

Ranking Natural Stone Products Using Promethee Method: The Case of Natural Stone Products from Hebron Governorate, Palestine

presented by
Maher Hushaysh, PhD

The College of Applied Professions, Palestine Polytechnic University
Hebron- Palestine
The Union of Stone and Marble Industry, Bethlehem, Palestine

e-PROMETHEE Days 2020 meeting in e-Rabat

June 2-4, 2020



Outline

- Introduction: Palestine in Figures
- Stone and marble industry in Palestine
- Evaluation the quality of stone products
 - The traditional approach
 - The scientific approach
- Evaluation model and data analysis
- Summary of findings
- Future Perspectives

Palestine in figures (PCBS, 2018)



- Convergence point of Asia, Africa and Europe
- **Currently, The Palestinian Authority 6020 KM** square kilometres
- Population: **4,854,013**
- GDP: USD **14500 \$** millions
- Unemployment: **25.9%**
- Industrial sector represents **14%** of the GDP
- **Stone and marble** is the main industrial sector

Hebron Governorate in Figures

- **1 M** of inhabitants
- **23%** of the Palestinian GDP
- **30%** of the Palestinian total exports
- **40%** of natural stone reserves
- **35%** of the total stone products
- **+ 600** stone and marble Enterprises

Stone and Marble Industry in Palestine



Nassar Stone storage near Bethlehem

- 4% of the world production (USAID, 2002)
- 4.5% of the Gross Domestic Product (GDP)
- +20000 employment positions
- +30% of national exports to more than 70 countries worldwide
- + USD 30 Billions of reserves
- +1200 enterprises
- 90% are SMEs

Research Problem

- Natural resource products/ quality vary from type to type
- The quality of the products is crucial for two main reasons:
 - The quality of a product implies its application (flooring vs. cladding and/or internal vs. external usage)
 - Wrong usage of Stone product costs a lot as repairing is very costly and difficult
 - The quality of the stone products determine their prices
- No prior studies have been conducted to rank the Palestinian stone products according to their quality
- Fill the gap of the knowledge between the Palestinian architects and the contractors about the quality of the stone products and their applications
- **Problematic**: How can we evaluate the quality of stone product, and what is the rank of the stone product types?

Stone quality: Evaluating approaches

To evaluate/rank the stone products according to their **Quality**, the researcher follows two approaches and make a comparison between them

Approach one

The traditional approach

Based on the opinion of **panel of experts** from the industry

Approach two

Multi Criteria Decision Aid (MCDA)/

Outranking approach

PROMETHEE Method

Do the result of the two approaches match or differ, Why?

Stone products from Hebron Governorate

23 stone types from Hebron Governorate in the Palestine stone products catalogue (total 58 types), those types are in the following table:

#	Stone Type	#	Stone Type
1	Injasah Ardi	13	Taffouh- Sowwaneh
2	Injasah Sud	14	Taffouh -Light
3	Injasah Metrains	15	Taffouh -Medium
4	Shyoukh Ardi White	16	Taffouh- Ardi
5	Shyoukh Ardi Cream	17	Tarqumia-Light
6	Layer 160 White	18	Tarqumia-Medium
7	layer 160 Cream	19	Tarqumia- Ardi
8	layer Sous 7	20	Tarqumia- Against Vein
9	Sannoot Against Vein	21	Yatta- Yellow
10	Samou Stone White	22	Yatta- Cream
11	Samou Stone Pink	23	Yatta-Pink
12	Injasah Yellow		

Note: the names are based on the locations of quarries and the given name of the layer in the same quarry

Stone Quarry



Stone layers



Injasah Metrains



Injasah Sud



Injasah Ardi

Different layer gives different types with different quality

Ranking the quality stone products from Hebron Governorate

Approach1: a Traditional Approach

- **10 experts** were Purposefully selected to give their opinion about the quality of the stone types
- For practical purposes, they were asked **to rank** the top **10 products** in descending order (no. 1: the product with the best quality and 10 the product with the lowest quality)
- **Telephone interview** to explain the purpose of the study and an **electronic questionnaire** were used to generate their point of views
- They were asked to give their opinion based on their perceptions/understanding of the quality dimensions

The ranking of the top 10 products according to the Traditional Approach

Rank	Stone Type
1	Injasah Ardi
2	Shyouk Ardi White
3	Layer 160 White
4	Layer 160 ream
5	Sannout Against Vein
6	Injasah Metrain
7	Shyouk Ardi Cream
8	Injasah Sud
9	Taffouh -Medium
10	layer Sous 7

Ranking the quality stone products from Hebron Governorate

Second Approach: a Multi Criteria Decision Aid Approach

- PROMETHEE-GAIA methodology is employed
- Two engineers were interviewed: they are
 - The manager of the Palestine Stone and Marble Center at the Palestine Polytechnic University (+25 years of experience at the industry, academia and testing of natural stone and construction materials)
 - The manager of the testing lab manager (+10 years experience in stone testing lab and academia). Their main role is to
 - ✓ Give weight for each criterion for evaluating the quality, and
 - ✓ Approach the indifference and preference thresholds for each criterion

Universally the quality (mechanical and physical properties of the natural stone products are evaluated against the following tests/
Criteria*

- **Water absorption:** The amount of water absorbed by a stone, expressed as a percentage by weight, the less water absorption the better stone quality. Usually tested according to ASTM C97.
- **Density:** The mass of a unit **volume of the stone**. Usually tested according to ASTM C97.
- **Compressive Strength:** A measure of the resistance of the stone to crushing loads. The more Compressive Strength the better stone quality. Usually tested according to ASTM C170.
- **Flexural Strength:** This test method covers the procedure for determining the flexural strength of stone by use of a simple beam using quarter-point loading. Usually it is tested according to ASTM C880.
- **Groove Length:** Shows you how to select, design, and install stone cladding systems for exterior walls. It is tested according to ASTM C1242.

**According to the American Society for testing material (ASTM)*

Criteria weights and thresholds

The decision makers/ the two engineers agree on:

- Excluding the flexural strength and Groove length criteria
- Allocating weights and thresholds for the rest criteria as follows

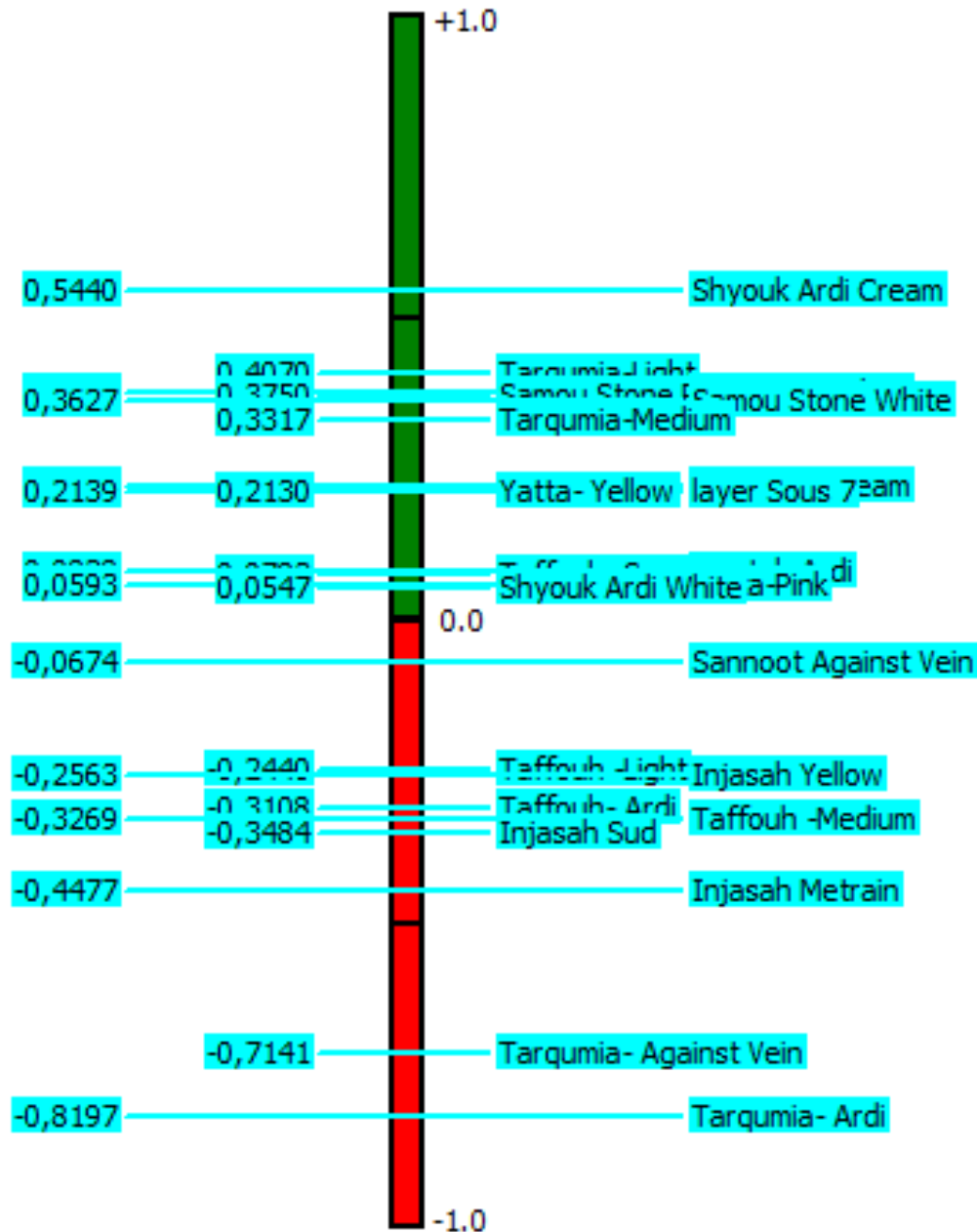
Criterion/test	Weight	Scale of measurement	Min. value	Max. value	Indifference threshold (q)	Preference threshold (p)	Preference function
Water absorption	30%	numerical	0.3	3.28	0,5	1	linear
Density	40%	numerical	2410	2660	50	100	linear
Compressive strength (dry)	15%	numerical	77.60	150.60	10	20	linear
Compressive strength (wet)	15%	numerical	69.70	135.10	10	20	linear

Table of performance/ Hebron Stone Testing results*

#	Stone Type	Water Absorption %	Density Kg/m ³	Compressive strength (Dry) Mpa	Compressive strength (Wet) Mpa	Flexural Strength (Mpa)	Groove Length (mm)
1	Injasah Ardi	0.89	2604	111.3	72.1	7.98	22.8
2	Injasah Sud	1.83	2519	100.5	95.2	8.45	22.3
3	Injasah Metrain	1.86	2518	102.9	73.5	8.39	23.6
4	Shyoukh Ardi White	1.13	2567	108.1	96.8	7.75	23.1
5	Shyoukh Ardi Cream	0.66	2637	150.6	153.1	8.55	21.8
6	Layer 160 White	0.77	2623	123.8	115.3	7.35	23.8
7	layer 160 Cream	1.06	2585	118.5	111.9	8.2	20.6
8	layer Sous 7	1.14	2593	123.7	116.9	8.78	20.3
9	Sannoot Against Vein	1.04	2587	77.6	80.8	8.63	22.4
10	Samou Stone White	0.9	2613	133.7	112.1	7.77	22.4
11	Samou Stone Pink	0.3	2664	112.2	96.6	8.07	23.8
12	Injasah Yellow	1.68	2552	106.4	78.5	7.01	26
13	Taffouh- Sowwaneh	1.15	2625	96.1	88.7	5.38	21.6
14	Taffouh -Light	2.02	2475	149.8	110.2	10.38	22.3
15	Taffouh -Medium	1.24	2522	89.1	72.9	8.72	22.9
16	Taffouh- Ardi	1.87	2477	123	106.3	6.89	22.4
17	Tarqumia-Light	0.91	2601	136.4	130.9	8.68	21.3
18	Tarqumia-Medium	0.95	2586	124.8	126.2	7.6	20.8
19	Tarqumia- Ardi	3.28	2410	95.8	75.9	10.82	21.2
20	Tarqumia- Against Vein	2.10	2410	94	77	10.82	21.2
21	Yatta- Yellow	0.53	2646	102.2	90.3	8.19	20.8
22	Yatta- Cream	0.72	2628	107.4	95.5	7.97	20.8
23	Yatta-Pink	0.86	2618	97.1	69.7	10.32	20.6

*Testing Result of natural stone product from Hebron Governorate, Palestine. Retrieved from Palestine Stone Products catalogue (Pal Cluster, 2017)

Ranking of Hebron stone products by using PROMETHEE 2 Full Ranking



Rank of stone products: Promethee table

Rank	action	Phi	Phi+	Phi-
1	Shyouk Ardi Cream	0,5440	0,5440	0,0000
2	Tarqumia-Light	0,4070	0,4256	0,0186
3	Layer 160 White	0,3753	0,4020	0,0267
4	Samou Stone Pink	0,3750	0,4497	0,0747
5	Samou Stone White	0,3627	0,3899	0,0272
6	Tarqumia-Medium	0,3317	0,3682	0,0365
7	layer 160 Cream	0,2237	0,2919	0,0682
8	Yatta- Cream	0,2141	0,3062	0,0921
9	layer Sous 7	0,2139	0,2899	0,0760
10	Yatta- Yellow	0,2130	0,3304	0,1174
11	Injasah Ardi	0,0828	0,2218	0,1390
12	Taffouh- Sowwaneh	0,0783	0,2224	0,1441
13	Yatta-Pink	0,0593	0,2318	0,1726
14	Shyouk Ardi White	0,0547	0,1921	0,1374
15	Sannoot Against Vein	-0,0674	0,1651	0,2325
16	Taffouh -Light	-0,2440	0,2437	0,4877
17	Injasah Yellow	-0,2563	0,0786	0,3349
18	Taffouh- Ardi	-0,3108	0,1680	0,4789
19	Taffouh -Medium	-0,3269	0,0777	0,4046
20	Injasah Sud	-0,3484	0,1045	0,4530
21	Injasah Metrain	-0,4477	0,0594	0,5071
22	Tarqumia- Against Vein	-0,7141	0,0180	0,7321
23	Tarqumia- Ardi	-0,8197	0,0056	0,8253

Comparing the results of the two Approaches

The Traditional Approach

Rank	Stone type
1	Injasah Ardi
2	Shyouk Ardi White
3	Layer 160 White
4	Layer 160 cream
5	Sannout Against Vein
6	Injasah Metrain
7	Shyouk Ardi Cream
8	Injasah Sud
9	Taffouh -Medium
10	layer Sous 7

PROMETHEE Approach

RankS	Stone type
1	Shyouk Ardi Cream
2	Tarqumia-Light
3	Layer 160 White
4	Samou Stone Pink
5	Samou Stone White
6	Tarqumia-Medium
7	layer 160 Cream
8	Yatta- Cream
9	layer Sous 7
10	Yatta- Yellow
11	InJasah Ardi
14	Shyoukh Ardi White



Discussion

- 4 products out of 10 are ranked at the top 10 products
- **Injasah Ardi** (perceived as a very well known brand) doesn't appear at PROMETHEE ranking
- **Shyoukh Ardi** doesn't appear at the top 10 PROMETHEE Ranking too
- Only the ranking of the **layer 160 white** type matches according to both approaches
- In general the results according to both approaches are **60% different**

Recommendations

- The result of the study will strongly impact the stone industry in Palestine, in terms of demand, supply, prices and applications of natural stone products
- The result of the study should be disseminated amongst the architects, engineers and contractors and businessmen for the industry to raise their knowledge about the quality of stone types
- The result might affect the application of different stone types, flooring/ cladding
- Some infamous types might be promoted using the result of this study
- The owners of the quarries well known brand (as currently perceived) should keep in mind that their product might negatively be affected. Therefore, they should build different business strategies
- Similar researches on other products is highly recommended

The background of the image is a piece of marbled paper with a complex, organic pattern of swirling lines and spots in shades of beige, cream, and light brown. The pattern is dense and fills the entire frame.

**THANK YOU FOR YOUR
ATTENTION**