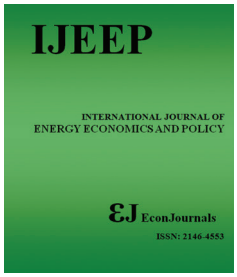

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(4), 60-67.

Assessing Sustainable Manufacturing Practices and Sustainability Performance Among Oil and Gas Industry in Iraq

Yousif Munadhil Ibrahim*, Norsiah Hami, Susan Sabah Abdulameer

School of Technology Management and Logistics, College of Business, Universiti Utara Malaysia, Kedah, Sintok, 06010, Malaysia.
*Email: yousifmonadhil58@gmail.com

Received: 15 January 2020 **Accepted:** 24 April 2020 **DOI:** https://doi.org/10.32479/ijeep.9228

ABSTRACT

The companies' interest in the level of their sustainable manufacturing practices (SMPs) has become necessary. This is because of its role in improving and balancing dimensions of sustainability performance (SP) which includes environmental sustainability (EnS), social sustainability (SoS) and economic sustainability (EcS). Therefore, the objective of the present study is the investigate about the extent of SMPs and SP to encourage the oil and gas industry (O and GI) in the context of Iraq to obtain a balance in the dimensions of SP, i.e. EcS, EnS and SoS. The data collected from 80 companies were analysed using descriptive statistics method by using SPSS version 25. The results revealed that the extent of the four SMPs and the three dimensions of SP in companies were implemented at a slight level. These results imply that although SMPs have become a required necessity expected from all industries, and companies should prefer to implement them, there is still needed to more efforts in implementation of SMPs among the O and GI to achieve a balance in the dimensions of SP.

Keywords: Sustainable Manufacturing Practices, Sustainability Performance, Oil and Gas Industry
JEL Classifications: Q52, Q56, Q58, Q380

1. INTRODUCTION

Sustainability performance (SP) is an important issue in the oil and gas industry (O and GI) in Iraq (Ibrahim et al., 2019b). This is because of the imbalance between the dimensions of SP (i.e. EcS, EnS and SoS) (Ibrahim et al., 2019a). For example, The report of the ESCWA published that the percentage of Iraqi exports of oil equivalent to 99% of the total annual exports (UN-ESCWA, 2018). Also, OPEC (2018) reported that the percentage of Iraqi oil exports in 2017 equivalent to 33% of the GDP. These indicators confirm the crucial economic role of this industry in Iraq. However, the O and GI in Iraq is one of the most contributing industries to social and environmental impacts (Elhuni and Ahmad, 2017).

Globally, the O and GI has damage impacts on the society and environment (Schneider et al., 2013; Schneider et al., 2011). More clearly, employees and society are exposed to many diseases, such as respiratory diseases and cancer diseases due to volatile particles from oil and gas companies (EPA, 2003). In Iraq, 70% of the major sites for exploration and manufacture of crude oil and its derivatives such as Basra, Kirkuk, Baghdad, Maysan and Mosul suffer from the problem of environmental pollution (Al-Haleem et al., 2013).

Furthermore, based on a review of literature, studies have pointed out that achieving sustainability in companies requires focusing on environmental, social and economic aspects (Annunziata et al., 2018; Ashrafi, 2014; Cavagnaro and Curiel, 2012; Dao et al., 2011; Elkington, 1999), including the O and GI (Liyanage, 2007; Schneider et al., 2011). Yet, the study of environmental sustainability (EnS), economic sustainability (EcS) and social sustainability (SoS) from a balanced and comprehensive aspect

This Journal is licensed under a Creative Commons Attribution 4.0 International License

in practice is still limited (Martínez and Calvo-Amodio, 2017). Obviously, sustainable manufacturing practices (SMPs) have not been broadly studied (Despeisse et al., 2012). Also, empirical studies concluded that SMPs contribute to improved EcS, EnS and SoS (Hami et al., 2016).

The literature review indicates that most studies on sustainable manufacturing and their practices have been conducted from multiple perspectives concerning variety in dimensions addressed (e.g. Abdul-Rashid et al., 2017b; Gimenez et al., 2012; Hami, 2015). However, there are a little number of studies on SMPs from the point of view of the product lifecycle (PLC) (e.g. Abdul-Rashid et al., 2017a; Abdul-Rashid et al., 2017b; Hami et al., 2019, Ibrahim et al., 2019; Ibrahim et al., 2019b). Therefore, there is a need to study SMPs from the view of the PLC with its four dimensions: SPD, SMP, SSCM and SEoLM. Therefore, the objective of the present study is the investigate about the extent of SMPs and SP to encourage the O and GI in the context of Iraq to obtain a balance in the dimensions of SP, i.e. EcS, EnS and SoS.

The current study includes five sections; following this introductory section is section 2, the literature review which presents the empirical literature about SMPs and SP, followed by section 3, which includes measures of variables, sample design and data collection and method of data analysis. Then, section 4 which involve the results and discussed. The last section is the conclusions of the study.

2. LITERATURE REVIEW

2.1. SMPs

SMPs have obtained major interest over the past few years (Hami et al., 2019).

Based on the perspective of the PLC, SMPs can be classified into four dimensions concerning the phase at which the practices are implemented. These dimensions include the SPD, SMP, SSCM and SEoLM (Abdul-Rashid et al., 2017a; 2017b; Hami et al., 2019; Ibrahim et al., 2019b). Which it is considered the dimensions of SMPs in this study, because it is in the line with O and GI (Ibrahim et al., 2019b; Millar and Russell, 2011; Russell and Millar, 2014).

In the past, the traditional role of product design in companies is to meet the needs of consumers (Nambiar, 2010). Whereas nowadays, given the increase of environmental concerns, there has been a noted pessimism about our planet and future generations (Billatos, 2001). Likewise, Chiu and Chu (2012) emphasised that the significant challenge facing the world today is to limit or eliminate environmental impacts. According to Hundal (2001), there is an increasingly clear necessary to develop products that are environmentally friendly. Besides, to minimize the environmental impacts and increased product effectiveness, product designers should consider ecological standards and core intervention during the design process (Gunasekaran and Spalanzani, 2012; Ilgin and Gupta, 2010; McAloone and Pigosso, 2017). In addition, Ashrafi (2014) noted that good design leads to less environmental impacts. Due to its handling of all expected environmental problems of the product (Fuller and Ottman, 2004).

The goods are created through the manufacturing stage. According to Jawahir et al. (2006), manufacturing phase "*is the phase where semi-processed materials are transformed into finished goods for sale.*" Likewise, Russell and Millar (2014) demonstrated the manufacturing process as "*the transformation activities that convert raw materials to finished goods.*" In addition, environmental aspects playing a significant role in the manufacturing process (Shojaeipour, 2015). Accordingly, must be taken into account the type of material and it's the resulting emissions during the manufacturing process (Carley et al., 2014). Likewise, it is essential that the manufacturing process is designed in such a way as to reduce air emissions, pollution of water and land in addition to not the generation of hazardous wastes solid and liquid (Gupta et al., 2015), and the efficiency of material and energy (Bautista, 2013; Hundal, 2001). However, the manufacturing process has multiple environmental impacts because it consumes non-renewable materials and vast amounts of energy (Despeisse et al., 2012; Duflou et al., 2012), generates wastes gaseous, solid and liquid (Duflou et al., 2012), as well as emissions in water, air and land and impacts on employees and society (Haapala et al., 2013). Specifically in the O and GI, literature has identified tools and machines are responsible for most of the consumption of energy and resources during the manufacturing process (Jayal et al., 2010; Lu et al., 2011; Schlosser et al., 2011). Therefore, manufacturing process is a significant phase in PLC and should be given proper attention.

At present, SSCM is receiving increasing attention from researchers and practitioners. Despite the SSCM field is very new (Morali and Searcy, 2013; Zailani et al., 2012), in recent years study of SSCM has expanded significantly in the academician and businesses areas (Bentahar and Benzidia, 2018; Seuring, 2011; Shamsuddoha, 2015). The expansion of companies' interest in sustainability in their operations has led them to adopt it in all supply chain management activities (Badurdeen et al., 2013; Fiksel, 2013). This is because of the enormous pressure by stakeholders on companies (Zailani et al., 2012). Accordingly, to achieving comprehensiveness sustainability across all company operations, the SSCM has become indispensable.

Nowadays, the end-of-life (EoL) products are a primary concern for employees, society and other stakeholders to the companies, as a result of the damage caused it if not addressed. Indeed, EoL management has become a hot topic and increasingly important (Alamerew and Brissaud, 2018; Kopacek and Kopacek, 2007; 2014; Kuik et al., 2016) and an essential requirement for internal and external stakeholders (Thierry et al., 1995). This is due to among the factors of economic, environmental and social which involves benefits the value recovery of products (Badurdeen and Jawahir, 2017). This factors includes government legislation and markets requirements (Gupta et al., 2015; Khor and Udin, 2013; Shaharudin et al., 2015), natural resources scarcity and disposal of used products (Kuik et al., 2016), the reduction of wastes from products (Haapala et al., 2013; Thierry et al., 1995), mitigation of environmental hazards (Millar and Russell, 2011), as well health hazards that may affect employees and people outside the company (Dehghanian and Mansour, 2009). Accordingly, many countries in the European Union, United States, Japan and Australia have

enacted legislation requires companies to recover their products at the EoL (Afrinaldi et al., 2013). There are many definitions for SEoLM. All these definitions did not take into account the three dimensions of sustainability when making EoL value recovery options. Therefore, this study defined SEoLM as the planning, implementation and controlling of sustainable practices for recovering materials, components or products at the EoL within recovery options: reuse, remanufacture and recycle to recover value and reduce energy and resources consumption.

2.2. SP

The terms "*sustainability*" and "*Sustainable Development*" (SD) are synonymous with many researchers (Aras and Crowther, 2009). The definition of sustainability first emerged in the 1980s in the "*World Conservation Strategy drafted by UNEP in 1980*" and became more widely used (Du Pisani, 2006; Worster, 1993). Where sustainability is defined in "Brundtland report" as "*the development that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs*" (WCED, 1987. p. 8).

In 1994 John Elkington introduced the term "*triple bottom line*" or (*TBL*), One year later he also developed "*3P formulation*" which include "*people, planet and profit*" (Elkington, 2004. pp. 1-2). Most definitions of SP depend on *TBL* because it covers the three dimensions - EcS, EnS and SoS (Krajnc and Glavič, 2005). Also *TBL* pronounces SP at the company (Sezen and Çankaya, 2013).

Elkington (1997. p. 70) defined TBL as "*focusing on economic prosperity, environmental quality, and — the element which business bad preferred to overlook — social justice*". Also stressed the simultaneous pursuit to achieve of these three dimensions (Elkington, 1997. p. 397), and consider them at once and balance them in practice (Zhang et al., 2017).

3. RESEARCH METHOD

3.1. Measures

The SMPs that include SPD, SMP, SSCM and SEoLM were operationalised using 27 items adapted from Abdul-Rashid et al. (2017a; 2017b). The measurement items used in the survey involves existing measures taken from the literature which were validated by other researchers. Moreover, adapt of scales from Abdul-Rashid et al. (2017a; 2017b) was justified because these studies have been conducted in the manufacturing industry, including the O and GI.

Correspondingly, in this study, three types of SP were measured. These types include EcS, EnS and SoS. EcS was operationalised using 8 items adapted from Bansal (2005); Elhuni and Ahmad (2017); Paulraj (2011) and Zhu and Sarkis (2004). EnS was operationalised using 9 items adapted from Elhuni and Ahmad (2017); Miidom et al., (2016); Paulraj (2011) and Zhu and Sarkis (2004). SoS was operationalised using 12 items adapted from Bansal (2005); Elhuni and Ahmad (2017); Miidom et al. (2016) and Infante et al. (2013).

Scaling design of the items will be measured on a six-point Likert scale: "1" = "Strongly Disagree" (SD); "2" = "Moderately Disagree" (MOD); "3" = "Slightly Disagree" (SLD); "4" = "Slightly Agree" (SLA); "5" = "Moderately Agree" (MOA); and "6" = "Strongly Agree" (SA). The reason for using the six-point Likert scale was to ensure that participants did not simply check the "indifference" choice or "midpoint," as commonly happen with a five-point scale. The reason for using the six-point Likert scale was to ensure that participants did not simply check the "indifference" choice or "midpoint," as commonly happen with a five-point scale. Additionally, participants from Asian countries tend to choose the middle category response than those from Western countries (Si and Cullen, 1998; Thrulogachantar and Zailani, 2011). It was also found that the validity and reliability of the findings tend to be higher for the even number response scale a six-point in particular (Chomeya, 2010) when compared to the odd number response scale (Alwin and Krosnick, 1991; Andrews, 1984; Birkett, 1986; Coelho and Esteves, 2007; Krosnick and Fabrigar, 1997).

To achieve effective survey research practices, the instrument (questionnaire) was validated by pre-test process that involves face validity based on six experts who are familiar with the constructs of this study to attest the face validity of the measurements. Then, a pilot test was conducted to ensure the validity of the questions and the potential reliability of the data (Saunders et al., 2016. p. 473) with 12 practitioners in O and GI based on recommendations of van Belle (2008).

Finaly, the feedback, recommendations and comments by academicians experts and practitioners were considered into the final draft of the instrument to improve the validity and reliability of the items used in the main study.

3.2. Sample Design and Data Collection

The population in this study is the companies in the O and GI in Iraq. Hence, the respondents of this study was from the rank of top managers or senior executives in the O and GI in Iraq. There are currently 115 companies in O and GI in Iraq that registered in Ministry of Oil and Ministry of Industry and Minerals. this study employed the sample size determination criteria of Krejcie and Morgan to determine the representative sample size for the study (Krejcie and Morgan, 1970). Most significantly, this criterion takes into consideration the level of confidence and precision which ensures that sampling error minimization. According to the sample size formula, a sample size of 89 would be required for a population of 115. Since there is a sampling frame, the probability sample is appropriate in the current study. This study uses stratified random sampling, which is one of the probability sampling designs (Kumar, 2014). Accordingly, 80 questionnaires were received from the companies, resulting in a response rate of 90%. The demographic profile of companies and respondents are shown in Table 1.

3.3. Data Analysis Method

Descriptive statistics method helps in the collection, summarise, presentation, and analysis of a set of data (Berenson et al., 2012. p. 4). There are three styles for conducting and displaying descriptive statistics that include graphical, tabular and statistical (de Vaus, 2002. p. 207). This type of statistical analysis includes central tendency measures (e.g. mean, median, and mode) and

dispersion measures (e.g. standard deviation) (Bryman and Bell, 2015). In the present study, the purpose of descriptive analysis is to investigate the extent of SMPs and SP in the O and GI using the mean scores and standard deviation acquired from the SPSS.25 outputs. As support, descriptive statistics check has been similarly applied in other studies deploying survey about the sustainable practices (e.g. Bamgbade et al., 2016; Hami et al., 2018; Nordin and Adebambo, 2016).

4. RESULTS AND DISCUSSION

As explained in the data analysis method, descriptive analysis was conducted to assess the extent of the implementation of SMPs and level of SP among the O and GI in Iraq. The results of this study are shown in Table 2. All the variables have been measured on "six-point scale" criteria ranging from "1 (strongly disagree) to 6 (strongly agree)". Especially, mean scores less than 4.00 show that the variables are had not been implemented, while those of 4.00 and higher illustrate that it has been implemented. More details in Appendix 1.

Table 1: Profile of companies and respondents

Demographic factors	Frequency	Percentage
Number of full-time employees		
<10	4	5.00
Between 10 and 29	1	1.25
Between 30 and 99	4	5.00
Between 100 and 500	17	21.25
Between 501 and 1000	20	25.00
Between 1001 and 2000	4	5.00
More than 2001	30	37.50
Number of years of company establishment		
<5 years	1	1.25
Between 5 and 10 years	6	7.50
Between 11 and 15 years	4	5.00
Between 21 and 25 years	6	7.50
More than 25 years	63	78.75
Company ownership		
Public	38	47.50
Private	8	10.00
Foreign	32	40.00
Mixed	2	2.50
Company certifications		
ISO 9000	19	23.75
ISO 14000	10	12.50
All	51	63.75
Current position in the company		
General manager	70	87.50
Chief executive officer	10	12.50
Number of years of working experiences in the industry		
<5	1	1.25
Between 5 and 10	15	18.75
More than 10	64	80.00

Table 2: Results of extent of SMPs implementation

Variables	Mean	Standard deviation
SPD	4.275	0.702
SMP	4.384	0.681
SSCM	4.395	0.674
SEoLM	4.458	0.666
SMPs	4.378	0.628
EcS	4.395	0.777
EnS	4.399	0.740
SoS	4.383	0.695
SP	4.392	0.691

SMPS: Sustainable manufacturing practices, SP: Sustainability performance, EnS; Environmental sustainability, SoS: Social sustainability, EcS: Economic sustainability

Table 2 shows that the average score of the independent dimensions (SPD, SMP, SSCM and SEoLM) ranged of 4.275, 4.384, 4.395 and 4.458 respectively, at the same time, the overall mean of SMPs was 4.378. These show that the managers in the O and GI have perceived that there is the slight extent of implementation of SPD, SMP, SSCM and SEoLM, i.e. a small extent of implementation of SMPs. With these results, there is still needed to more efforts in implementation of SMPs among the O and GI.

Moreover, the average score of the dependent dimensions (EcS, EnS and SoS) ranged of 4.395, 4.399 and 4.383 respectively, at the same time, the overall mean of SP was 4.392. Such scores mean that managers in the O and GI have perceived that there is a slight extent of achievement of EcS, EnS and SoS for the past 3 years i.e. a slight level of SP. Specifically, EcS was achieved a higher extent of achievement under the prior 3 years compared with EnS and SoS.

5. CONCLUSION

The current study investigates the extent of implementation of SMPs and SP among O and GI in Iraq. Empirical evidence in the literature confirms that the implementation of SMPs by companies leads to improving and balancing the SP with its environmental, social and economic dimensions. In fact, the results of the current study reveal that the oil and gas companies in Iraq had adopted a certain level of the four SMPs (SPD, SMP, SSCM and SEoLM), but they were at weak levels. This level of implementing sustainable practices has led to a weak level of SP as well as an imbalance of the three dimensions of SP (EcS, EnS and SoS). These results demonstrate that SMPs and SP in Iraq are not yet complete. Accordingly, much effort is needed to ensure that the oil and gas companies in Iraq consider sustainable practices more seriously to ensure the achievement and balance of SP.

The current study contributes valuable information on the current status of SMPs and SP implemented by oil and gas companies in Iraq. This information will serve as a useful reference for stakeholders associated with this industry, such as policymakers, top management, and managers in making important decisions and actions that relate to enhancing the environmental and social actions in addition to economic development. Given that this study is descriptive in nature, we suggest for future works to study the relationship or impact between SMPs and the SP, whether in the O and GI or other industries in the Iraqi context or other countries.

REFERENCES

Abdul-Rashid, S.H., Sakundarini, N., Ghazilla, R.A.R., Ramayah, T. (2017a), Drivers for the adoption of sustainable manufacturing practices: A Malaysia perspective. International Journal of Precision Engineering and Manufacturing-Green Technology, 18(11), 1619-1631.

Abdul-Rashid, S.H., Sakundarini, N., Ghazilla, R.A.R., Ramayah, T. (2017b), The impact of sustainable manufacturing practices on sustainability performance: Empirical evidence from Malaysia. International Journal of Operations and Production Management, 37(2), 182-204.

Afrinaldi, F., Mat Saman, M.Z., Shaharoun, A.M. (2013), A new methodology for integration of end-of-life option determination and disassemblability analysis. In: Jawahir, I.S., Sikdar, S.K., Huang, Y., editors. Treatise on Sustainability Science and Engineering. Dordrecht: Springer Netherlands. p31-49.

Alamerew, Y.A., Brissaud, D. (2018), Modelling and Assessment of Product Recovery Strategies through Systems Dynamics. Procedia CIRP, 69, 822-826.

Al-Haleem, A.A., Awadh, S.M., Saeed, E.A.J. (2013), Environmental Impact from Drilling and Production of oil Activities: Sources and Recommended Solutions. Iraq: Paper Presented at the International Conference on Iraq Oil Studies.

Alwin, D.F., Krosnick, J.A. (1991), The reliability of survey attitude measurement: The influence of question and respondent attributes. Sociological Methods and Research, 20(1), 139-181.

Andrews, F.M. (1984), Construct validity and error components of survey measures: A structural modeling approach. The Public Opinion Quarterly, 48(2), 409-442.

Annunziata, E., Pucci, T., Frey, M., Zanni, L. (2018), The role of organizational capabilities in attaining corporate sustainability practices and economic performance: Evidence from Italian wine industry. Journal of Cleaner Production, 171, 1300-1311.

Aras, G., Crowther, D. (2009), Corporate sustainability reporting: A study in disingenuity? Journal of Business Ethics, 87(1), 279.

Ashrafi, N. (2014), A review of current trend in design for sustainable manufacturing. IOSR Journal of Mechanical and Civil Engineering, 11(4), 53-58.

Badurdeen, F., Goldsby, T.J., Iyengar, D., Jawahir, I.S. (2013), Transforming supply chains to create sustainable value for all stakeholders. In: Jawahir, I.S., Sikdar, S.K., Huang, Y., editors. Treatise on Sustainability Science and Engineering. Dordrecht: Springer Netherlands. p311-338.

Badurdeen, F., Jawahir, I.S. (2017), Strategies for Value Creation Through Sustainable Manufacturing. Stellenbosch, South Africa: Paper Presented at the Proceedings of the 14th Global Conference on Sustainable Manufacturing.

Bamgbade, J.A., Kamaruddeen, A.M., Nawi, M.N.M. (2016), Assessing the Sustainable Construction of Large Construction Companies in Malaysia. Paper Presented at the AIP Conference Proceedings.

Bansal, P. (2005), Evolving sustainably: A longitudinal study of corporate sustainable development. Strategic Management Journal, 26(3), 197-218.

Bautista, L.S. (2013), Sustainable Manufacturing: Turning Waste into Profitable Co-products. (Doctoral Dissertation). Liverpool, England: University of Liverpool.

Bentahar, O., Benzidia, S. (2018), Sustainable supply chain management: Trends and challenges. Transportation Research Part E: Logistics and Transportation Review, 119, 202-204.

Berenson, M.L., Levine, D.M., Stephan, D.F., Krehbiel, T.C. (2012), Basic Business Statistics: Concepts and Applications. 12th ed. Upper Saddle River, New Jersey: Prentice Hall PTR.

Billatos, S.B. (2001), Design methodologies for the environment. In: Hundal, M.S., editor. Mechanical Life Cycle Handbook: Good Environmental, Design and Manufacturing. New York: Marcel Dekker. p81-98.

Birkett, N.J. (1986), Selecting the Number of Response Categories for a Likert-type Scale. In: Rothwell, N., editor. Paper Presented at, Cognitive aspects of survey methodology. Proceedings from the Survey Research Methods. Alexandria, Virginia: American Statistical Association.

Bryman, A., Bell, E. (2015), Business Research Methods. 4th ed. Oxford: Oxford University Press.

Carley, S., Jasinowski, J., Glassley, G., Strahan, P., Attari, S., Shackelford, S. (2014), Success Paths to Sustainable Manufacturing. Available from: https://www.spea.indiana.edu/doc/research/sustainability-2014.pdf.

Cavagnaro, E., Curiel, G. (2012), The Three Levels of Sustainability: London: Routledge.

Chiu, M.C., Chu, C.H. (2012), Review of sustainable product design from life cycle perspectives. International Journal of Precision Engineering and Manufacturing, 13(7), 1259-1272.

Chomeya, R. (2010), Quality of psychology test between Likert scale 5 and 6 points. Journal of Social Sciences, 6(3), 399-403.

Coelho, P.S., Esteves, S.P. (2007), The choice between a fivepoint and a ten-point scale in the framework of customer satisfaction measurement. International Journal of Market Research, 49(3), 313-339.

Dao, V., Langella, I., Carbo, J. (2011), From green to sustainability: Information Technology and an integrated sustainability framework. The Journal of Strategic Information Systems, 20(1), 63-79.

de Vaus, D.A. (2002), Surveys in Social Research. 5th ed. Crows Nest, Australia: Allen & Unwin.

Dehghanian, F., Mansour, S. (2009), Designing sustainable recovery network of end-of-life products using genetic algorithm. Resources, Conservation and Recycling, 53(10), 559-570.

Despeisse, M., Mbaye, F., Ball, P.D., Levers, A. (2012), The emergence of sustainable manufacturing practices Production Planning and Control, 23(5), 354-376.

Du Pisani, J.A. (2006), Sustainable development historical roots of the concept. Environmental Sciences, 3(2), 83-96.

Duflou, J.R., Sutherland, J.W., Dornfeld, D., Herrmann, C., Jeswiet, J., Kara, S., Kellens, K. (2012), Towards energy and resource efficient manufacturing: A processes and systems approach. CIRP Annals, 61(2), 587-609.

Elhuni, R.M., Ahmad, M.M. (2017), Key performance indicators for sustainable production evaluation in oil and gas sector. Procedia Manufacturing, 11(Supplement C), 718-724.

Elkington, J. (1997), Cannibals with Forks: The Triple Bottom Line of 21st Century Business. 1st ed. Oxford: Capstone.

Elkington, J. (1999), Triple bottom-line reporting: Looking for balance. Australian CPA, 69(2), 18-21.

Elkington, J. (2004), Enter the triple bottom line. In: Henriques, A., Richardson, J., editors. The Triple Bottom Line: Does it All Add Up? 1st ed. UK and USA: Earthscan. p1-16.

EPA. (2003), Environmental Impact of the Petroleum Industry. Environmental Protection Agency. Available from: https://ww.cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.files/fileID/14522.

Fiksel, J. (2013), Meeting the challenge of sustainable supply chain management. In: Jawahir, I.S., Sikdar, S.K., Huang, Y., editors. Treatise on Sustainability Science and Engineering.). Dordrecht: Springer Netherlands. p269-289.

Miidom, F.D., Nwuche, A.C., Anyanwu, S.A.C. (2016), Operations management activities and organizational sustainability in oil and gas companies in rivers state. International Journal of Advanced Academic Research, 2(11), 34-56.

Fuller, D.A., Ottman, J.A. (2004), Moderating unintended pollution: The role of sustainable product design. Journal of Business Research, 57(11), 1231-1238.

Gimenez, C., Sierra, V., Rodon, J. (2012), Sustainable operations: Their impact on the triple bottom line. International Journal of Production

Economics, 140(1), 149-159.
Gunasekaran, A., Spalanzani, A. (2012), Sustainability of manufacturing and services: Investigations for research and applications. International Journal of Production Economics, 140(1), 35-47.
Gupta, S., Dangayach, G.S., Singh, A.K., Rao, P.N. (2015), Analytic Hierarchy Process (AHP) Model for Evaluating Sustainable Manufacturing Practices in Indian Electrical Panel Industries. Paper Presented at the Proceedings of the 18th Annual International Conference of the Society of Operations Management (SOM-14).
Haapala, K.R., Zhao, F., Camelio, J., Sutherland, J.W., Skerlos, S.J., Dornfeld, D.A., Rickli, J.L. (2013), A review of engineering research in sustainable manufacturing. Journal of Manufacturing Science and Engineering, 135(4), 041013-041016.
Hami, N. (2015), Sustainable Manufacturing Practice and Sustainability Performance Mediated by Innovation Performance. Ph.D Thesis. Malaysia: Universiti Teknikal Malaysia Melaka.
Hami, N., Ibrahim, Y.M., Yamin, F.M., Shafie, S.M., Abdulameer, S.S. (2019), The moderating role of sustainable maintenance on the relationship between sustainable manufacturing practices and social sustainability: A conceptual framework. International Journal of Engineering and Advanced Technology, 8(5C), 222-228.
Hami, N., Muhamad, M.R., Ebrahim, Z. (2016), The impact of sustainable manufacturing practices on sustainability. Jurnal Teknologi, 78(1), 139-152.
Hami, N., Yamin, F.M., Shafie, S.M., Muhamad, M.R., Ebrahim, Z. (2018), Sustainable manufacturing practices among SMEs in Malaysia. International Journal of Technology, 9(8), 1658-1667.
Hundal, M.S. (2001), Introduction to design for the environment and life cycle engineering. In: Hundal, M.S., editor. Mechanical Life Cycle Handbook: Good Environmental, Design and Manufacturing. New York: Marcel Dekker. p1-26.
Ibrahim, Y.M., Hami, N., Othman, S.N. (2019a), Assessing of imbalance among economic, environmental and social sustainability: Evidence from oil and gas industry in Iraq. Journal of Physics: Conference Series, 1294, 072006.
Ibrahim, Y.M., Hami, N., Othman, S.N. (2019b), Integrating sustainable maintenance into sustainable manufacturing practices and its relationship with sustainability performance: A conceptual framework. International Journal of Energy Economics and Policy, 9(4), 30-39.
Ilgin, M.A., Gupta, S.M. (2010), Environmentally conscious manufacturing and product recovery (ECMPRO): A review of the state of the art. Journal of Environmental Management, 91(3), 563-591.
Infante, C.E.D., Mendonça, F.M.D., Purcidonio, P.M., Valle, R. (2013), Triple bottom line analysis of oil and gas industry with multicriteria decision making. Journal of Cleaner Production, 52, 289-300.
Jawahir, I.S., Dillon, O., Rouch, K., Joshi, K.J., Venkatachalam, A., Jaafar, I.H. (2006), Total Life-cycle Considerations in Product Design for Sustainability: A Framework for Comprehensive Evaluation. Spain: Paper Presented at the Proceedings of the 10th International Research/Expert Conference Barcelona.
Jayal, A.D., Badurdeen, F., Dillon, O.W., Jawahir, I.S. (2010), Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. CIRP Journal of Manufacturing Science and Technology, 2(3), 144-152.
Khor, K.S., Udin, Z.M. (2013), Reverse logistics in Malaysia: Investigating the effect of green product design and resource commitment. Resources, Conservation and Recycling, 81, 71-80.
Kopacek, P., Kopacek, B. (2007), End of life management of automation devices. IFAC Proceedings, 40(2), 54-58.
Kopacek, P., Kopacek, B. (2014), End of life management of automation and IT devices. IFAC Proceedings, 47(3), 3503-3508.
Krajnc, D., Glavič, P. (2005), How to compare companies on relevant dimensions of sustainability. Ecological Economics, 55(4), 551-563.
Krejcie, R.V., Morgan, D.W. (1970), Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607-610.
Krosnick, J.A., Fabrigar, L.R. (1997), Designing rating scales for effective measurement in surveys. In: Survey Measurement and Process Quality. New York: John Wiley and Sons, Inc. p141-164.
Kuik, S.S., Kaihara, T., Fujii, N. (2016), Product recovery configuration decisions for achieving sustainable manufacturing. Procedia CIRP, 41, 258-263.
Kumar, R. (2014), Research Methodology: A Step-by-Step Guide for Beginners. 4th ed. Thousand Oaks, California: SAGE Publications.
Liyanage, J.P. (2007), Operations and maintenance performance in production and manufacturing assets: The sustainability perspective. Journal of Manufacturing Technology Management, 18(3), 304-314.
Lu, T., Gupta, A., Jayal, A.D., Badurdeen, F., Feng, S.C. Jr., Jawahir, I.S. (2011), A Framework of Product and Process Metrics for Sustainable Manufacturing. Berlin, Heidelberg: Conference Paper.
Martínez, L.H.C., Calvo-Amodio, J. (2017), Towards lean for sustainability: Understanding the interrelationships between lean and sustainability from a systems thinking perspective. Journal of Cleaner Production, 142(Part 4), 4384-4402.
McAloone, T.C., Pigosso, D.C.A. (2017), From ecodesign to sustainable product/service-systems: A journey through research contributions over recent decades. In: Stark R, Seliger G, Bonvoisin, J., editors. Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives. Cham: Springer International Publishing. p99-111.
Millar, H.H., Russell, S.N. (2011), The adoption of sustainable manufacturing practices in the Caribbean. Business Strategy and the Environment, 20(8), 512-526.
Morali, O., Searcy, C. (2013), A review of sustainable supply chain management practices in Canada. Journal of Business Ethics, 117(3), 635-658.
Nambiar, A.N. (2010), Challenges in Sustainable Manufacturing. Dhaka, Bangladesh: Paper Presented at the Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management, Dhaka, Bangladesh.
Nordin, N., Adebambo, H.O. (2016), Descriptive analysis of sustainable manufacturing indicators in Malaysian manufacturing firms. Journal of Mechanical Engineering and Sciences, 10(2), 2127-2134.
OPEC. (2018), Annual Statistical Bulletin. Vienna, Austria: Organization of the Petroleum Exporting Countries Available from: http://www.thegulfintelligence.com/mediafiles/downloadfile/4833753a-f159-46f2-8dc0-f2335344ebe6.pdf.
Paulraj, A. (2011), Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability. Journal of Supply Chain Management, 47(1), 19-37.
Russell, S.N., Millar, H.H. (2014), Exploring the relationships among sustainable manufacturing practices, business performance and competitive advantage: Perspectives from a developing economy. Journal of Management and Sustainability, 4(3), 37-53.
Saunders, M., Lewis, P., Thornhill, A. (2016), Research Methods for Business Students. 7th ed. Bengaluru, Karnataka: Pearson Education Limited.
Schlosser, R., Klocke, F., Lung, D. (2011), Sustainabilty in Manufacturing Energy Consumption of Cutting Processes. Conference Paper: Berlin, Heidelberg.
Schneider, J., Ghettas, S., Merdaci, N., Brown, M., Martyniuk, J., Alshehri, W., Trojan, A. (2013), Towards sustainability in the oil and gas sector: Benchmarking of environmental, health, and safety efforts. Journal of Environmental Sustainability, 3(3), 6-15.

Schneider, J., Vargo, C., Campbell, D., Hall, R. (2011), An analysis of reported sustainability-related efforts in the petroleum refining industry. The Journal of Corporate Citizenship, 44, 69-84.

Seuring, S. (2011), Supply chain management for sustainable products insights from research applying mixed methodologies. Business Strategy and the Environment, 20(7), 471-484.

Sezen, B., Çankaya, S.Y. (2013), Effects of green manufacturing and eco-innovation on sustainability performance. Procedia Social and Behavioral Sciences, 99(Supplement C), 154-163.

Shaharudin, M.R., Zailani, S., Tan, K.C. (2015), Barriers to product returns and recovery management in a developing country: Investigation using multiple methods. Journal of Cleaner Production, 96, 220-232.

Shamsuddoha, M. (2015), Integrated supply chain model for sustainable manufacturing: A system dynamics approach. In: Sustaining Competitive Advantage Via Business Intelligence, Knowledge Management, and System Dynamics. Vol. 22B. Bingley, United Kingdom: Emerald Group Publishing. p155-399.

Shojaeipour, S. (2015), Sustainable manufacturing process planning. The International Journal of Advanced Manufacturing Technology, 78(5), 1347-1360.

Si, S.X., Cullen, J.B. (1998), Response categories and potential cultural bias: Effects of an explicit middle point in cross-cultural surveys. The International Journal of Organizational Analysis, 6(3), 218-230.

Thierry, M., Salomon, M., Van Nunen, J., Van Wassenhove, L. (1995), Strategic issues in product recovery management. California Management Review, 37(2), 114-136.

Thrulogachantar, P., Zailani, S. (2011), The influence of purchasing strategies on manufacturing performance: An empirical study in Malaysia. Journal of Manufacturing Technology Management, 22(5), 641-663.

UN-ESCWA. (2018), External Trade Bulletin Of The Arab Region. Retrieved from New York: United Nations Economic And Social Commission For Western Asia. Available from: https://www.unescwa.org/recurring-publication-identifier/external-trade-bulletin-arab-region.

van Belle, G. (2008), Statistical Rules of Thumb. 2nd ed. Hoboken, New Jersey: Wiley.

WCED. (1987), Our Common Future. Portland: United Nations, The World Commission on Environment and Development. Available from: http://www.un-documents.net/our-common-future.pdf.

Worster, D. (1993), The Wealth of Nature: Environmental History and the Ecological Imagination. Oxford: Oxford University Press on Demand.

Zailani, S., Jeyaraman, K., Vengadasan, G., Premkumar, R. (2012), Sustainable supply chain management (SSCM) in Malaysia: A survey. International Journal of Production Economics, 140(1), 330-340.

Zhang, X., Liu, C., Li, W., Evans, S., Yin, Y. (2017), Effects of key enabling technologies for seru production on sustainable performance. Omega, 66(Part B), 290-307.

Zhu, Q., Sarkis, J. (2004), Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. Journal of Operations Management, 22(3), 265-289.

Appendix 1

		N	Mean	Std. Deviation
First: Sustainable Product Design Our company is practicing				
SPD.1	Eliminating the use of hazardous materials during the design of the products.	80	4.27	00.842
SPD.2	Design the products which will facilitate disassembly of retired products, separation of parts according to materials, as well as reprocessing of materials.	80	4.28	0.711
SPD.3	Design the products which will facilitate repair, rework and refurbishment.	80	4.21	0.807
SPD.4	Design the products which will reduce material use.	80	4.29	0.750
SPD.5	Design the products which will reduce energy consumption.	80	4.29	0.814
SPD.6	Use environmental-friendly materials (e.g. recyclable materials).	80	4.34	0.745
SPD.7	Design the products which support maintenance.	80	4.29	0.830
SPD.8	Design the products which will prolong its lifetime.	80	4.24	0.846
Second: Sustainable Manufacturing Process Our company is practicing				
SMP.1	Save energy during the manufacturing process.	80	4.26	0.775
SMP.2	Emissions reduction during the manufacturing process.	80	4.36	0.750
SMP.3	Improve manufacturing and machines efficiency.	80	4.36	0.783
SMP.4	Utilise lean production processes.	80	4.44	0.824
SMP.5	Commitments to sustainable programmes, standards or regulations.	80	4.37	0.891
SMP.6	Setting sustainable targets and objectives.	80	4.46	0.762
SMP.7	Measure and inspection of material flows or wastes.	80	4.43	0.839
Third: Sustainable Supply Chain Management Our company is practicing				
SSCM.1	Adopts of sustainable suppliers.	80	4.38	0.736
SSCM.2	Influence suppliers to practice sustainable initiatives.	80	4.31	0.722
SSCM.3	Sustainable collaboration with suppliers.	80	4.37	0.769
SSCM.4	Impact customers to accept sustainable practices, services or products.	80	4.36	0.750
SSCM.5	Use a less, cleaner or reusable packaging.	80	4.46	0.745
SSCM.6	Use energy-efficient transportation.	80	4.45	0.810
SSCM.7	Use energy-efficient logistics (e.g. warehouse location and routes).	80	4.42	0.759
Fourth: Sustainable End-of-Life Management Our company is practicing				
SEoLM.1	Prolong the service life of products or materials by providing support services to customers.	80	4.43	0.725
SEoLM.2	Providing hazardous waste treatment in the company for products after recovery from the market.	80	4.47	0.779
SEoLM.3	Providing and managing product warranty returns.	80	4.44	0.777
SEoLM.4	Providing and managing recalls (e.g. reconditioning, reselling).	80	4.46	0.795
SEoLM.5	Provide recycling support for materials and components used.	80	4.49	0.763
First: Economic Sustainability In the last three years, please describe your company's achievements for economic performance caused by the current practices (as you described in section one)				
EcS.1	Increased net profits.	80	4.47	0.941
EcS.2	Increased revenue.	80	4.40	0.866
EcS.3	Increased revenue through the sale of waste products.	80	4.30	0.920
EcS.4	Increased return on assets.	80	4.42	0.808
EcS.5	Increased return on investment.	80	4.48	0.968
EcS.6	Decreased costs.	80	4.34	0.810
EcS.7	Commitment to production plan as %.	80	4.37	0.933
EcS.8	Improving delivery performance.	80	4.38	0.877
Second: Environmental Sustainability In the last three years, please describe your company's achievements for environmental performance caused by the current practices (as you described in section one).				
EnS.1	Reduced emissions of greenhouse gases.	80	4.41	0.807
EnS.2	Reduced flaring gas.	80	4.34	0.841
EnS.3	Reduced solid waste.	80	4.41	0.852
EnS.4	Reduced liquid waste.	80	4.34	0.826
EnS.5	Reduced water usage.	80	4.49	0.928
EnS.6	Reduced oil spills.	80	4.38	0.891
EnS.7	Reduced energy consumption.	80	4.46	0.927
EnS.8	Reduced consumption of hazardous/harmful/toxic materials.	80	4.45	0.855
EnS.9	Reduced environmental accidents.	80	4.31	0.908
Third: Social Sustainability In the last three years, please describe your company's achievements for social performance caused by the current practices (as you described in section one).				
SoS.1	Increased local procurement and supplier development.	80	4.39	0.907
SoS.2	Increased preventing corruption.	80	4.36	0.661
SoS.3	Increased workforce diversity.	80	4.40	0.936
SoS.4	Increased workforce engagement.	80	4.41	0.837
SoS.5	Increased workforce training and development.	80	4.40	0.821
SoS.6	Decreased rates of work-related injuries frequency.	80	4.36	0.815
SoS.7	Decreased rates of work-related occupational illnesses.	80	4.36	0.903
SoS.8	Decreased rates of work-related deaths.	80	4.41	0.807
SoS.9	Participation in community affairs.	80	4.36	0.889
SoS.10	Provide societal health facilities.	80	4.42	0.839
SoS.11	Improved health and safety community.	80	4.40	0.851
SoS.12	Increased social investment.	80	4.31	0.805