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Decision Support System for Industrial Social Performance

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Abstract

Sustainability is an interdisciplinary concept that involves social, economic, and environmental issues. Recently, most researches focus on economical and environmental aspect. In this research, the social impact of the industries will be integrated with the economic and environmental aspects to measure the overall performance of the industries. A mathematical model called value contribution will be developed to measure the social performance of the industries, with the consideration of environmental and economic dimensions. The model will be implemented on the stone and marble industry in Palestine as an example. As a result, the industries can be evaluated based on their high positive performance. The decision makers can use the result of this study and similar ones as an evaluation tool to support the industries with the highest overall performance.

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Keywords: Value contribution, social performce, sustainbility

1. Introduction

Sustainable development is mostly defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. Sustainability involves the integration of economic, environmental, and social dimensions. Economic aspect forms the framework for making decisions. Environmental aspects recognize the impacts of human on the ecosystem. Social aspect refers to interactions between institutions and people, human values, aspirations and well-being, ethical issues, and decision making process.

Sustainable engineering principles require the life cycle analysis of products and use of efficient management tools. In addition common sustainability metrics need to be studied. Sustainability metrics are generally based within certain disciplines such as ecology, economics, and physics, and how they may reflect on other disciplines [2]. Sustainable manufacturing is defined as the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, safe for employees, communities, and consumers and are economically sound [18].

On other hand there are dozens of environment performance indicators, EPIs that can be used to evaluate sustainability. Examples of multi-component methods that allow comparisons at a national level, which is necessary for promoting many types of systemic changes, include ESI, and EMPI. Environmental sustainability index (ESI), the ESI uses 76 variables to create 21 indicators of sustainability. The EMERGY (The term, EMERGY, is a contraction of Embodied enERGY) performance index (EMPI) differs in omitting the social variables, and instead creates a single unit that can be used to describe the production and use of any natural or anthropogenic resource [19]. There have been many works to build commonly accepted standardized metrics including indicators set by Global Reporting Initiative GRI and core indicators by the Organization for Economic Corporation and Development.

Shuab in [3] and Silva [4] developed a product sustainability index, ProdSI, and implement it to compare sustainability performance of electronic products.

Mishima in [5] proposed a new evaluation index for sustainability of products and named it total performance

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indicator TPI and applied it to evaluate energy efficiency of manufacturing processes considering manufacturing quality. The IPK offered Benchmarking index – analysis for SME to measure their business performance based on indicators of balanced scorecard BSC.

The value contribution model will be used for assessing sustainability and industry in this paper. It will integrate economic, environment and social aspects of sustainability. The proposed model will be implemented then on stone and marble industry SMI on Palestine being as one of the largest industries and affecting environment substantially [6].

2. Stone and Marble in Palestine

According to the competitiveness assessment report 2006 for the Palestinian stone and marble cluster "the actual size of national stone reserve is unknown, making the current annual production rate excessive for the size of a small country like Palestine. While the cluster enjoys skilled human resources there are no vocational training programs or technical institutions to develop new generation of workers or to promote innovation in the cluster." The SMI in Palestine can be considered mostly as SME as it is heavily dominated by small factories and workshops with limited capacity for export and with unsophisticated management capacity; only few companies with export experience. SMI generates large amounts of waste in both quarrying and processing, such waste damage the environment and affects adversely human health.

SMI plays and important role in Palestine industry and economy contributing to 4.5% of the GNP and a total revenue of 270 million $/year as shown in table 1 .

Table 1. *Marble and Stone Industry in the Palestinian Territories*. Source Asia Holy Land Marble & Stone Co (Research and Development Department,2010)..

% of GNP	4.5
% of GDP	5.5
Total investment	$ 700 million
Number of employees	15,000
Total current annual production	14.5 million square meter
Total annual revenue	$440 million
Annual sector export	60 million $
contribution to Palestinian export	26%

2.1. Improve the wastewater treatment capacity of enterprises

Large amounts of water are used in the SMI. Water is used mostly for cooling during cutting and polishing. Water acts also as dust suppressant where most of the dust is captured by the water. The waste water as slurry creates new problem to the SMI and to the environment if it is disposed of in a wrong way. Effective wastewater treatment is an important gap within the stone and marble industry. Improving capacity of industry to manage waste efficiently is a strategic option for stone producers, as it demonstrates the ability to re-use wastewater. Treatment of waste water and recycling it will reduce adverse effect on the environment and at the same time reduce the water bill and production cost.

2.2. Develop the capacity of the sector to utilize waste to create new product offerings

A major by-product of the production processes of the stone and marble sector is powder that poses a big environmental problem in Palestine. The powder is generated during the cutting and polishing process of the stone. Most part is caught in the waste water the rest is dust and air pollutant and mostly driven out of the factory and get carried away by air and wind. The part in the slurry can be recovered using settling silos and tanks followed by filtration using filter presses or other means. Approximately one million tons of the powder is generated annually. There is potential to utilize this by-product to develop new products, and in the process develop a new sub-value chain of high value products that also reduces environmental waste. Suggestions include artificial stone, using additives in concrete industry, as well as using in paint and plastering.

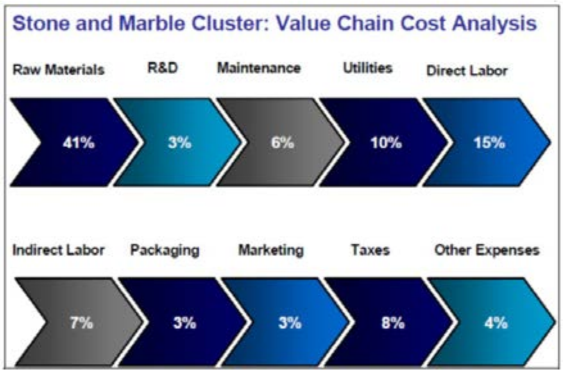
2.3. Better environmental waste management systems are needed

Roughly 0.5 million cubic metres of water are used annually. Although this water is used at various points in the value chain, its main purpose is to cool the saws used to cut blocks and slabs. When the wastewater mixes with dust it creates a compound commonly known as slurry. Anywhere from 0.7 to 1 million tons of this waste is produced each year and it can have negative impacts on the surrounding environment. Although some of this waste is captured and recycled in some factories, the majority of Palestinian factories lack the know-how needed to tackle waste by-products in an efficient and environmentally friendly manner [7, 8].

Based on above, development needs in the Palestinian stone and marble sector includes; facilitate implementation of quality management systems within the enterprise base, improve the wastewater treatment capacity of enterprises, as well as develop the capacity of the sector to utilize waste to create new product offerings.

Fig 1 shows the value chain cost analysis of SMI. This chart shows that the R&D has a minor contribution which explains the main weaknesses of this sector.

Fig. 1. Palestinian stone and marble cluster value chain cost



analysis. Source *The Palestinian Stone and Marble Cluster: Assessment Report 2006*

3. Concept of value

Axiology, from the Greek axios i.e. worthy, valuable and logos i.e. discourse, reasoning is the discipline that deals with values in a systematic way [23]. Value is one of the most powerful words in the lexicon of management arts and science, however, it possesses a ubiquitous nature stemming from its semantic vagueness [11]. The first academic investigation of value was undertaken by sages of ancient Greece. Historically, values have been studied from philosophical, ethical, economical, psychological, and technological viewpoints. Values can be classified by absoluteness, objectivity, and subjectivity [22]. While customers are the final arbiters of value, value can be defined and measured from the point of view of a particular customer: individual, organization, or society [13]. Value offering is an industry's interpretation of and responsiveness to customer requirements via a combination of product and relational advantage which can be grouped into four categories:

- Performance value,
- Pricing value,
- Relationship building value,
- Co-creation value [16].

Industries achieve competitive advantage by producing products more efficient than their competitors, or by using less resource to create the same products produced by their competitors. The more value an industry creates, the more likely it is to survive. Four types of value creation capabilities of innovation intermediaries are

- value creation through best-cost capabilities,
- value creation through timing capabilities,
- value creation through product solution capabilities, and
- value creation through market response capabilities [20].

Value engineering is a scientific method of analyzing a product or service so that its function can be provided at the lowest overall cost, without sacrificing quality [12]. To create new or better products, industries need to reallocate resources, to combine new resources, or to combine existing resources in new ways [21].

Resources refer to all existing assets, both tangible and intangible. Two resources that really matter in today's economy: knowledge and relationships or industry's competencies and customer [15].

Economic development is an iterative process of creating and realizing value through resource combinations and exchanges [14]. A resource has been defined as valuable if it either enables customer needs to be better satisfied, or if it enables industry to satisfy needs at lower costs than competitors. Also resources are valuable if they enable industry to conceive or implement strategies that improve its efficiency and effectiveness [9]. The creation of economic value is a process that involves the use of resources. Securing the "best use of resources" is the challenge not only for industry but society as a whole, particularly if growth or development is a concern.

Value creation modules consist of the major factors needed to create value, these factors are: product, process, equipment, organization, and humans [18]. Modules are to be modelled and valuated on different levels of aggregation e.g. from a single workplace for component manufacturing to regional value adding in production equipment for mobility or energy as areas of human living. Value creation factors shape value creation modules to be evaluated in ecological, economic and social sustainability dimensions. The dynamics of cooperation and competition drive for horizontally or vertically integrating modules to networks [19]. In order to survive in global competition, industries focus more and more on their core competencies. They increasingly divide the value creation among numerous enterprises and organize themselves in global value creation networks.

Value chain is used to characterize the process through which a good or service moves from raw materials to final consumption. Every industry occupies a position on a value chain. Upstream, a supplier provides inputs; the industry then adds value to these inputs, before passing them downstream to the next actor in the chain. Value refers to the level of usefulness or importance of activities generated between stages of the chain [17].

Utility theory states that consumer spend their income so as to maximize the satisfaction they get from products [9]. The value is created when the monetary amount realized for this product or service is greater than what might be derived from alternative resources producing the same product or service. Customers assess the overall value of a product on the perceptions of what is given and what is received. Value has two main components [10]:

- Perceived use value is assessed subjectively, based on the customers' perceptions of their needs and the extent to which the product might meet those needs.
- Exchange value is realized when the product is sold. It is the amount paid by the customer to the producer for the perceived use value.

4. Conceptual model of value contribution (VC)

4.1 General value model

The general concept of value contribution (VC) can be simplified in the conceptual model shown in Fig 2.

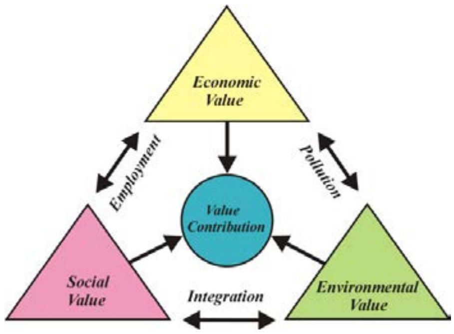


Fig 2. General concept of value contribution

The conceptual model in Fig 2 shows that value contribution of the SMI depends mainly on three values; economic value, social value and environmental value. The sum of contributions of the three values makes the total value contribution. The social value is related to the economic value through the human resources (employees). Employment increases the economic level of individuals that leads to increasing in societal economy. On the other hand, social value is connected to the environmental value through the integration of human being into the environment. This integration comes through raising awareness of environmental aspects and how to concentrate on green behavior in the different activities and processes of SMI. The economic value gives indicators about the quantity and quality of production. Production processes are accompanied with polluting wastes like dust, sludge cake and noise. These pollution outputs have drastic influence on environment.

4.2 Economic value sub-model

Economic VC as shown in Fig 3, is the function that transfers the process inputs into an output.

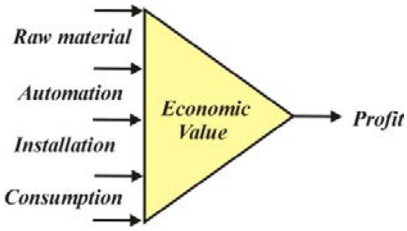


Fig 3. Economic value sub-model

The inputs to the economic transfer function (value) are: the automation, installations, raw materials and consumption while the output of this process is the profit gained from the product. This leads to the fact that the economic value is the ratio between these output and inputs:

Economic value contribution = Profit /Cost of resources used [Raw material + Automation + Installation + Consumption]

4.3 Social value sub-model

Social value contribution is shown in Fig 4. Social value contribution is the ratio between the employees' quality of living as an output and the cost of the accidents and health.

Social value contribution = Employees / cost of accidents and health

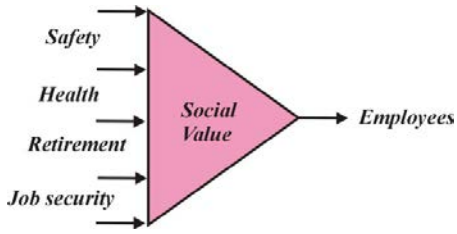


Fig. 4 Social value sub-model

4.4 Environmental value sub-model

Environmental value contribution depicted in Fig 5 is the ratio between the production as an output and the consumption and pollution (Raw material, Water, Energy, Pollution and Natural resources) as inputs.

Environmental value contribution = production / consumption and pollution *[Water + Energy + Pollution + Natural resources]*

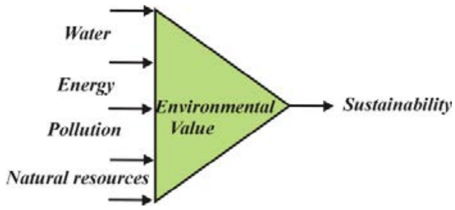


Fig. 5 Environmental value sub-model

These parameters of inputs and outputs can be measured using the indicators illustrated in the next section. These parameters can be represented by quantitative values to calculate the total value contribution.

5. Value contribution calculation

5.1 Value contribution indicators

Every parameter represents an input or output for any of the three values can be measured using a corresponding indicator.

The main function for these indicators is to translate the different inputs and outputs to quantitative values (monetary quantity for example).

The economic output is the profit and this is the easiest to measure in terms of money because it is a direct quantitative value. The output of the social value is the human resources (employees). This output can be determined quantitatively by calculating the labor salaries; this translates this output to money as well. The most difficult output is the environmental output ,one of the measurement indicators for this output is the quantitative amount of savings (in terms of money) due to using sustainable resources like: renewable energy, water recycling and solid waste reuse.

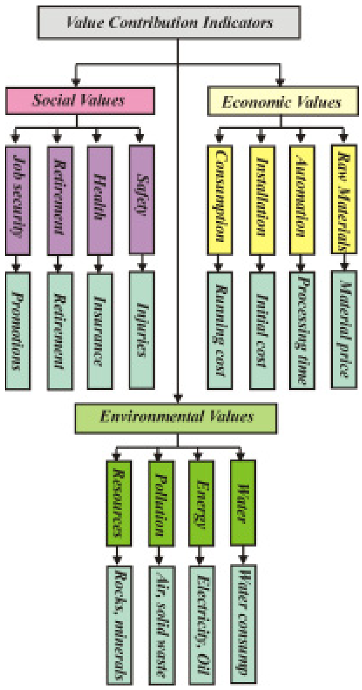


Fig 6. Indicators used to define the inputs and outputs of the values

Fig 6 demonstrates all indicators corresponding to the different inputs. Safety is measured by the cost of injuries and work accidents. Health is measured quantitatively by the cost of health insurance contracts of the employees. Retirements and promotion costs are measures for job security. Raw materials are evaluated by the cost of purchasing these materials. Automation is calculated by the cost of processing time where using automation decreases the processing time which increases the productivity. Installation is represented by the initial cost of mounting the machines and production lines. Consumption is measured by the running cost of machine operation and maintenance. The cost of water is calculated by price of cubic meter of consumed water per unit production. The indicator of the energy is the price per kWh of electricity consumption and the price per liter of fuel consumed. Pollution is measured by the cost of dust cleaning and solid waste reusing like producing sludge cake. Natural resources are measured by the price of purchased rocks and stones to operate the different processes.

5.2 Implementation of indicators

To implement the foregoing indicators, a sample of 10 stone and marble cutting factories was selected. Table 2 includes data about production rate, employees, water consumption, raw stone consumption and scrap waste in these 10 factories. Figures 7 to 9 depict the factors that influence this sector as calculated from data of tabe 1; where all factors have been normalized to the production rate of each factory. Factories with water management and recycling show a lower water factory. Higher stone utilization factor implies more efficient use of natural resources. Higher productivity is obtained for factories with automated and modern equipment.

Table 2: Real case study on 10 factories

Fact-ory	**Prod-uction m^2/ month**	**Empl-oyees**	**Consumed water m^3/month**	**Raw stone m^3/ month**	**Scrap m^3/ month**
1	1800	13	40	120	35
2	7000	29	120	300	60
3	3700	25	80	250	120
4	15,000	66	350	650	150
5	2000	10	120	150	60
6	3000	51	240	180	90
7	1500	8	40	100	40
8	1500	15	120	80	25%
9	2500	35	160	250	NA
10	7200	32	700	300	NA

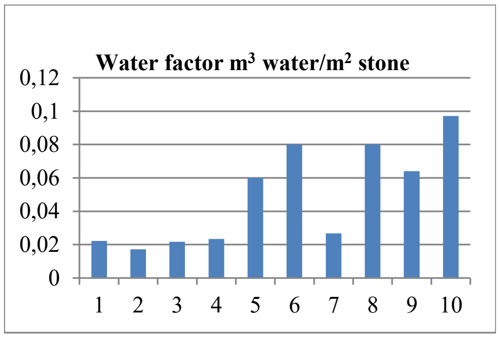


Fig 7. Water factor for stone and marble sector

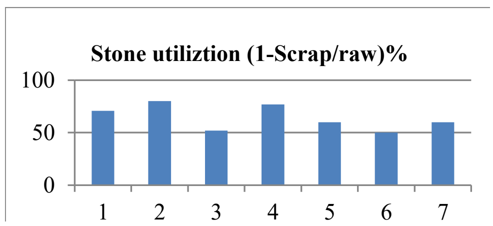


Fig 8. Stone utilization factor for stone and marble sector

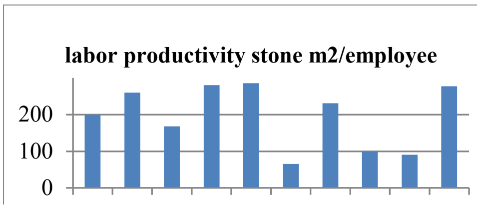


Fig 9. Labor productivity factor for stone sector

Conclusions

This paper presents the measures required to assess the performance of the stone and marble sector in Palestine. A general model was designed to connect all inputs and output through specific indicators for the purpose of value contribution assessment. Finally, the indicators were implemented on a sample of 10 factories to show the impact of these indicators on the sector's general performance.

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