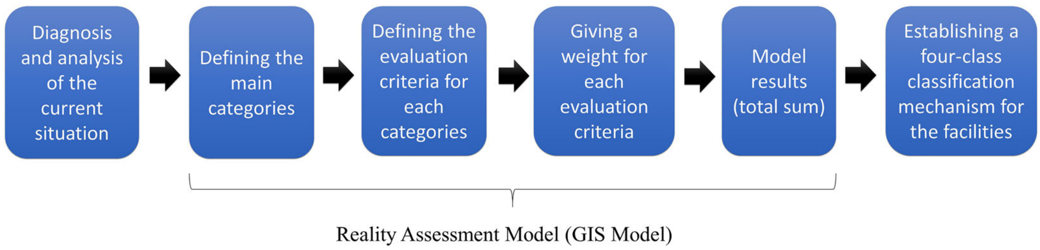

Figure 5. The research methodology (Researchers).

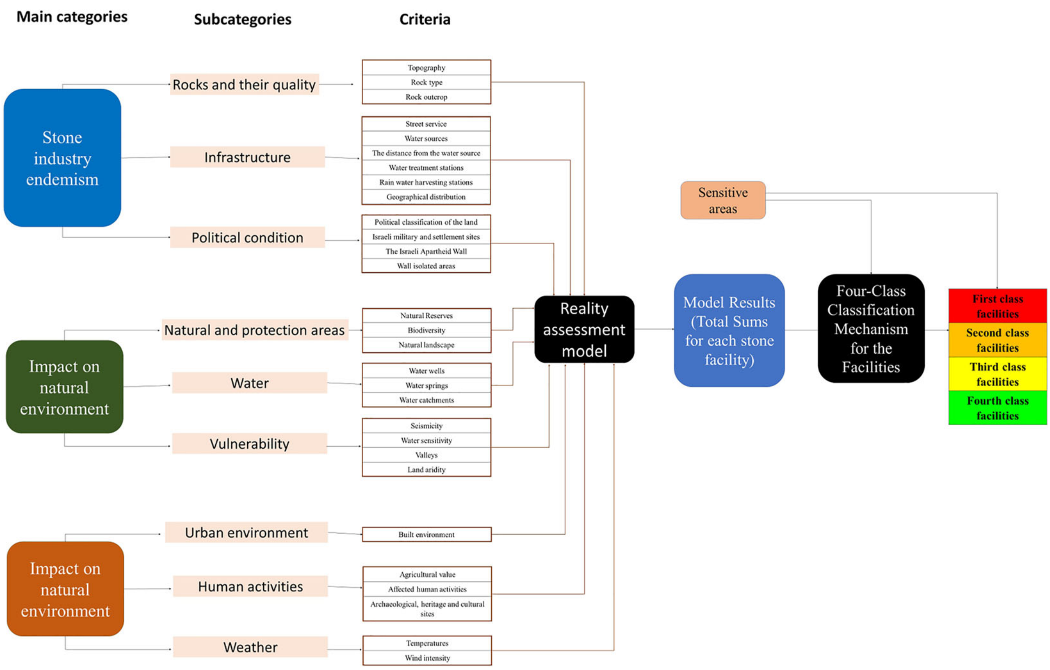

Figure 6. The detailed research methodology (Researchers).

the impact of this industry on the natural and built environments in the study area, respectively (Figure 6).

Defining the criteria

The second step in the modeling process is defining the criteria for each of the three categories. These criteria will bridge the gap between economy and environmental sustainability by minimizing the negative impact of the stone industry's facilities on both the built and natural environments, while simultaneously ensuring that the stone industry facilities are located in areas that have the basic elements and components -also known as stone industry endemism- that guarantee their development and continuity.

Stone industry endemism criteria focus on the impact of the site on the industry. This comprises an integrated system of factors that supports the stone industry, including criteria for rocks and their quality. The local topography, rock type and outcrop are all factors to be taken into consideration, as they affect the quality of the extracted stone. Criteria to measure the availability of good infrastructure, including a viable road network, water availability from different sources, the geographical distribution of the stone industry facilities and the areas where the facilities are clustered are also of significance. And lastly, criteria to identify the geopolitical condition represented by the political classification of land in Palestine, Israeli military sites, settlements, and the apartheid wall (Figure 6), (Table 1a).

Each one of these criteria affects and reflects the economic factor. For example, the availability of stone of good quality in abundance in a specific area will render it more valuable economically, while areas with little amount of stone or stone of lower quality will be of a lesser economic value. Moreover, the availability of good infrastructure reduces the cost for the industry and increases the productivity. A stable political condition will also have the same effect.

The impact of the stone industry facilities on the natural environment and its various elements is very important for the achievement of environmental sustainability. The impact of the stone industry on many natural elements has been studied and evaluated based on the facilities' locations, as well as their presence inside or near natural and protection areas. This includes areas of biodiversity, natural reserves and natural landscape areas. Furthermore, the impact on other elements of the natural environment such as water resources, including wells, springs, and catchments has also been studied. In addition, natural vulnerability, which includes the solid waste running through valleys, natural hazards, as well as seismic vulnerability and the stone industry's impact on them has been studied, as well (Figure 6 and Table 1b).

The last category of criteria focuses on the impact of the stone industry's facilities on the built environment inhabited by people. This includes the presence of stone facilities inside or near built areas, areas rich in cultural elements, urban areas, infrastructure and services, as well as examining the impact of these facilities on agriculture, which is a human activity of great significance, and the presence of stone facilities inside or near areas of high agricultural value. Various weather conditions including climate and wind severity also contribute to the transfer of pollutants and dust to built-up areas, thus negatively affecting people's health (Figure 6 and Table 1b).

It is worth noting that each criterion was assigned a score ranging between 0 and 10 based on its situation and degree of suitability, as the score of 0 means absolutely inappropriate, while the score of 10 represents the highest fit and best possible score (Tables 1a and 1b).

Giving a weight for each evaluation criteria

After the criteria were set, a weight was given for each criterion, depending on the type of facility and the limit of its environmental impact, in addition to stone industry endemism criteria (Tables 1a and 1b).

Stone is extracted from quarries, so it must be from sites that meet the stone industry endemism criteria, such as being rich in high-quality stone, originating from a topography of high altitudes and the abundance of stone in these sites. The availability of appropriate elements of infrastructure and other factors supporting this particular stone industry facility is vital due to the reliance of quarries on the extraction of stones from specific locations and sites.

Therefore, it can be noted that the total weight of stone industry endemism criteria for quarries are approximately 50%, highlighting their importance. There is a large number of cutting firms and stone workshops that represent a source of income for many local residents and therefore, are given a weight of 45%, while crushers are given a weight of 39% (Table 1a). These weights are given to ensure the presence of stone industry facilities next to each other in appropriate areas for this industry to flourish, while simultaneously reducing the geographical area over which these facilities spread, thus reducing their environmental impact. But as for stone industry dumpsites, it was found that it was not necessary to have them in close vicinity with other stone industry facilities, thus a weight of 20% was given to ensure their relative proximity to other sites, reducing the area of geographical pollution and the resulting environmental impact.

Table 1a. Stone industry endemism criteria, the ranking mechanism, and the weight for each criterion.

Categories		Criterion	Ranking mechanism	Weights (100%)			
				Quarries	Crushers	Cutting firms	Stone dumpsite
Stone industry endemism criteria	Rocks and their quality	Topography	10 - More than 880 m, … … ….,6 – 400-500 m, 5 – 300-400 m, … … 1 – Less than –200.	7	4	3	2
		Rock type	10 - Terra Rossas, Brown Rendzinas and Pale Rendzinas,7-Brown Litholsols and Loessial Arid Brown Soils, 3 - Grumusols, 1 -Loessial Serozems.	11	7	5	3
		Rock outcrop	10- Second degree, 7 - Third degree,3-First degree	3	0	0	0
	Infrastructure	Street service	10 –Served –10-, the rest according to distance from the nearest paved street (8, 6, 4, 2)	2	2	2	3
		Water sources	10 –Palestiniansources,1–Israeli sources	2	2	2	0
		The distance from the water source	2 –More than 6.34 km, 4 –(3.55–6.34 km), 6–(2.44–3.55 km), 8 –(1.44–2.44 km), 10 –Less than 1.44 km	1	1	2	0
		Water treatment stations	2 –More than 15.3 km, 4 –(12- 15.3 km), 6–(8–12 km), 8 –(4–8 km), 10 –Less than 4 km	3	7	6	0
		Rain water harvesting stations	2 –More than 6.1 km, 4 –(4.55 – 6.1 km), 6–(3.2 – 4.55 km), 8 –(2–3.2 km), 10 –Less than 2 km	2	3	3	0
		Geographical distribution	10 –Cluster Level 1 7 –Cluster Level 2 4 –Cluster Level 3 1 –Random distribution	7	0	10	0
	Political condition	Political classification of the land	10 –Area A, 7 -Area B,5 –Area C, 3–Special Areas, 1 -Reserves	6	7	6	10
		Israeli military and settlement sites	1– 100 m, 2– 200 m, … … 5– 500 m, … …, 9– 900 m, 10– more than 1000 m	3	3	3	0
		The Israeli Apartheid Wall	1– 100 m, 2– 200 m, … …5– 500 m, … …, 9– 900 m, 10– more than 1000 m	1	1	1	0
		Wall isolated areas	1– Fully isolated, 4– Will isolate, 10 –the other areas	2	2	2	2
			SUM	50	39	45	20

Table 1b. Impact on the environment criteria, the ranking mechanism, and the weight.

Categories / Subcategories		Criterion	Ranking mechanism	Weights (100%)			
				Quarries	Crushers	Cutting firms	Stone dumpsite
Impact on the natural environment criteria	Natural and protection areas	Natural Reserves	1-Nature Reserve scope, the other according to distance from Nature Reserve scope (3, 5, 7, 10)	2	3	2	3
		Biodiversity	1-Biodiversity areas, the other according to distance from biodiversity areas (3, 5, 7, 10)	2	3	2	3
		Natural landscape	1-Natural landscape area, the other according to distance from Natural landscape areas (3, 5, 7, 10)	5	6	5	6
	Water	Water wells	1 –Within the water wells scope (500 m), 10 –the other areas	3	4	3	4
		Water springs	1 –Within the water springs scope (200 m), 10 –the other areas	2	2	2	2
		Water catchments	1 –Catchment area of a huge amount of water 5 –Catchment area of a moderate amount of water 10 –Catchment area of a small amount of water	3	3	3	5
	Vulnerability	Seismicity	1-High severity seismic, 5- Medium intensity, 10-low intensity	4	0	0	0
		Water sensitivity	1 –High, 3 –Sensitive, 5 –Medium, 7 –Low, 10 –Insensitive	3	4	4	8
		Valleys	1 –Valleys, 3 –Scope 200 m, 4–Range 250 m,5 –Range 300 m, 6 –Range 350 m, 7 –Range 400 m, 10–Other	5	6	6	10
		Land aridity	10 –Arid land, 5 –Semiarid land, 2 –Semi-wet land	1	1	1	3
			SUM	30	32	28	44
Impact on the built environment criteria	Urban environment	Built environment	10 –Inside industrial area and other areas, 7 – Urban expansion1000m, 5 – Urban expansion500m, 3 – Urban expansion 200 m,1 – Inside the master plan	5	7	7	10
	Human activities	Agricultural value	1 –Forests / High-value , 5 –Mid-value, 10 –Low-value	4	6	6	6
		Affected human activities	10 –Less than 2 services . . . .,,5 – 15-17 services, ... 1 –greater than 26 services	2	2	2	6
		Archaeological, heritage and cultural sites	1 –Archaeological site scope, 10 –the other areas	2	2	2	2
	Weather	Temperatures	10 –Less than 17°, 7 –17°-19°, 4 –19°-21°, 1 –Greater than 23°	1	2	2	4
		Wind intensity	1 –Very high intensity, 4 –High intensity, 7 –Mid intensity, 10 –Low intensity	6	10	8	8
			SUM	20	29	27	36

The environmental impact of each facility is also of high importance. As for quarries, a weight of 50% has been given to their impact on the environment, 20% of which was given to their impact on the built environment, and 30% to their impact on the natural environment, as its preservation is vital. While crushers, cutting firms and stone workshops are given more weight in terms of environmental impact, ensuring that it is minimized. As for dumpsites, it was found that they have a large effect on the environment in general, and on the natural environment in particular. Therefore, weights of 44% and 36% were assigned to each of their effects on the natural and built environment, respectively (Table 1b).

The scores and weights that were given to each criterion reflect the goal of the paper to reduce the gap between the economic factor and the different environmental impacts. For example, and in support of the previously mentioned concept, the weight of quarries represents 50% of industrial endemism, which in turn reflects their economic strength, and 50% of the environmental impact.

Then the score of each criterion was multiplied by its weight and the resulting values were added to obtain the total sum (out of 1000) for each facility. There are 29 criteria, each of which have a maximum score of 10. When multiplied by their weights, the maximum total sum will be 1000, which represents the final model result. The stone facilities classification equation provides an estimation for the stone facility total sum (out of 1000) for each facility, and can be described as follows:

$$y = x_1 w_1 + x_2 w_2 + x_3 w_3 + \ldots\ldots + x_{29} w_{29} \quad (1)$$

where:y is Stone facility total sum;$x_{i,\ i\ =\ 1,\ .,\ 29}$ - Score of the criterion;$w_{i,\ i\ =\ 1,\ .,\ 29}$ - Weight of the criterion.

Model results (total sums)

After the criteria were applied according to the weight that was set for each type of facility, the results were obtained, with 1000 being the total sum and highest possible value. Accordingly, a classification was reached for each type of facility that will be reviewed in turn.

Stone quarries

The assessment was performed on all 200 quarries in the West Bank. The lowest total sum was 667 (out of 1000), while the maximum total sum was 859 (out of 1000). The average total sum for quarries was 756 (out of 1000), with a standard deviation of 42.7 (Figure 7).

Stone crushers

The evaluation was performed on all 60 crushers in the West Bank. The lowest total sum was 602 (out of 1000), while the maximum total sum was 891 (out of 1000). The average total sum for crushers was 751.2 (out of 1000), with a standard deviation of 61.2 (Figure 7).

Cutting firms and stone workshops

The evaluation was conducted on all 1101 cutting firms and workshops in the West Bank. The lowest total sum obtained was 499 (out of 1000), while the maximum total sum was 874 (out of 1000). The average total sum was 719 (out of1000), which was the lowest average sum compared to the sums of quarries and crushers, with a standard deviation of 65.7 (Figure 7).

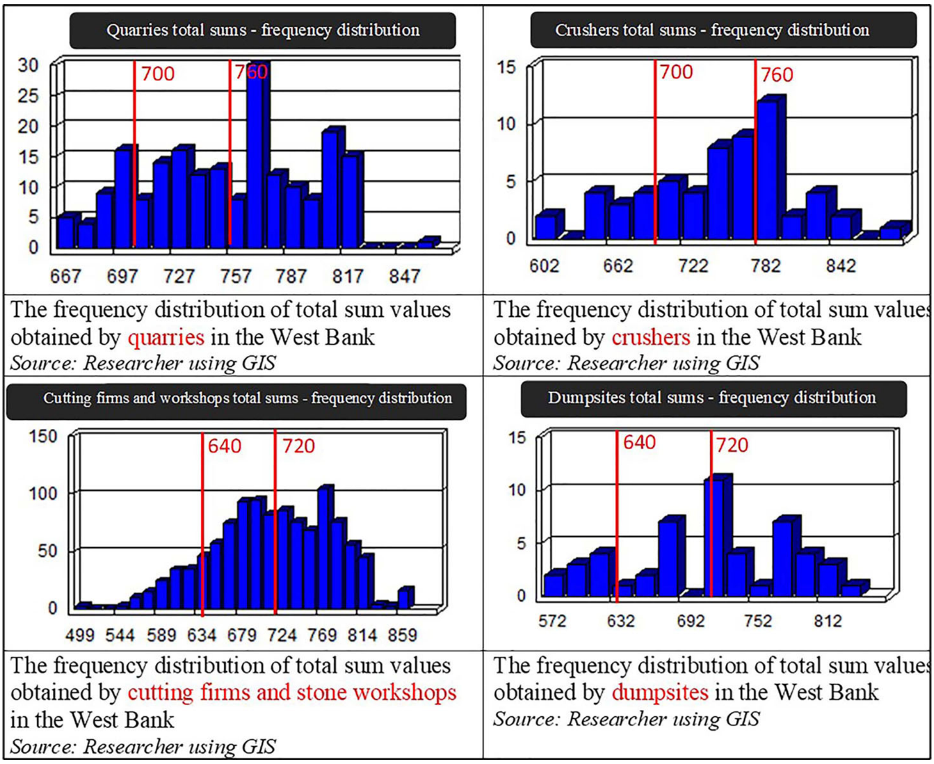

Figure 7. The frequency distribution of total sum values obtained by stone-industry facilities (Researchers).

Stone dumpsites

The evaluation was conducted on all 50 stone dumpsites in the West Bank. The lowest total sum obtained was 572 (out of 1000), while the maximum total sum was 846 (out of 1000). The average total sum was 716.8 (out of 1000), which was the lowest average sum among all types of facilities, with a standard deviation of 71.4 (Figure 7).

Establishing a four-class classification mechanism for the facilities

After the total sum values were calculated for all facilities, a mechanism was established for evaluation and classification, which consists of 4 main levels, illustrated in (Figure 8).

First-class facilities have been identified in sensitive areas and the total sum is not taken into consideration for them because of the unacceptable damage resulting from them, while the grading process affects second, third and fourth-class facilities where the resulting damage is less and can be minimized or accepted. Nevertheless, the process of grading and halting the damage inflicted on the environment relied greatly on studying the local political and economic situations in Palestine through interviews with experts and those interested in this field for each type of facility, while taking into account the frequency of the distribution of the total sum results obtained by each facility. This was in order to reduce the environmental impact to the minimum without compromising the economic factor.

Results and discussion

The previous mechanism has been applied to all facilities, obtaining a suitable classification for different types of facilities on the four developed levels. The results for each facility are listed below.

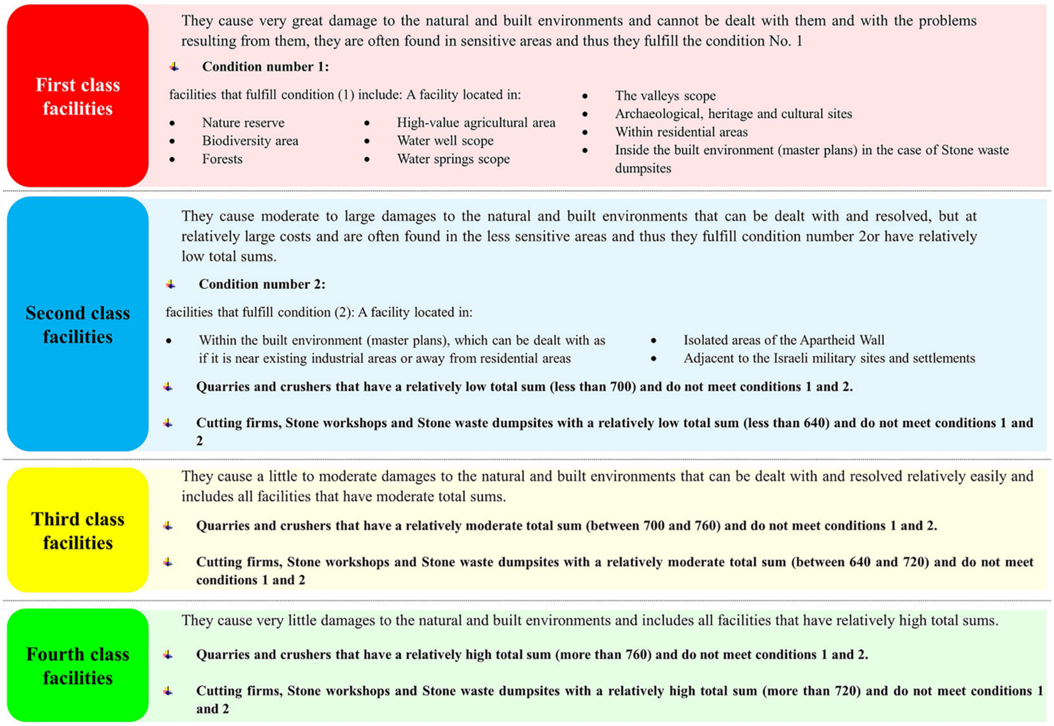

Figure 8. The four-class classification mechanism for stone facilities (Researchers).

Quarries results

About 29% of quarries are classified as first class (Level 1), which cause great damage to natural and built environments, a lot of which are concentrated in the south of the West Bank. The classification of quarries in the north varies in different classes, most of which appear sporadically, contrary to those in the south in Bethlehem and Hebron that appear in the form of clusters. Quarries that are classified as being of the first class were found to be located in the south-east of the West Bank, especially in Bethlehem and Hebron, while quarries of the fourth class, which cause little damage, are located in the western part (Figure 9).

The percentage of second-class quarries reaches 22% and third-class 13%, while the percentage of fourth-class quarries in good condition reaches 36%, meaning that they can be kept in their existing condition.

The results indicate that first-class quarries tend to affect and destroy the natural environment. There are 34 out of 57 within natural reserves, 2 within areas of biological diversity, 3 within areas of high agricultural value and 7 within the scope of water wells. They also affect the built environment, though not as significantly, for it can be noticed that there are 19 quarries within built-up areas (Figure 10a). On the other hand, second-class quarries tend to affect the built environment more prominently, as there are 28 out of 44 quarries inside built-up areas, in addition to 8 quarries within a 250 m buffer around these areas.

Crushers results

Only 10% of crushers are classified as first class (Level 1) in terms of damage caused to natural and built environments, which is a small and good percentage compared to the situation of other

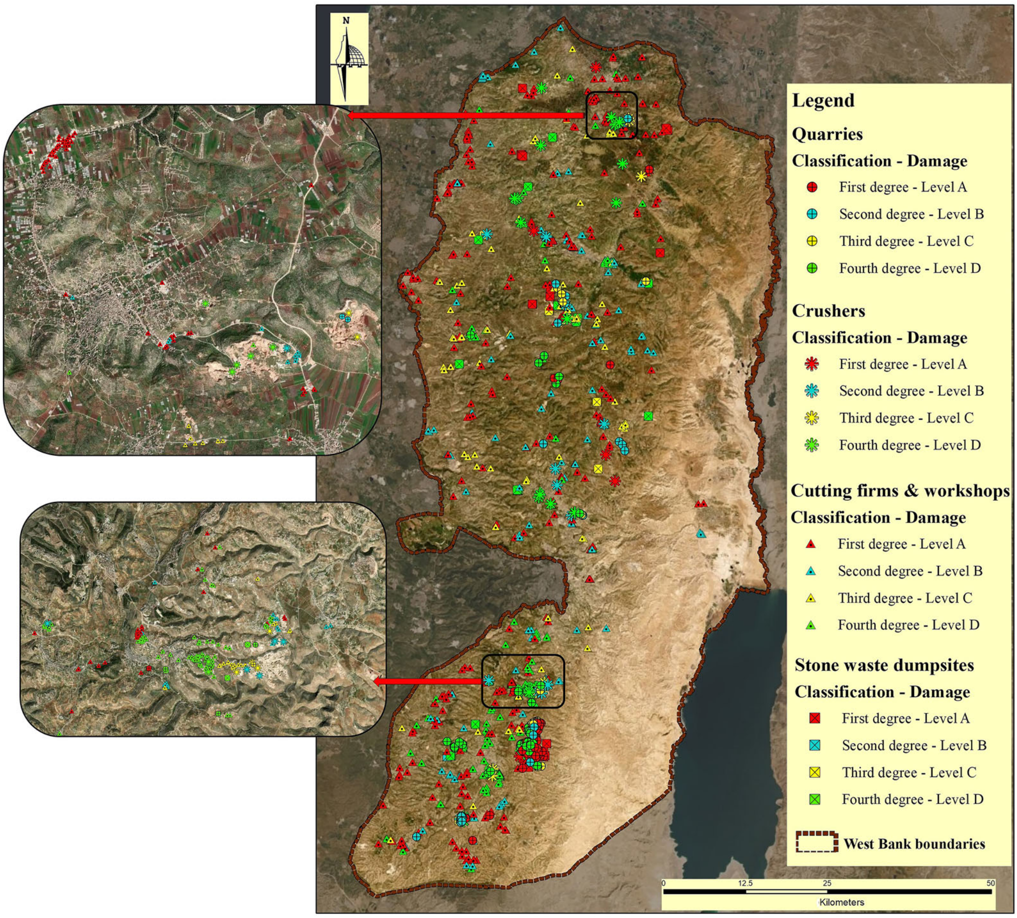

Figure 9. Stone-industry facilities classification results in the study area (Researchers).

facilities distributed over different parts of the study area. It is noted that 62% of crushers are classified as being of the third and fourth class, which indicates that the situation of crushers is the best and that their negative environmental impacts in the West Bank are minimal (Figure 9). This is perhaps due to their small number and concentration in specific areas. However, the 28% of crushers of the second class cause serious problems that need to be addressed. It is not a small percentage and should be reduced, thus improving the current situation.

The results indicate that first-class crushers tend to affect the natural environment as 6 out of 6 of them are within areas of high agricultural value, 2 of them within the scope of water wells. Contrastingly, they have little effect on the built environment, as there are only 3 crushers within built-up areas (Figure 10b). It is also noted that second-class quarries have a more prominent effect on the built environment, with 7 out of 17 crushers existing inside built-up areas, in addition to 6 existing within a 250 m buffer around the built-up area.

Cutting firms and stone workshops results

About 35% of cutting firms and stone workshops are classified as being of the first class (Level 1), as they cause great damage to both natural and built environments. These facilities are mostly concentrated in the north of the West Bank -especially the Jenin governorate- and the in south of

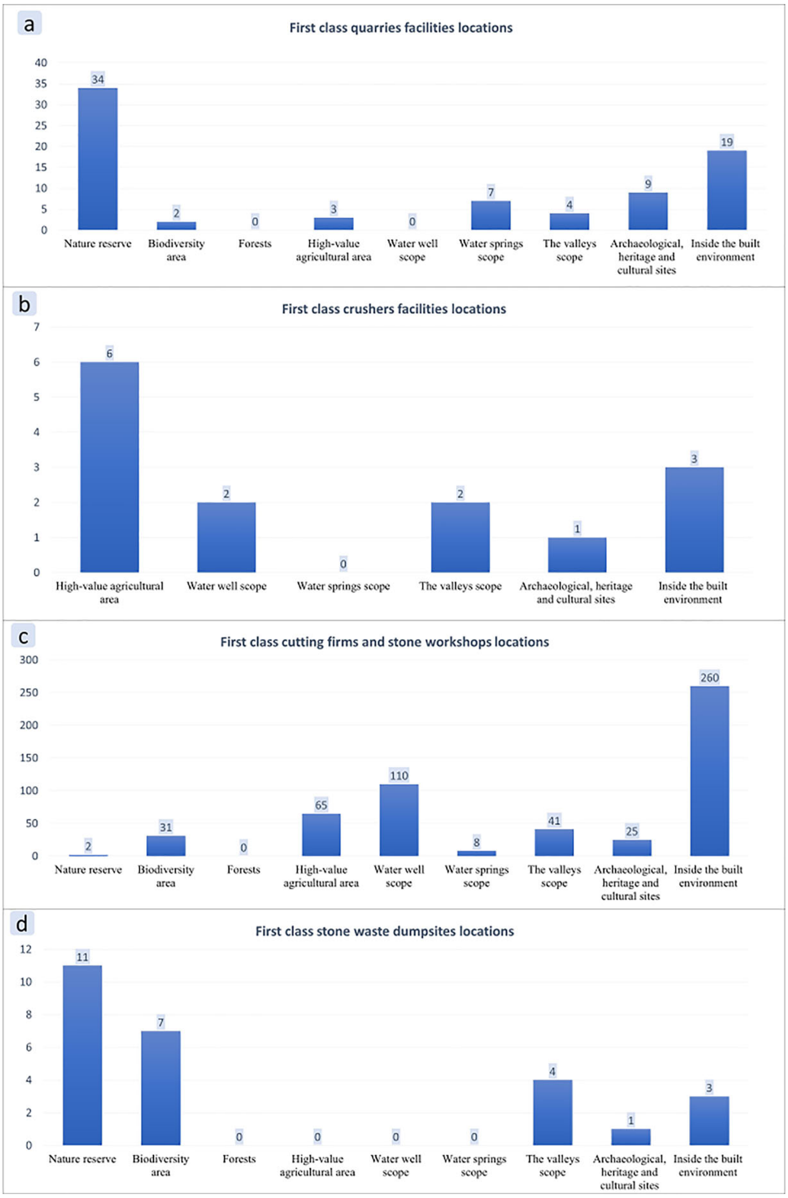

Figure 10. First class Stone-industry facilities locations & effects (Researchers).

the West Bank, and in the Hebron governorate in particular. The central area of the West Bank is characterized by diversity and variation in the degrees of classification of damage caused by them, which is often due to random distribution of the facilities. While fourth class cutting firms and stone workshops, which do not cause damage, are found in the southern governorates of the West Bank in both Bethlehem and Hebron (Figure 9). The percentage of second-class cutting firms and stone workshops reaches 18%, and third-class 14%, while the percentage of fourth-class cutting firms and stone workshops in good condition reaches 34%, meaning they can be kept in their existing condition.

The results indicate that first-class cutting firms and stone workshops tend to affect the built environment by impacting people's health and quality of life. There are 260 out of 386 within

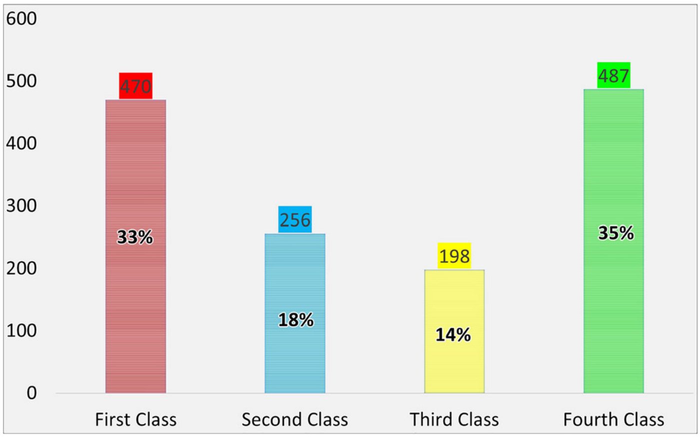

Figure 11. Percentage and Number of different classes of stone-industry facilities (Researchers).

built-up areas, with a lesser impact on the natural environment -especially water resources-, for there are 110 cutting firms and stone workshops within the scope of water wells, 8 within the scope of water springs, 41 within the scope of valleys, in addition to 31 within areas of biological diversity and 65 within areas of high agricultural value (Figure 10c). While second-class cutting firms and stone workshops tend to affect the built environment as well, for 91 out of 194 cutting firms and stone workshops exist within built-up areas, in addition to 61 within a 250 m buffer around the built-up area.

Stone waste dumpsites results

About 42% of stone waste dumpsites are classified as being of the first class (Level 1), which cause great damage to natural and built environments. It is noticed that they are mainly concentrated in the Hebron Governorate south of the West Bank, and are distributed in various parts in the north- especially in southern Nablus (Figure 9). There are a few stone waste dumpsites classified as being of the second and third class, while there are also 42% classified as being of the fourth class, meaning they do not cause significant damage. It can be observed that dumpsites in the southern region tend to be concentrated in specific areas and less randomly, while there is randomness in the distribution of dumpsites on a large geographical area in the northern and central parts of the West Bank, multiplying their negative impact by various classes. It is also noted that the percentage of second-class dumpsites reaches 2%, and third-class 14%.

The results indicate that first-class stone waste dumpsites tend to destroy and pollute the natural environment. It is noted that 11 out of 21 exist within natural reserves, 7 within areas of biological diversity and 4 within the scope of valleys (Figure 10d).

All stone industry facilities results

Half of the various types of stone industry facilities have negative environmental impacts and cause damage ranging from medium to very high, for it is noted that 51% of the facilities are classified as first and second class (Figures 11 and 12). These facilities need to minimize the negative impacts they cause, while the other half of facilities which do not cause significant damage due to their locations, for they are far from urban areas, and natural and cultural landscapes, can be built upon in future plans.

In general, it can be observed that the situation in the north of the West Bank is more difficult, as there is a random distribution of facilities over large areas, while there is a concentration

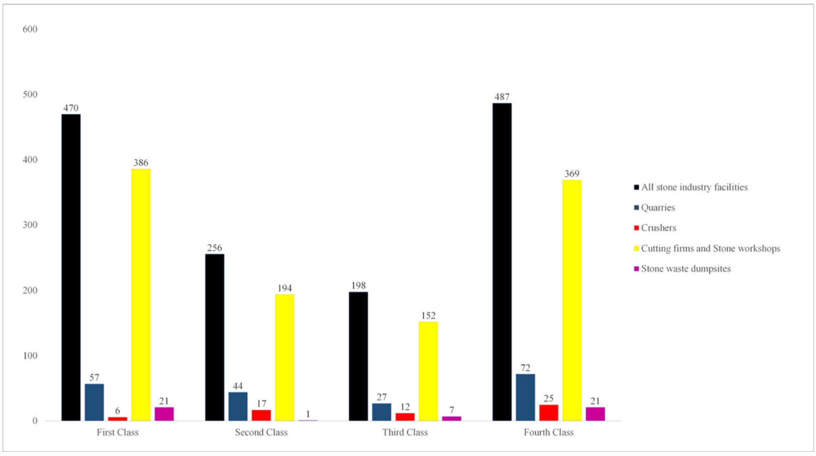

Figure 12. Number of different classes of the different types of stone-industry facilities (Researchers).

of facilities in the south of the West Bank, regardless of whether these facilities are classified as being of the fourth or first class (Figure 9).

Finally, the strength of the classification mechanism that has been developed comes from its flexibility, rapid and easy acceptance of changes, ease of implementation of feedback, in addition to inclusiveness in the classification process. For example, there are many lands classified as natural reserves or forests on maps but not on the ground, causing the owner of the facility to submit an application to remove the protection from the land. The classification process took these cases into consideration by taking the total sum into account, the large sum meaning a small negative impact and a suitable location. For example, the stone industry facility which obtained a good total sum, but due to its presence in a natural reserve, it was classified as being of the first class, and if it is proven that there is no protected area within the site, then it can be exploited well.

Recommendations

Actions for the four classified stone industry facilities:

- First-class facilities **must be closed**, due to the fact that they cause very high negative environmental impacts and great damage that cannot be reduced, minimized, or eradicated, and will affect highly sensitive areas if they are kept.
- Second- class facilities can be either closed or have the negative impact eradicated. This depends on the status of each facility and if its negative impact on the natural and built environments are moderate or large. These negative impacts can be eradicated or reduced; however, the cost will be relatively high.
- Third class facilities can be kept in their current state by resolving their major negative impacts, depending on the extent of the negative impact (low or moderate) on natural and built environments.
- Fourth class facilities can be kept in their current state by solving their minor negative impacts, as most of these facilities have very little impact on natural and built environments.

The stone industry needs to be regulated in order to promote its growth. By operating within a framework of greater awareness and consideration of the industry's potentially negative impacts, a wide network of cooperative support can be garnered. This network consists of local governmental authorities and community stakeholders. By implementing the former, the stone industry can contribute to a sustainable and more prosperous future for Palestine as a whole.

The Preparation of a National Plan for the various facilities of the stone industry should be prepared, while taking into consideration both land use and environmental issues. This can be achieved by pointing out areas that can be used for stone industry in the future, and if they require mitigation and control of the environmental, urban, social or economic impacts through this planning system.

A land suitability study for potential stone industry facilities should be conducted after closing first-class facilities (470 facilities), thus, an area of 17.7 million m2 is needed. The sites of good-quality stone industry facility clusters (fourth and third class) should be planned and developed as stone industrial zones on land use plans or regional plans to regulate them. These areas could be of economic support and do not adversely affect natural and built environments.

Licensing the unlicensed stone industry: facilities that don't have major environmental impacts: The presence of unlicensed facilities that have the most negative environmental impacts is the main problem with the stone industry. However, only facilities that have minimum impacts will be licensed by the Ministry of National Economy (MNE), which is the authorized ministry to license the stone industry facilities as in the Natural Resources Law 1/1999: "No natural or legal person can survey or excavate or extract or exploit any natural source or a metal out of the ground within the Palestinian territories and territorial waters and exclusive economic zone of its subsidiaries except after obtaining a license from the ministry for a fee determined by the ministry under a special regime issued by the ministry".

MNE also determines the quantity of material that can be extracted. Thus, it is the MNE's responsibility to monitor stone industry sites throughout the country to ensure that the operational limitations and obligations set within the terms of the license are being followed, as well as identifying and taking action against sites that are operating without a license. (DAAR (Decolonizing Architecture Art Residency) 2015).

The ministry of Environment (ME) is responsible for the protection of both the environment and natural resources from pollution inflicted upon them by the stone industry according to the Environment Law, No. 7 1999. Due to this, it is considered the duty of the ME to correlate with all other agencies, thus bringing them into a harmonious relationship and setting proper environmental regulations for the various operations of the stone industry facilities. Moreover, it is amongst the ME's rights to demonstrate and confirm compliance of stone industry operations with the previously set environmental regulations, while involving other ministries and authorities in this process. However, and as a result of the truancy of legal regulations, and executive decisions in particular, there is a problem with the determination of the assignment of duties and responsibilities to the competent authorities in the stone industry. Nonetheless, the major issue in this case is that local councils and communities are excluded from this process. Thus, duties and responsibilities of each affiliation relating to the regulation of the stone industry should be distinctly defined. The establishment of a guide for the laws and regulations that are to be applied is needed prior to granting licenses to quarries and crushers. Lastly, it can be noted that the comprehensive licensing of stone industry facilities can aid in the enforcement of environmental regulations (DAAR (Decolonizing Architecture Art Residency) 2015).

Closing Stone Industry Facilities of Major Environmental Impacts: As was mentioned prior, the major issue with the stone industry is the considerable negative environmental impacts the industry's facilities inflict, due to the fact that most of them are established without being licensed. Therefore, the MNE should close all facilities which inflict major negative environmental effects. Ministerial Resolution No. 1 of 2000, Article 9 of the decision imposes a legal provision on anyone who violates the provision of the license, for it is vital to work on activating the provisions of the article and its text "everyone who obtains a license for any type of quarry must comply with the licensing terms and instructions attached to the license. The quarry until all conditions are implemented, and in the event of repeated violation, and the Ministry of National Economy has the right to withdraw the license and close the quarry" (PSAACB (Palestinian State Audit and Administrative Control Bureau) 2013).

Rehabilitation of the closed quarries: Rehabilitation should be mandated before licensing stone industry facilities. The formal submission of plans for post-operational site rehabilitation should be made when obtaining a license for all stone quarries. Plans for utilizing quarries in an economically productive and socially functional way should be given priority, as well. Alternative uses should be proposed for the closed facilities in order to use the land efficiently and stop their negative environmental impacts on natural and built environments, thus converting them to sites that provide services to the population. Unfortunately, the provisions of the judicial undertaking signed "in favor of the Ministry of Agriculture" by the owner of the quarry or the crusher to rehabilitate the sites are not enforced.

To start rehabilitation for closed sites, first a preliminary qualification process for the facility must take place. Quarries are the most difficult to qualify and the most expensive, as the rehabilitation of finished quarries is achieved by burying the unfit and poor-quality stone resulting from the quarries in the floor of the finished quarry. In contrast, the qualification process of the rest of the facilities is limited to the cleaning and arrangement of the site. Secondly, a diagnostic study for each facility is prepared, followed by the proposal of new uses that take into account the privacy of the site and its surroundings.

Some of the proposed uses include reclaiming the site for cultivation, gardens, parks and entertainment areas. This in addition to qualifying and converting the site in order to be used for other industries in general, or for a different type of stone industry establishments. That is not all; sites can be converted into agricultural, residential and rural housing areas. Deduction of the site for roads are also possible, in addition to converting these sites into public use areas or locations for water tanks.

However, the easiest and least expensive use in comparison to others proposed, is converting the closed stone industry facility into a craft and light industrial area.

Conclusions

The approach in this paper is not a mere study of the negative environmental impact of the stone industry in Palestine. However, it proposes an alternative trajectory of analysis than previous researches by focusing on the reconciliation between two necessities, which are environmental protection, and economic and developmental benefits of the stone industry. This reconciliation is built to ensure sustainability through the development-driven utilization of unrenewable resources. The Reality Assessment Model developed in this paper seeks to deal with the concept of "finding land suitability" as a pivotal parameter in building the intended compromise. The Reality Assessment Model is a comprehensive spatial model that is the first of its kind to be implemented on a complex context like that of Palestine, where there is an absence of legislative framework, weak law enforcement entities, an absence of state structures and state sovereignty, and the existence of various systems of control on the ground that govern a long-term conflict on land and resources. This context puts more value on the economic benefit than on that of the environment. The model was developed to perform a comprehensive spatial (GIS) diagnosis and analysis and to produce evidence-based results. The model in itself is quite unique due to the fact that it builds specific criteria which is applicable on the Palestinian context to create a sense of balance between the negative impact of the stone industry facilities and their economic benefits. Any industrial facility can be placed under the lens of this model to check and determine if this site is suitable for the built and natural environment located in its vicinity, while ensuring that the economic benefit that sustains an economic return is achieved. That having been said, this Model can be adapted and used on other contexts that are similar to that of Palestine. This model will be an alternative system/model that helps the related ministries and institutions to manage and protect both built and natural environments, while keeping the means of economic development. Applying the model on the stone industry's facilities in Palestine produces a four-level categorization (levels one through four) based on their environmental impact. It is found that 51% of facilities are classified in the first and second level, meaning they have negative environmental impacts, causing damage ranging from medium to very high which must be minimized. The remaining 49% are classified in the third and fourth level, meaning they have a less significant impact and cause minor damage to the built environment due to their location, therefore can continue working. The results indicate that the most significant impact of quarries, crushers, and dumpsites is on the natural environment, while cutting firms and stone workshops have a larger impact on the built environment. Driven by a problem-solving oriented research, the model leads to the identification of the elements of strength, opportunities, weaknesses and threats that exist and contribute to supporting and/or weakening the industry from an economic perspective. The methodology/model presented in this paper can also be applied as an analytical tool for stone industry's facilities in contexts other than Palestine, especially in developing countries where the stone industry plays an important role in the national economy, despite the lacking policies to regulate this industry which are not effectively crafted, nor implemented. This model assists in the managing of the stone industry, while aiming to attain the highest economic returns with the least environmental impact.

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References

Abu Hanieh, A., S. AbdElall, and A. Hasan. 2014. Sustainable development of stone and marble sector in Palestine. *Journal of Cleaner Production* 84:581–8. doi: 10.1016/j.jclepro.2013.10.045.

Al-Halaiqa, H. A. 2010. The impacts of stone quarrying and cutting industries on the economic, social and environmental conditions in Hebron District. Master thesis, University of Birzeit. (in Arabic)

Ananza, A. A. 2003. Environmental and Geomorphological Effects of Stone Quarries in Karak Governorate. *Mu'tah Journal for Research and Studies* 18 (13):125–51. (in Arabic)

Capitano, C., G. Peri, G. Rizzo, and P. Ferrante. 2017. Toward a holistic environmental impact assessment of marble quarrying and processing: Proposal of a novel easy-to-use IPAT-based method. *Environmental Monitoring and Assessment* 189 (3):108. doi: 10.1007/s10661-017-5825-6.

DAAR (Decolonizing Architecture Art Residency). 2015. The Stone Industry in Palestine. Final Report, Ministry of Planning, Ramallah, Palestine.

IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014- International soil -classification system for naming soils and creating legends for soil maps. Reports No. 10, FAO World Soil Resources Reports No. 106, Rome. Accessed December 10, 2020. http://www.fao.org/3/i3794en/I3794en.pdf.

Khan, M. M., R. Nawaz, N. Ehsan, S. Ahmad, M. W. Nawaz, and M. H. Nawaz. 2016. Health hazards and socioeconomic effects of stone crushing industry on its workers: A case study of Sargodha. *Pakistan. Journal of Environmental and Agricultural Sciences* 6:40–6.

Lameed, G. A., and A. E. Ayodele. 2010. Effect of quarrying activity on biodiversity: Case study of Ogbere site, Ogun State Nigeria. *African Journal of Environmental Science and Technology* 4 (11):740–50.

Langer, W. H. 2001. Potential environmental impacts of quarrying stone in Karst—A literature review. Open-File Report OF-01-0484, U.S. Geological Survey (USGS). Accessed April 07, 2021. http://geology.cr.usgs.gov/pub/ofrs/OFR-01-0484/.

Makhool, B., and M. Abu-Alrob. 1999. Quarries, crushers and the stone industries in Palestine: Current situation and prospects. Palestine Economic Policy Research Institute (MAS). Accessed November 8, 2020. https://library.palestineeconomy.ps/public/files/server/20142511163038-1.pdf.

Masri, R. 2017. Environmental consequences of quarries and stone quarries in Hebron Governorate. *Afaq Environmental Magazine*, September 1. Accessed December 20, 2020. https://www.maan-ctr.org/magazine/article/1638/

MoLG (Ministry of Local Government). 2020. Geomolg: Integrated spatial information system in Palestine. Accessed September 10, 2020. https://portal.geomolg.ps/portal/apps/sites/#/molg-hub-1.
Naik, D. P., Ushamalini, and R. K. Somashekar. 2007. Noise pollution in stone quarrying industry—A case study in Bangalore district. Karnataka, India. *Journal of Industrial Pollution Control* 23 (1):43–8.
Pal, S., and I. Mandal. 2017. Impacts of stone mining and crushing on stream characters and vegetation health of Dwarka river basin of Jharkhand and West Bengal. *Journal of Environmental Geography* 10 (1–2):11–21. doi: 10.1515/jengeo-2017-0002.
PIPA (Palestinian Investment Promotion Agency). 2020. Stone and marble. Accessed November 25, 2020. http://www.pipa.ps/page.php?id=1aaf99y1748889Y1aaf99. (in Arabic)
PSAACB (Palestinian State Audit and Administrative Control Bureau). 2013. The environmental audit, the reality of the stone industry in Palestine, the extent of compliance with environmental laws, regulations and standards. Palestinian State Audit and Administrative Control Bureau, Ramallah. Accessed January 9, 2021. https://saacb.ps/BruRpts/FQR-%202013.pdf. (in Arabic)
Sababhi, S. S. 2012. Geographic factors affecting the endemism industrial in Hail Area. *Journal of American Science* 8 (7):440–7.
Salem, H. S. 2021. Evaluation of the Stone and Marble Industry in Palestine: Environmental, geological, health, socioeconomic, cultural, and legal perspectives, in view of sustainable development. *Environmental Science and Pollution Research International* 28 (22):28058–80. doi: 10.1007/s11356-021-12526-4.
Sayara, T. 2016. Environmental impact assessment of quarries and stone cutting industries in Palestine: Case study of Jammain. *Journal of Environment Protection and Sustainable Development* 2 (6):32–8.
Sayara, T., Y. Hamdan, and R. Basheer-Salimia. 2016. Impact of air pollution from quarrying and stone cutting industries on agriculture and plant biodiversity. *Resources and Environment* 6 (6):122–6. doi: 10.5923/j.re.20160606.04.
Szczepańska, A. 2017. The quality of the living environment versus natural factors – the case study of Olsztyn. Paper presented at Environmental Engineering 10th International Conference, Vilnius, Lithuania, April 27–28.
Titi, A., M. Dweirj, and K. Tarawneh. 2015. Environmental effects of the open cast mining a case study: Irbid Area, North Jordan. *American Journal of Industrial and Business Management* 05 (06):404–23. doi: 10.4236/ajibm.2015.56041.
Umana, K. 2018. Environmental impacts of quarrying in Nigeria. Accessed November 04, 2021. https://research-cyber.com/environmental-impacts-quarrying-nigeria/
USMIP (Union of Stone and Marble Industry in Palestine). 2011. Stone and Marble in Palestine developing a strategy for the future. Accessed November 25, 2020. Last Modified February 17, 2021.http://www.lacs.ps/documentsShow.aspx?ATT_ID=4618. (in Arabic)
USMIP (Union of Stone and Marble Industry in Palestine). 2019. Stone and Marble in Palestine developing a strategy for the future. Accessed November 25, 2020. https://www.usm-pal.ps/industry.php?lng=1. (in Arabic)
Vandana, M., S. E. John, K. Maya, and D. Padmalal. 2020. Environmental impact of quarrying of building stones and laterite blocks: A comparative study of two river basins in Southern Western Ghats. *Environmental Earth Sciences* 79 (14):366. doi: 10.1007/s12665-020-09104-1.