Birzeit University & An-Najah National University

MSc Sustainable Engineering in Production

Development of a Sustainability Assessment Tool for Palestinian Plastic Manufacturers

تطوير أداة تقييم الاستدامة لمصنعي البلاستيك الفلسطينيين

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Dedication

To my parents who supported me in every stage of my life.

To my wife who stood by my side and provided me with continuous motivation and encouragement.

To all my friends, family and teachers that believed in me.

Acknowledgement

First of all, I thank Allah for giving me the power to believe in my passion and pursue my dreams.

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Abstract

This research aims to develop an assessment tool to assess the sustainability of Palestinian plastic manufacturers. The end result of the research was to build a computer application to simplify the assessment process for plastic manufacturers. The research was divided into three stages. The first stage, was to compile a set of indicators from the literature. The sustainability indicator repository developed by the United States National Institute for Standards and Technology, that contains 170 indicators, was selected as the source of indicators. The set was further filtered using predefined criteria and categorized under the three main aspects of sustainability, environment, social and economic. As a result 100 indicators remained. The second stage uses the set of indicators produced in stage one to conduct an expert and industry survey. The experts surveyed were from all fields related to the concepts of sustainability covering four academic, seven government and three non-government organization experts. The experts scored the indicators based on their importance in Palestine. Using the expert scores, the highest twenty indicators form each aspects of sustainability were chosen to be used in the industry survey. In the industry survey, the participants judged the indicator based on five criteria to determine their applicability in the companies. The indicators with the highest ten scores from each aspect of sustainability were chosen as the final set of indicators.

The next stage of the research aimed to develop the assessment tool. First, the analytical methods to calculate the overall sustainability score were explored.

The analytical methods include indicator normalization, weighting and calculating the sustainability score. Next, the methods that most suit the tool were chosen. Finally, a computer program was built to calculate the assessment. The application was programed using HTML, CSS, JavaScript and Electron. The application has features to allow the user to easily make sustainability assessments. Two methods of assessment were built into the application. The first method allows for comparison between factories, and the second allows comparison of the same factory over the years.

The final stage of research was to test the tool on a local manufacturer and gather comments on the tool. The annual comparison method was used to assess the sustainability of the manufacturer between 2017 and 2018. After the manufacturer completed the assessment, a questionnaire was filled to know how the tool could be improved. The assessment resulted in a score of 0.833 in year 2017 and 0.906 in year 2018, showing that the company improved its sustainability. The assessment took 60 minutes to complete, while strongly agreeing that it would take less time to complete in the next assessment.

الملخص

يهدف هذا البحث إلى تطوير أداة لتقييم استدامة مصنعي البلاستيك الفلسطينيين. النتيجة النهائية للبحث هي بناء تطبيق الكتروني لتبسيط عملية التقييم لمصنعي البلاستيك. تم تقسيم البحث إلى ثلاث مراحل. المرحلة الأولى هي تجميع مجموعة من المؤشرات من الابحاث المختلفة. تم اختيار مستودع مؤشرات الاستدامة الذي طوره معهد الولايات المتحدة الوطني للمعايير والتكنولوجيا باعتباره المصدر الرئيسي لهذه المؤشرات ، حيث انه يحتوي على 170 مؤشر. تم استخراج عدد من المؤشرات من هذه المجموعة باستخدام معايير محددة مسبقًا و تصنيفها الى مجالات الاسدامة و هي البيئية و الاجتماعية و الاقتصادية، و كنتيجة لذلك تم إبقاء 100 مؤشر. المرحلة الثانية تستخدم مجموعة المؤشرات التي تم إنتاجها في المرحلة الأولى لإجراء استبيان للخبراء والمصانع. شمل الاستبيان خبراء من جميع المجالات المتعلقة بمفاهيم الاستدامة والتي شملت 4 خبراء أكاديميين و 7 حكوميين و 3 من المنظمات غير الحكومية، وقام الخبراء بتقييم المؤشرات بناءً على أهميتها في فلسطين، و باستخدام هذه النتائج تم اختيار اعلى 20 مؤشر حصلوا على اعلى تقييم في كل مجال من مجالات الاستدامة. أما في الاستبيان الذي شمل المصانع، حكم المشاركون على المؤشرات بناءً على خمسة معايير لتحديد مدى قابليتها للتطبيق في الشركات. تم اختيار المؤشرات التي حصلت على أعلى عشر درجات للمجموعة النهائية من المؤشرات.

هدفت المرحلة التالية من البحث إلى تطوير أداة التقييم نفسها. أولاً ، تم استكشاف الطرق التحليلية لحساب درجة الاستدامة الإجمالية، والتي من بعدها تم اختيار الطريقة الأكثر ملاءمة للأداة ، تشمل الطرق تحليل تسوية المؤشرات و توزينها و حساب النتيجة النهائية للاستدامة. وبعد ذلك ، تم تصميم برنامج كمبيوتر لحساب التقييم. تمت برمجة التطبيق باستخدام HTML و CSS و JavaScript و Electron . يحتوي التطبيق على ميزات للسماح للمستخدم بإجراء تقييمات الاستدامة بسهولة. بنيت طريقتان للتقييم في

التطبيق، الأول يسمح للمقارنة بين المصانع المختلفة والثاني يسمح للمقارنة بين نفس المصنع على مر السنين.

المرحلة الأخيرة من البحث هي اختبار الأداة على مصنع محلي وجمع التعليقات على الأداة. تم استخدام طريقة المقارنة السنوية لتقييم استدامة الشركة المصنعة بين عامي 2017 و 2018. بعد الانتهاء من التقييم، تم ملء استبيان لمعرفة كيفية تحسين الأداة. نتج عن التقييم درجة 0.833 في عام 2017 و 0.906 في عام 2018، مما يدل على أن الشركة حسنت استدامتها خلال هذه السنة. استغرق التقييم 60 دقيقة لإكماله، بينما وافق المقيّم بشدة على أنه سيستغرق وقتًا أقل لإكماله في التقييم التالي.

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List of Abbreviations

AHP	Analytical Hierarchy Process
BOD	Benefit of the Doubt
CSS	Cascading Style Sheets
EQA	Environmental Quality Authority
EW	Equal Weighting
GRI	Global Reporting Initiative
GVA	Gross Value Added
HIV/AIDS	Human Immunodeficiency Virus Infection / Acquired Immune Deficiency Syndrome
HTML	Hypertext Markup Language
ISIC	International Standard Industrial Classification
JS	JavaScript
LCSP	Lowell Center for Sustainable Production
MADM	Multi-Attribute Decision Making
MDG	Millennium Development Goals
NIST	National Institute of Standards and Technology
NGO	Non-Government Organization
SDG	Sustainable Development Goals
SMEs	Small Medium Enterprises
UN	United Nations
WCED	World Commission on Environmental and Development
WEEE	Waste Electrical and Electronic Equipment

CHAPTER ONE
INTRODUCTION

1.1. Introduction

Humanity has made great leaps forward in the past years. Developing new technologies that increase production output, transportation systems to travel the globe, medical breakthrough to cure diseases and building a large energy infrastructure to catch up with the continuous development.

However, despite all these technological developments, billions are living in poverty. Wealth and power are unequally distributed. Moreover, the increase in demand on natural resources has caused depletion of these resources, in addition to environmental degradation, such as, deforestation, droughts, land degradation, freshwater scarcity and loss of biodiversity (United Nations 2015).

All these challenges that the world faces, including Palestine, are hindering the ability to continue the path of development. For this reason, the concept of sustainable development has emerged as a goal for all societies to strive for. The challenges have been formally addressed in recent years with efforts such as, The Millennium Development Goals (MDG) and the Sustainable Development Goals (SDG) (United Nations 2015) (UN General Assembly 2000).

In recent years, a new field of research has emerged dedicated to developing methods to assess the progress towards sustainable development, in order to guide the efforts. The assessment methods developed have aimed at multiple

levels, from global assessment to corporate assessment (Ness, et al. 2007). The specific field of corporate sustainability assessment and in particularly manufacturing enterprises is a new filed that has produced a lot of published papers in the past years (Chen, et al. 2014) (Singh, et al. 2007) (Madanchi, et al. 2019) (Tan, et al. 2015) (Sparks 2014). Yet the field is in need of further research, in order to develop tools that properly address the sustainability issues and could be used internally by the companies to improve their sustainability.

1.2. Problem Statement

There is an absence of a suitable sustainability assessment tool for Palestinian manufacturers, and in particular plastic manufacturers. This limits the manufacturer's ability to make decisions for improving their sustainability. Such improvement is necessary for the development of a sustainable Palestinian economy.

1.3. Research Significance

The latest tools developed for assessing the sustainability of manufacturers do not systematically identify the proper indicators to measure sustainability. From the literature review, it has been found that the tool's developers choose the indicators from already existing tools that are used for different purposes. The selection of these indicators are commonly done by the judgment of the researcher. This leads to bias in the selection and cannot credibly consider the social, economic, environmental, political, cultural and technological context that the assessment is targeting (Østdal 2014). This causes the tools to be ill-suited

for smaller-medium manufacturers, which are the most common size of manufacturers in Palestine, and not take into consideration the priorities of the nation that they are used in. For example, developing countries have different priorities than developed countries. As an alternative, this study aims to develop the indicators based on the issues that are most important in Palestine and are suitable for Palestinian companies by taking into consideration expert opinion about the sustainability priorities in Palestine and the opinion of the decision makers in the companies about the applicability of the indicators in their companies. Moreover, most of the researchers do not develop tools that can be easily used by the companies. For this reason, this research will develop a computer software for the companies to self-assess their progress towards sustainability.

1.4. Research Purpose and Objectives

General objective:

To systematically develop a sustainability assessment tool that takes into consideration the unique conditions in Palestine and also fits the needs and capabilities of Palestinian plastic manufacturers.

Specific objectives:

The following is a list of the specific objectives of this research:

1. Compile a list of all indicators used in the literature to assess manufacturing sustainability.

2. Determine the most significant sustainability assessment indicators for Palestine according to expert judgment.
3. Determine the sustainability assessment indicators that are most applicable to Palestinian plastic manufacturers.
4. Derive the analytical methods necessary to compute the weights, normalization factor of the indicators and overall sustainability composite score.
5. Develop a software to be used by manufacturers to assess their sustainability.
6. Test the developed software using local plastic manufacturers.

1.5 Research Questions

The following is a list of questions that the research aims to answer:

1. What are the main sustainability indicators that local concerned experts consider most important for Palestine?
2. What are the main sustainability indicators which are applicable in sustainability assessment tool for local plastic manufacturing companies?
3. What are the analytical methods that most fit the requirements of sustainability assessment tool?
4. What is the appropriate assessment tool to be used by the companies?

1.6 Thesis Structure

The remainder of this thesis is structured as follows: Chapter 2 presents a background and review of the most recent literature related to the thesis topic;

Chapter 3 explains the methodology followed in the thesis; Chapter 4 presents the results and discussion and Chapter 5 concludes the thesis along with recommendations for further research.

CHAPTER TWO
BACKGROUND AND LITERATURE REVIEW

2.1. Chapter Overview

This chapter will first introduce the main concepts that the theses topic is related to, such as, manufacturing, sustainability and their relevance in the Palestinian context. Next, a literature review of sustainability assessment tools will be done with an emphasis on sustainability assessment tools directed to manufacturing companies.

2.2. Background

2.2.1 Overview of manufacturing

Manufacturing is defined as "The transformation of materials into items of greater value by means of one or more processing and/or assembly operations" (M. Groover 2014). During the 18th century, Britain and then the rest of Europe witnessed a change from an agrarian and handicraft economy to an economy dependent on industry and machine manufacturing (Vries 1994). This process of change has been defined as the industrial revolution. Since the start of the industrial revolution, industrial activities has been a driving force for economic development (Crafts and O'Rourke 2013). During the past century, more and more countries have moved in the direction of industrialization. However, modern research has shown that the traditional path to industrialization that countries took in the past has not benefited the developing countries that are now

industrializing to the same extent that industrialization has benefited countries in the past and has proven to not be sustainable (Sampath 2016).

2.2.2 Plastic Industry

Plastics are materials categorized under polymer materials, along with rubbers. Polymers are organic materials consisting of long chain molecules based on carbon (M. P. Groover 2007). Plastics are used for many applications including but not limited to clothing, packaging building materials consumer electronics and automobiles (Andrady and Neal 2009). The use of plastic in the previously mentioned applications is due to characteristics of plastics such as, high strength or modulus to weight ratios, toughness, resilience, resistance to corrosion, lack of heat and electric conductivity, color, transparency, processing, and low cost (Brinson and Brinson 2008).

2.2.3 Palestine Industry and the Plastic Industry in Palestine

The manufacturing industry in Palestine added 1,013 million US Dollars to the economy in 2014 (PCBS, Palestinian Central Bureau of Statistics 2014). Which equals 13.5% value added of Gross Value Added (GVA) in 2014 (PCBS, Palestinian Central Bureau of Statistics 2014). Manufacturing also employed 13.4% of the Palestinian workforce as of the year 2015 (PCBS, Palestinian Central Bureau of Statistics 2019). These statistics show the importance of this sector in the economy. There are 18056 industrial establishments in Palestine as of 2015 (PCBS 2015). According to the International Standard Industrial

Classification (ISIC) of All Economic Activities (UN 2008), manufacturing is classified into 21 divisions.

The plastic industry consists of 240 establishments, employing 2952 employees as of 2017 (PCBS, Palestinian Central Bureau of Statistics 2017). The plastic manufacturing companies are located in all parts of Palestine with a concentration in the cities of Hebron and Ramallah. The plastic manufacturing companies manufacture many different types of products including plastic pipes and fittings, sanitation fittings, plastic bags and sacks, different size and multipurpose plastic (Palestinian Federation of Industries 2009).

2.2.4 Overview of Sustainability

Humanity has continuously faced issues related to sustainability. The ancient Egyptian, Mesopotamian, Greek and Roman civilizations all faced environmental problems such as deforestation and reduced fertility of soil (van Zon 2002). However, the term “Nachhaltigkeit”, the German word for sustainability, was coined in 1713 by Hans Carl Von Carlowitz, the head of the Saxon mining administration. Carlowits suggested balancing the cutting down of trees with ensuring the presence of enough young trees to replace them (Jalkanen and Pekka 2005).

In the late 20th century the interest in sustainability and Sustainable Development as a global issue became more prominent. As a result the world conservation strategy was published by the International Union for Conservation of Nature in 1980, which contained one of the earliest references to Sustainable Development

(IUCN, UNEP and WWF 1980). Next, in 1982 the United Nations adopted the World Charter for Nature that set five principles to guide and judge all human activities affecting nature (UN General Assembly 1982). In 1987, the Bruntland report for The World Commission on Environment and Development (WCED 1987) defined sustainable development as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

In 2000, all 191 UN member states signed a declaration to commit to the Millennium Development Goals and achieving the goals by 2015. The goals were to eradicate extreme poverty and hunger, to achieve universal primary education, to promote gender equality and empower women, to reduce child mortality, to improve maternal health, to combat HIV/AIDS, malaria, and other diseases, to ensure environmental sustainability and to develop a global partnership for development (UN General Assembly 2000).

After the period given to achieve the Millennium Development Goals ended in 2015, countries adopted The 2030 Agenda for Sustainable Development. This new agenda consisted of 17 Sustainable Development goals covering areas considered to be of critical importance for humanity and the planet (United Nations 2015). These goals will guide the next decade's trends in sustainable development.

2.3 Literature Review

2.3.1 Introduction

In this section an extensive review will be presented, covering the main topics that this thesis covers. The research areas that were reviewed are the characteristics of sustainability assessment tools, the methods used to select indicators for sustainability assessment tools, and the analytical methods used to calculate composite score or any other quantifiable values that the tool calculates.

2.3.2 Indicator selection methodology

This section reviews the selection methods used to select indicators for sustainability assessment tools. The tools reviewed are aimed to assess sustainability on the corporate level with an emphasis on manufacturing companies. It was found that the tools vary in the selection method. Some researchers do not present any justification on how the indicators were selected. Other researchers select the indicators from the literature but do not give justification for the selection, while others gave justification for the selection form the literature. Adding to the complexity of the methodology, researchers used input from surveys directed to industry and academia to justify the selection of the indicators. In these methods the initial set of indicators were first derived from a known set of indicators. In other cases, the researchers based their selection on sources other than known sets of indicators.

The methods will be now presented in order from the least to the most sophisticated methods. First, Garbie (2014) uses a set of indicators without presenting the source or justification for the set. However, this could be because the main purpose of the paper was to present analytical methods for assessment. Harik (2015) conducted an extensive literature review. A list of indicators was developed that contain quantitative and qualitative indicators. The list was divided into four domains: social, economic, environmental and manufacturing.

Many tools derive their indicators from literature reviews using criteria to guide the selection. Singh, Olugu and Fallahpour (2013) selected a list of 22 indicators from literature based on the characteristics of Small Medium Enterprises (SMEs). However, the criteria is not further discussed and the indicators are not evenly distributed over the three aspects of sustainability. Chen (2014) reviewed 100 papers and indicator based tools to develop a set of 133 indicators. The criteria used to help select the indicators from the review are as follows: suitability for rapid assessment, easily understandable to non-experts, the necessary data needs to be easily accessible. Sparks (2014) selected indicators from The National Institute of Standards and Technology (NIST) (2010), Global Reporting Initiative (GRI) (2011), ProdSI (Shuaib et al., 2014), Sus-VSM (Faulkner et al., 2012), and Chen and Johnson (2011). The selection was justified by how relevant the indicators are in the contexts of the sustainable value stream management. However, this approach to indicator selection does not provide a holistic set of indicators. Ocampo (2015) uses a set of indicators maintained by the United States National Institute for Standards and Technology. The researcher provides

justification for using this set of indicators: (1) this set is based on 11 indicator sets published by recognized international bodies, manufacturing leaders, research and private institutions, (2) within the process of selection, a systematic and rigid process was used, (3) the framework developed is a hierarchy that puts the indicators into groupings, subgrouping, categories and then into sustainable manufacturing dimensions, (4) it is currently the most comprehensive indicator set developed. Madanchi (2019) selected indicators for this tool by comparing other assessment tools and then identifying the most common indicators. Sustainability reports and publication are then used to gather the data needed for the indicators. Only quantitative indicators were selected because they are more objective and less biased than qualitative indicators.

To add justification to the selection process, researchers have depended partly on input from other sources such as industry and academia. The following text reviews a few tools that used this methodology. Paju (2010) gives the complete decision of indicator selection to the manufacturer according to the company's goals. Fan, Carrell and Zhang (2010) used GRI indicators as a base. A survey was used to collect information and opinions from industry and academia. However, the survey was not used to select the indicators. The industry survey aimed to collect information about the indicators already used in the companies and the management opinion about the indicators. The academia survey focused on selecting indicators such relevance, analytical soundness and measurability of the indicators. Amrina and Yusof (2013) developed a set of initial indicators by integrating manufacturing performance measures and sustainable manufacturing

measures. Next, the adaptability of the selected indicators with industry practices was confirmed using a survey in the selected local manufacturing sector. The survey consisted of a questionnaire asking the manufacturers to rate the indicators from 1 (not important at all) to 5 (very important). Ziout (2013) selected indicators by a survey distributed to industry and an analysis of national laws and regulations. The participants of the survey were asked to rate the indicators on a scale 1 to 4. However, the researcher does not explain where the initial set of indicators are selected from. Tan, et al. (2015) developed a procedure for systematic identification and selection. The list of indicators was used for an assessment tool aimed at assessing the sustainability of SME manufacturers in Singapore. The first step is the elimination of indicators based on the following criteria: indicators should be simple to understand and be able to be used by non-experts, they should be applicable to local Singapore SMEs and relevant to sustainability improvement. The indicator elimination is based on opinions of experts from industry and academia. This is in order to reduce uncertainties. The next step is to combine and categorize the indicators into dimensions and sub-categories. This is suggested to be done through brain storming. After that, using input from industry through interviews and discussions, the definitions of the indicators are improved and the applicability of the indicators are also improved until a final set of indicators is developed. Moldavska and Welo (2019) developed a tool used for corporate sustainability assessment. In order to select indicators to be used in the tool, first, a list of criteria for sustainability was proposed and the indicators should be based on these criteria. The researcher

suggested that the indicator selection should be conducted by specialists in sustainability. Moreover, it was emphasized that the indicators development be driven by the criteria and not by the availability of the data. The researcher also added that the companies should not influence the selection. This was justified by the importance that the indicator be relevant to sustainable development and not what is desirable or comfortable for the company.

It is notable that in earlier research, in contrast with more recent research, the indicators were not derived from already existing sets because there was a lack of well-established sets of indicators. Veleva and Ellenbecker (2001) is one of the first publication that address the selection of indicators to assess the sustainability of manufacturing. The indicators were derived from the Lowell Center for Sustainable Production (LCSP) definition of sustainable production which defines sustainable production as "The creation of goods and services using processes and systems that are non-polluting; conserving of energy and natural resources; economically viable; safe and healthful for employees, communities and consumers; and socially and creatively rewarding for all working people". Gerbens-Leenes, Moll and Schoot Uiterkamp (2003) took a different approach to indicator selection by first identifying the main environmental issues on a global level and then based on the global issues a set of indicators were proposed to measure the issues. Four constraints were identified to select indicators: relevance of the information provided by the indicator about the sustainability of the system, possibility of reliable and accurate measurement, availability of data and provided information could be used for decision making.

It could be concluded that there is a trend in recent research to involve stakeholders, sustainability experts from academia and the companies that the tools will assess, in the selection process of indicators to better justify the selection. It is also apparent that NIST and GRI sets of indicators are frequently used as an initial list or source of indicators.

Table 2.1 summarizes the literature review by classifying the methods used to select the indicators for sustainability assessment tool directed to manufacturing.

Table 2.1: Classification of tools based on selection method of indicators.

Indicator selection method	Tools
No justification regarding the selection	Garbie 2014
Indicators from literature without justification	Harik 2015
Indicators from literature with justification	Singh, Olugu and Fallahpour 2013 Chen 2014 Spark 2014 Ocamp 2015 Madachi 2019
Using surveys directed to industry and academia	Paju 2010 Fan, Garrell and Zhong 2010 Amrina and Yusof 2013 Ziout 2013 Tan 2015 Moldavska and Welo 2019

2.3.3 Analytical methods

There are different methods to assess sustainability. These methods include indicators, product-based assessment, and integrated assessment (Ness, et al. 2007). The indicator assessment is the most popular method because of its simplicity, being quantifiable and its timely identification (Díaz-Balteiro and Romero 2007). At the end of the last century there was an increase of literature dedicated to developing these methods. It was suggested by the United Nations to develop indicators for sustainable development in order to provide an analytical foundation for policy analysis and decision making at different levels (UNCED 1992).

In this section, the analytical methods used to calculate the composite score of sustainability assessment will be reviewed. First the theoretical background of each method is presented and after that a review of the methods used for sustainability assessment tools is done. The assessment process uses three main steps in its calculations. The steps are in order of implementation: normalization, weighting, and composite calculations.

2.3.3.1 Normalization methods:

The different indicators used in the assessment are measured with different units. Because of this, it is not possible to add their values together in their original form. In order to add them together, normalization is done. Normalization transforms the indicator values into a form that makes it possible to conduct calculations on all indicators regardless of their units (Pollesch and Dale 2016).

There are three methods used for normalization (Pollesch and Dale 2016), (Madanchi, et al. 2019). These methods are summarized below:

a. Minimum- Maximum

The normalized values of the indicators with positive and negative impact on sustainable development are calculated by equations 2.1 and 2.2, respectively.

$$I^{+}_{N_{i,j,t}} = \frac{I^{+}_{i,j,t} - I^{+,MIN}_{i,t}}{I^{+,MAX}_{i,j} - I^{+,MIN}_{i,j}} \quad \forall i \in I^{+,MAX}_{i,j} = \max_{t\epsilon T} I^{+}_{i,j,t} \ \wedge I^{+,MIN}_{i,j} = \min_{t\epsilon T} I^{+}_{i,j,t} \tag{2.1}$$

$$I^{-}_{N_{i,j,t}} = \frac{I^{-}_{i,j,t} - I^{-,MIN}_{i,t}}{I^{-,MAX}_{i,j} - I^{-,MIN}_{i,j}} \quad \forall i \in I^{-,MAX}_{i,j} = \max_{t\epsilon T} I^{-}_{i,j,t} \ \wedge I^{-,MIN}_{i,j} = \min_{t\epsilon T} I^{-}_{i,j,t} \tag{2.2}$$

In this method $I^{+}_{i,j,t}$ and $I^{-}_{i,j,t}$ are the values of the indicator i from the group of indicators j in year t. Where, $I^{+}_{i,j,t}$ and $I^{-}_{i,j,t}$ are the positive and negative impact indicators, respectively. Moreover, $I^{+}_{N_{i,j,t}}$ and $I^{-}_{N_{i,j,t}}$ are the normalized values of the indicators. The highest and lowest value for indicator i with positive impact are $I^{+,MAX}_{i,j}$ and $I^{+,MIN}_{i,j}$, respectively. The highest and lowest value for indicator i with negative impact are $I^{-,MAX}_{i,j}$ and $I^{-,MIN}_{i,j}$, respectively.

Using this method normalized indicators will have values from 0 to 1. However, if $I^{+}_{i,j,t} = I^{+,MIN}_{i,j}$, then the normalized value will equal 0. In the case where $I^{+}_{i,j,t} = I^{+,MAX}_{i,j}$, then the normalized value will equal 1. For negative impact indicators, a normalized value of 1 will be achieved when $I^{-}_{i,j,t} = I^{-,MIN}_{i,j}$.

The values of $I^{+,MAX}_{i,j}, I^{+,MIN}_{i,j}, I^{-,MAX}_{i,j}$ and $I^{-,MIN}_{i,j}$ are taken from a database of values of indicators. In the case where new values are added to the data base that

change the minimum and maximum values, the normalized values will be changed and the composite score will need to be recalculated.

b. Distance to reference

This method is used to calculate the normalized value by calculating the ratio between the indicator value and external benchmark value. The normalized indicators for this method are calculated by the following equations 2.3 and 2.4:

$$I^{+}_{N_{i,j,t}} = \frac{I^{+}_{i,j,t}}{I^{Benchmark}_{i,j}} \tag{2.3}$$

$$I^{-}_{N_{i,j,t}} = \frac{I^{Benchmark}_{i,j}}{I^{-}_{i,j,t}} \tag{2.4}$$

Where, $I^{Benchmark}_{i,j}$ is the benchmark for indicator i from group j. The normalized value could have a value higher than 1 in the case where the indicator value is higher than the benchmark.

c. Percentage of annual differences over consecutive years

Normalization by this method is done by equations 2.5 and 2.6:

$$I^{+}_{N_{i,j,t}} = \frac{I^{+}_{i,j,t} - I^{+}_{i,j,t-1}}{I^{+}_{i,j,t-1}} \tag{2.5}$$

$$I^{-}_{N_{i,j,t}} = \frac{I^{-}_{i,j,t} - I^{-}_{i,j,t-1}}{I^{-}_{i,j,t-1}} \tag{2.6}$$

2.3.3.2 Weighting methods:

Weights are used to determine the importance of the indicators and its contribution to the composite score. There are many methods to determine the weights. The methods that will be included in this review are Equal Weightings

(EWs), Benefit Of the Doubt approach (BOD) and Analytic Hierarchy Process (AHP) (Zhou, et al. 2012), (Madanchi, et al. 2019), (Krajnc and Glavic 2005), (Singh, et al. 2007). The weighting methods are:

a. Equal weightings (EWs)

In this method equal weight are given to each indicator. Therefore, the relative importance of each indicator is not reflected in the composite score, leading to unrealistic results.

b. Budget allocation process (BAP)

This methods depends on expert opinion of the importance of the indicators. To implement this method, first, a list of expert are determined. Next the expert are asked to allocate one hundred points to the list of indicators, according to the importance. After that, the average allocated to each indicator is calculated to determine the budget.

c. Analytic Hierarchy Process (AHP)

As in the BAP method, AHP depends on expert opinion. This method transforms complex problems into a hierarchy. This hierarchy consists of the overall goal at the top, with the criteria and indicators at lower levels. After constructing the hierarchy, a pair-wise comparison between each pair of indicators is done by the experts. The results are then arranges into a matrix. Finally, the eigenvector with the largest eigenvalue is found. The eigenvector presents the weights and the eigenvalue measures the consistency of each judgment. (Saaty 1980)

2.3.3.3 Aggregation methods:

Aggregation methods are used to combine a set of indicators into one composite indicator (Krajnc and Glavic 2004). The simple additive weighting is the most commonly used aggregation function. However, other methods are also used such as, weighting product, weighting displaced ideal, social multi-criterion evaluation method (Zhou and Zhang 2018).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Chapter Overview

This chapter will explain the methodology used in the research. Section 3.2 will present the general methodology used. Sections 3.3 - 3.6 will explain the detailed methodology of each stage of the research.

3.2. General Methodology and Research Stages

The sustainability assessment tool for Palestinian plastic manufacturers was developed by implementing three consecutive stages. The first stage was a literature review of sets of sustainability indicators and assessment tools to come up with a preliminary list of indicators. The second stage developed the final list of indicators used for the tool. The last stage was the development of the tool itself. This was done by choosing the analytical methods that will be used to calculate the compost score and building the software program for the users. The general methodology of the research is illustrated in Figure 3.1.

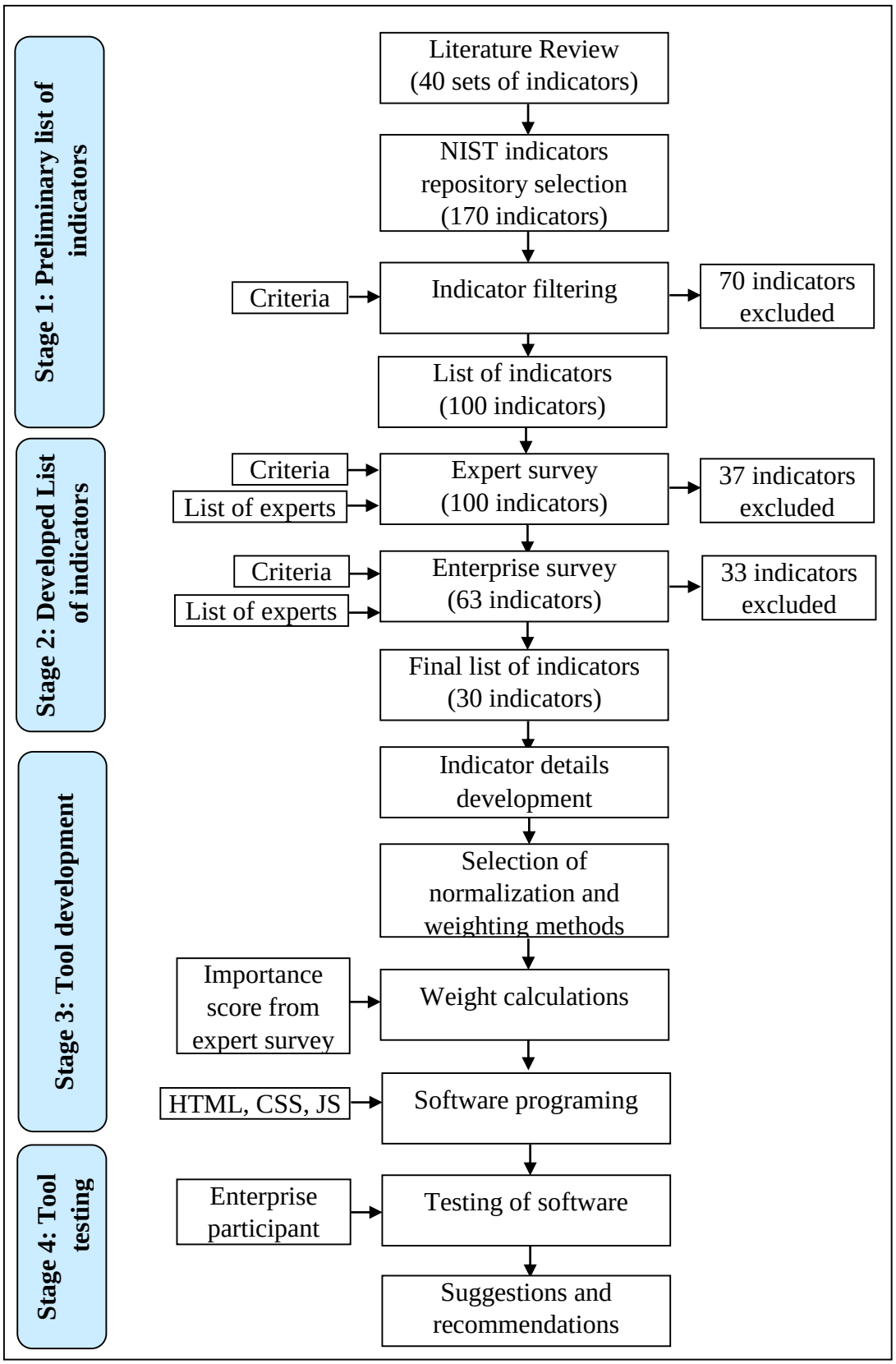

Figure 3.1: General methodology of research.

3.3. Stage 1: Preliminary List of Indicators

The list of indicators was compiled from other tools that assess the sustainability of manufacturing by using internet searches in the relevant databases. The list was comprised of three categories based on the sustainability aspects, environment, economy and social.

The search strategy that was used is as follows. A list of keywords were identified that are related to the topic of study. These keywords were used in combination with each other using Boolean operators. The search term used is as follows: Sustainability AND (indicators OR assessment) AND (manufacturing OR factory OR production OR company). Regarding the language, only English results were considered. Finally, only results published after 1/1/2010 were considered.

Next, the search results were filtered by removing indicators that are not categorized under the three main pillars of sustainability, indicators that are not quantifiable and indicators that are repeated or directly linked.

3.4. Stage 2: Developed List of Indicators

Selecting the proper indicators for the tool requires significant knowledge of the most relevant aspects of sustainability in Palestine. As stated in the introduction, Palestine is unique with regards to its environment, economic situation and social characteristics. Moreover, for the sustainability assessment tool to be applicable in the broad range of manufacturing and corporate sophistication present in

Palestine, the indicators must poses certain characteristics that are fit for Palestinian manufacturers. Based on the two previous points, the method for selecting the final indicators was divided into two stages conducted in sequence. In the first part, experts evaluated the significant of the indicators in Palestine. Then, enterprises evaluated the indicators based on multiple criteria.

3.4.1. Expert survey

For the first part of indicator selection, which was done by the experts, a list of experts evaluated the significance of the indicators in Palestine. The list of experts was selected by using the expert sampling method. Expert sampling is a sampling method classified under purposive sampling, which is a type of nonprobability sampling. Purposive sampling, also known as judgment sampling, is used when participants with specific attributes are needed. Expert sampling is the case when the selected participants are experts in a particular field (Etikan, Musa and Alkassim 2015). For this research, three categories of experts were defined. First category, an academic expert, a person that works as a lecturer or researcher in a field related to one of the sustainability aspects in an academic institution of higher education in Palestine. Second is a government expert, holding a high position in a government institution related to one of the sustainability aspects. The third category is a Non-Government Organization (NGO) expert, who is an individual that has high position in a Non-Government Organization (NGO) related to one of the sustainability aspects. To produce a comprehensive result at least one expert from each category and aspect of sustainability must be selected.

The academic experts were selected by searching for academic programs in Palestine related to the sustainability aspects and selecting lecturers and researchers from the programs. For the government experts, the government institutions related to the aspects of sustainability were chosen and then individuals with position related to policy making were selected. For the NGO experts, an internet search was done to find NGOs that work in the fields of sustainability aspects. Then, the individuals with decision making roles in the NGOs were selected. After selecting the experts, they were contacted by telephone, email and personal visits to request from them to participate in the survey.

Survey structure:

Three different surveys were made, each for a different aspect of sustainability. The survey contained two parts. The first, intended to document general information about the expert. The second part was for assessing the indicators. In this part, the indicators were listed in a table with the indicator's definition and a box for the expert to assess the indicators on a scale from 1 to 5. The English and Arabic expert surveys are shown in appendix A.

Data analysis:

The score for each indicator in this part is calculated by averaging the score given to the indicator by each expert.

3.4.2. Enterprise survey:

Indicator assessment criteria:

In second part of indicator selection, the applicability of the indicators in Palestinian plastic manufacturing companies was measured. The criteria to measure the applicability of the indicators was set based on a literature review. Rosen and Kishawy (2012) described four characteristics of effective indicators for sustainability. These characteristics are relevance, understandability, reliability and assessable. In a similar manner, Joung, et al. (2012) also described the qualities of applicable indicators. The qualities are described as, measurable, understandable, data accessible, and timely manner. Therefore, the applicability of the sustainability indicators was judged according to these five criteria:

1. Expected time taken to measure.
2. Amount of resources needed to measure.
3. Availability of data.
4. Understandability to non-experts.
5. Relevance to the enterprise production.

Survey structure:

An English and Arabic survey forms were made. The survey comprised of three parts. The first part was intended to document general information about the enterprise. The second part was general information about the participant filling the survey. The third part was for the indicator assessment. The indicator

assessment was split into three section corresponding to the three aspect of sustainability, where each section contained the indicators related to each aspect. The participants were asked in the third part to score the indicators on a scale from 1 to 5 based on the applicability criteria listed above. A supplementary table explaining the indicators was given to the participants to help understand and assess the indicators. The survey used is shown in appendix B.

Data analysis method:

Each indicator assessment criterion was given a weight. The weights of the criteria is shown in Table 3.1. The relevance to the enterprise production was given the highest weight because of the indicator is not relevant to the production, then there is no need to measure it. The score of each individual indicator for each survey was calculated by calculating the weighted average.

Table 3.1: Indicator assessment criterion and weight.

Criteria	Weight
Relevance to the enterprise production	4
Expected time taken to measure	1
Amount of resources needed to measure	1
Availability of data	1
Understandability to non-experts	1

Enterprise sampling method:

The population which is considered for this research is all plastic manufacturers in Palestine. According to the Palestinian Central Bureau of Statistics, the number

of plastic and rubber manufacturers as of 2017 were 240 (PCBS, Palestinian Central Bureau of Statistics 2018).

Due to the difficulties of travel between the different parts of Palestine to reach the entire randomized sample, a sampling method based on random sampling was hard to achieve. As a result convenience sampling was used. Convenience sampling is a nonprobability sampling method. In Convenience sampling the participants are chosen based on availability or who volunteer to participate (Etikan, Musa and Alkassim 2015).

3.5. Stage 3: Tool Development

To develop the assessment tool, multiple tasks were done. First, the analytical method that would be used to calculate the sustainability composite score were assessed and selected. Next, a software program was built for users to easily make assessment of their enterprises.

3.5.1. Analytical method

Normalization methods:

The distance to reference method was used to normalize the data. In this method, the indicator value for one year or one company is divided by the value of the same indicator for a different year or company. The normalized value is calculated using Equation 3.1.

$$N = \begin{cases} 1 & if \quad i_2 = 0 \; or \; i_1 > i_2 \\ \frac{i_1}{i_2} & if \quad i_2 > i_1 \end{cases} \tag{3.1}$$

Where, N is the normalized indicator value, i_1 is the value of the indicator in year 1 or company 1 and i_2 is the value of the indicator in year 2 or company 2.

Weighting methods:

Determining weights using methods such as AHP and BAP are time demanding for the number of indicators used in this tool. They could be used by just a few experts' opinions, however, this will sacrifice the validity of the results. For this reason, the experts opinions score from the expert survey in stage 2 in addition to the relevance criteria score given to the indicators by the industry in the industry survey were combined to determine the weights. The expert and industry scores were added together. Next, the sum of all the scores for the indicators were calculates. Finally, the indicator score was divided by the sum of all the indicator scores, using Equation 3.2. This produced the weights for the indicators.

$$w_i = \frac{s_i}{\sum_1^n s_i} \tag{3.2}$$

Where,

w_i: The weight of the indicator i.

s_i= Expert importance score + industry relevance score.

Composite score calculations:

The simple additive weighting method was used to calculate the overall sustainability score. Figure 3.2 summarizes the steps to calculate the score.

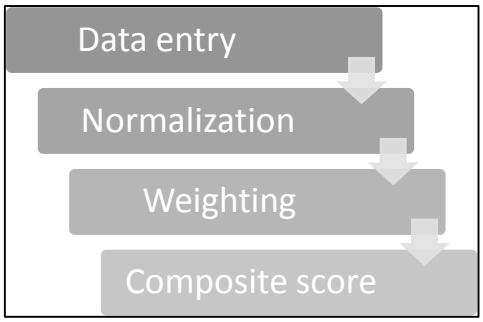

Figure 1.2: Calculations steps for the composite score

3.5.2 Software development

Application requirements:

The intended characteristics of the computer application is as follows:

1. Input the indicator values by the user.
2. Calculate the composite score using the analytical methods described in the previous section.
3. Display the results in tables and graphs.
4. Easy to use by non-experts.
5. Ability to be transferred onto multiple computers.

Programing language and tools:

The following languages and tools were used to develop the software:

Hypertext Markup Language (HTML): HTML is the standard markup language for creating web pages and web applications. HTML provides a means

to create structured documents by denoting structural semantics for text such as headings, paragraphs, lists, links, quotes and other items (Faulkner, et al. 2017).

Cascading Style Sheets (CSS): CSS is used to add styling to such as fonts and colors to web documents. CSS is used alongside mark-up language such as HTML to provide presentation (Atkins Jr., Etemad and Rivoal 2019).

JavaScript (JS): JS is a high-level programing language. With HTML and CSS, JavaScript is one of the three core technologies of the World Wide Web. (Pluralsight 2019) Using a frame work such as Electron it is possible to develop desktop applications using JS, which was originally developed for web applications (electronjs 2019).

3.6 Stage 3: Tool testing

The final software application was tested to verify the usability of the tool and obtain recommendations for future improvements. One factory was selected to test the tool. The factory was contacted to get its approval to participate in the testing. After the factory completed the assessment using the software, a questionnaire was used to document the general opinion of the participants regarding the tool and the usability of the software. Also, any further questions or comments directed to the researcher by the participants were recorded.

The questionnaire was built using a mix of different types of questions. The types of questions include, agreement scale and comprehensive questions. The questions regarding the usability of the software were based on two questionnaires used for software testing (Lewis 2018).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Chapter Overview

This chapter presents the results of the five stages in the research with a discussion of the results. In section 4.2, the results and discussion of stage 1 includes the list of selected indicators with justification of the selection. In section 4.3, the data collected in the expert and enterprise surveys is summarized. The discussion part of this section highlights the most significant results. Section 4.4 presents and discusses results of the third stage of the research (Tool development). This includes indicator details, weight calculations and the software development. Section 4.5 presents the results of the tool test and discusses the results.

4.2. Stage 1: Preliminary List of Indicators

4.2.1 Results:

After conducting the internet search, 40 international indicator sets, tools and papers were reviewed. However, an indicator repository made by the US National Institute of Standards and Technology (NIST 2011) was chosen as the base set of indicators of this thesis.

This repository of indicators was chosen because the methodology used to select the indicators is similar to the methodology set for this stage. Also, the steps of the methodology were clearly presented with results in their publications (Joung,

et al. 2012). The steps taken to come up with the indicators are as follows, first, a review of 11 well established sets of indicators was conducted. The sets of indicators include, Global Report Initiative (GRI), Dow Jones Sustainability Indexes (DJSI) and the United Nations Indicators of Sustainable Development. Next, the relative meaning of the indicators for a manufacturing enterprise was determined following a precise criteria. Finally, the indicators were categorized into five dimensions (environmental stewardship, economic growth, social well-being, technological advancement and performance management). The indicators selected for the repository have the following characteristics: Measurable, relevant, understandable, reliable/usable, taken in a timely manner and long term-oriented (Feng and Joung 2011). Moreover, each indicator in the repository was give the following attributes: indicator name, identification (ID), measurement type (quantitative/qualitative), unit of measurement, references and application level (Chen, et al. 2014).

The indicators that were not categorized under the main three pillars of sustainability (environmental, economic and social) were removed. Also, the results were then filtered by removing non quantifiable indicators and combining similar indicators to reduce the number. This resulted in reducing the original number of indicators from 170 indicators under the three main aspects to 100 indicators. The final set of indicators that will be used in the next stage of the research is shown in table 4.1, with the description of the indicators included in Appendix C.

Table 4.1: Preliminary List of Indicators.

Aspect	Name of indicator
Environment	Waste water amount
	Treated/non-treated waste water
	Total generated waste
	Reusable, Recyclable and Remanufacturable waste produced
	Hazardous materials used
	Eco-toxic substance effluent
	Chemical Spills
	Eco-toxic substances emission
	Green House Gases emissions
	Noise emission
	Acidification substances
	Air quality
	Particulate emission
	Specific material used
	Material intensity
	Specific recycled, reused, repurposed or remanufactured material
	Fluid consumption
	Recyclable and reusable materials used by contracted service providers
	Reclaimed packaging
	After-sales servicing materials
	Energy consumption
	Energy intensity
	Renewable energy consumption
	Renewable energy generated
	Energy efficiency
	Water used by source
	Recycled water used
	Intake water quality
	Land used
	Land quality
	Surrounding protected lands
Economic	Revenue
	Profits generated
	Material acquisition costs
	Energy costs
	Tooling costs
	Labor costs
	Waste treatment costs
	Packaging costs
	Delivery costs
	Storage costs
	Brand management costs
	Responsibility, risk & crisis management
	Employment costs and employee benefits
	Environmental protection expenditures
	Use energy costs

	User taxation
	Recycling costs for WEEE
	(Labor) Productivity
	Innovation & R/D investments
	Charitable investments and community development
	Renewable energies and energy efficiency investments
Social	Injury rate
	Lost workdays
	Health education and wellness programs
	Sick days
	Health index of on-site food (cafeteria)
	Paid days off
	Employee toxin exposure
	Safety measures adopted
	Injury rate
	Line stops due to safety concerns
	Representation in joint management-worker health and safety committees
	Health and safety agreements
	Diffusion of work-related illness
	OSHA reported events
	Average hours of training
	Skills management programs
	Employee performance and career development review
	Employee Training in Sustainability
	Job satisfaction
	Life cycle assessment for health and safety impacts
	Incidents of non-compliance with voluntary codes
	Product quality assurance and management
	Customer satisfaction assessment
	Customer complaints
	Product and service information required by procedures
	Legal actions for anti-competitive behavior
	Composition of governance bodies
	Salary ratio
	Composition of workforce
	Employee turnover
	Operation risk assessment for child labor
	Operation risk assessment for force compulsory labor
	Employees covered by collective bargaining
	Operation change notice period
	Operation risk assessment for freedom of association and collective bargaining
	Human rights screening
	Human rights screening for suppliers and contractors
	Human rights training
	Incidents of discrimination
	Anti-corruption training
	Response to incidents of corruption

	Paid bribes
	Incident of conflict of interests
	General non-compliance fines for products
	Incidents of marketing communications or product non-compliance
	Programs for adherence to laws
	Violations of human rights
	Sustainability report publishing

4.2.2 Discussion:

The method of using already existing sets of indicators that are used internationally and have been rigorously tests is a common method used in various tools (Fan, Carrell and Zhang 2010) (Sparks 2014). In addition, as stated by Tan, et al. (2015) the purpose of using a set of indicators as a starting point is "to build on the work of previous groups and organizations rather than to reinvent the wheel".

The reduction in indicators for the environmental aspect was mostly due to the combination of air emission gases combined into one indicator and other indicators were removed because of their qualitative nature. For the social aspects, it was difficult to eliminate indicators because they are very diverse covering areas such as employee's, health, community and consumers.

4.3. Stage 2: Developed List of Indicators

4.3.1 Results:

Expert survey:

A list of academic programs in multiple universities, government organizations and NGOs was compiled, covering all aspects of sustainability. In some cases,

the names of the experts themselves were documented. The list contained the names, contact information and addresses. Next, emails and phone calls were used to contact the expert that the contact information was available, in order to ask them to participate in the survey. After that, personal visits were made to the organizations and experts to gather more surveys. When at least one survey was obtained for each category and aspect, the survey gathering was stopped.

This effort resulted directly contacting 21 experts and obtaining 14 surveys, with a response rate of 66.7%, covering all aspect and categories. With the concentration of surveys in the environmental aspects. The reasons why seven of the contacted expert did not participate are as follows, five agreed to participate and to send the field questionnaire by email, however, did not send it even after contacting them again, two of the experts did not agree with the research methodology, however, the methodology was not fully explained to them. The distribution of experts by category and aspect is shown in table 4.2.

Table 4.2: Distribution of experts by category and aspect.

Field of expert	Academic	Government	NGO	Total number
Environment	2	5	1	8
Social	1	1	1	3
Economy	1	1	1	3

The score of each indicator was calculated by averaging all the scores given to the indicator by the experts. Table 4.3 below demonstrates the calculation.

Table 4.3: An example of expert scoring of an indicator.

Indicator	Experts								Average score Score
	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8	
Waste water amount	4	5	3	5	4	3	5	4	4.125

Next, the indicators for each aspect were ranked by their scores. The indicators with the top 20 scores were selected for the next stage. In the case where the indicator ranked 20 had the same score as the next ranked indicator, both indicators were selected, resulting in selecting 21 indicators. In the three tables Table 4.4, Table 4.5 and Table 4.6 below, the selected indicators along with their ranking are shown.

Table 4.4: Environmental indicator ranking from the expert survey.

Indicator	Rank	Indicator	Rank
Treated/non-treated waste water	1	Eco-toxic substances emission	12
Eco-toxic substance effluent	1	Particulate emission	12
Water used by source	1	Chemical Spills	14
Hazardous materials used	4	Green House Gases emissions	14
Recycled water used	4	Fluid consumption	14
Intake water quality	4	Surrounding protected lands	17
Waste water amount	7	Total generated waste	18
Energy intensity	8	Specific material used	19
Air quality	9	Recyclable and reusable materials used by contracted service providers	20
Energy consumption	10	Land used	20
Specific recycled, reused, repurposed or remanufactured material	11		

Table 4.5: Social indicator ranking from the expert survey.

Indicator	Rank	Indicator	Rank
Injury rate	1	Human rights screening	11
Operation risk assessment for child labor	1	Incident of conflict of interests	13
Employee toxin exposure	3	General non-compliance fines for products	13
Salary ratio	3	Incidents of marketing communications or product non-compliance	13
Composition of workforce	3	Sustainability report publishing	13
Health education and wellness programs	6	Human rights screening for suppliers and contractors	17
Sick days	6	Incidents of discrimination	17
Paid days off	6	Programs for adherence to laws	17
Legal actions for anti-competitive behavior	6	Violations of human rights	17
Anti-corruption training	6	Operation risk assessment for force compulsory labor	17
Operation risk assessment for freedom of association and collective bargaining	11		

Table 4.6: Economic indicator ranking from the expert survey.

Indicator	Rank	Indicator	Rank
Profits generated	1	Storage costs	11
Material acquisition costs	1	Brand management costs	11
Labor costs	1	Employment costs and employee benefits	11
(Labor) Productivity	1	Waste treatment costs	15
Energy costs for using the produced product	1	Responsibility, risk & crisis management	15
Revenue	6	Innovation & R/D investments	17
Energy costs	6	Environmental protection expenditures	17
Delivery costs	6	Recycling costs for WEEE	19
User taxation	9	Charitable investments and community development	20
Tooling costs	10	Renewable energies and energy efficiency investments	21
Packaging costs	11		

Enterprise survey:

After conducting the enterprise survey, 17 plastic manufacturing companies were surveyed. Six of the companies were in Ramallah and Al-Bireh governorate, while 11 where in Hebron governorate. These two governorates where chosen because of the concentration of plastic industries in these governorates. However, 6 factories were visited without getting any surveys because the administration refused to fill the survey. There were two main reasons for refusing to participate. The first reasons is that the administration was too busy to participate. The second reason, they were not willing to provide information claiming it was sensitive information. There are other factories that their address were visited and it was found out that they shut down. Others however, their phone numbers did not work either because they changed the number or the factories were also shut down.

The classification of the factories visited in the survey by production method is illustrated in Figure 4.1. The figure illustrates that the factories included in the survey cover different plastic production methods. Each method may have unique attributes that may affect the sustainability of the factory.

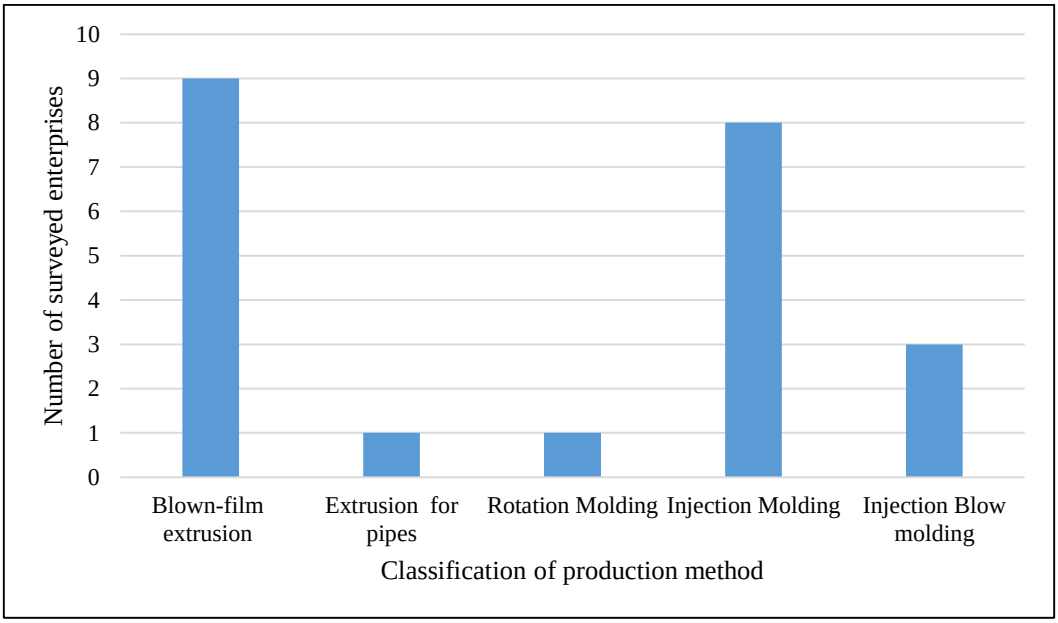

Figure 4.1: Classification of surveyed factories by production methods.

After calculating the score of each indicator based on the set criteria, the average score of each indicator from all the surveys was calculated. An example of how the scores were calculated is shown in Table 4.7 and Table 4.8. The final indicator scores from the enterprise surveys are shown in Table 4.9, also showing the indicators with the 10 highest scores in each of the sustainability aspect, which are the indicators that are chosen for the tool. Figure 4.2, Figure 4.3 and Figure 4.4 visually illustrate the indicator scores.

Table 4.7: Indicator score calculation for an individual enterprise survey.

Indicator	Criteria					Score
	Relevance to your production	Expected time taken to measure	Amount of resources need to measure	Availability of data	Understandability to non-experts	
Waste water amount	1	4	4	4	3	2.375

Table 4.8: Final indicator score as an average of all survey scores of an individual indicator (Waste water amount).

Survey number	Indicator score
1	2.375
2	2.375
3	3.75
4	2.75
5	2.875
6	2.125
7	2
8	2.625
9	2.25
10	2.125
11	2.25
12	2.625
13	2.75
14	2.25
15	2.375
16	2.375
17	2.375
Final score	2.125

Table 4.9: Final indicator scores and final chosen indicators.

Aspect	Indicator	Score	Selected
Environment	Energy consumption	4.10	X
	Specific recycled, reused, repurposed or remanufactured material	3.29	X
	Specific material used	3.07	X
	Energy intensity	2.83	X
	Land used	2.52	X
	Waste water amount	2.49	X
	Treated/non-treated waste water	2.35	X
	Water used by source	2.33	X
	Air quality	2.16	X
	Recyclable and reusable materials used by contracted service providers	2.04	X
	Total generated waste	1.99	
	Particulate emission	1.97	
	Green House Gases emissions	1.73	
	Fluid consumption	1.65	
	Recycled water used	1.59	
	Hazardous materials used	1.58	
	Eco-toxic substance effluent	1.55	
	Eco-toxic substances emission	1.45	
	Surrounding protected lands	1.28	

	Intake water quality	1.17	
	Chemical Spills	1.1	
Social	Lost workdays	3.55	X
	Operation risk assessment for child labor	3.15	X
	Composition of workforce	3.09	X
	Sick days	3.07	X
	Paid days off	2.98	X
	Health education and wellness programs	2.93	X
	Salary ratio	2.85	X
	Operation risk assessment for force compulsory labor	2.83	X
	General non-compliance fines for products	2.73	X
	Sustainability report publishing	2.64	X
	Operation risk assessment for freedom of association and collective bargaining	2.17	
	Incidents of discrimination	2.01	
	Programs for adherence to laws	1.97	
	Employee toxin exposure	1.85	
	Incident of conflict of interests	1.85	
	Incidents of marketing communications or product non-compliance	1.77	
	Legal actions for anti-competitive behavior	1.56	
	Anti-corruption training	1.51	
	Human rights screening	1.42	
	Violations of human rights	1.07	
	Human rights screening for suppliers and contractors	1.05	
Economy	Profits generated	4.78	X
	Energy costs	4.27	X
	Material acquisition costs	4.08	X
	Revenue	4.00	X
	Labor costs	3.52	X
	Charitable investments and community development	3.34	X
	Tooling costs	3.19	X
	(Labor) Productivity	3.18	X
	Innovation & R/D investments	3.15	X
	Delivery costs	2.97	X
	Environmental protection expenditures	2.80	
	Packaging costs	2.80	
	Storage costs	2.69	
	Waste treatment costs	2.48	
	Employment costs and employee benefits	2.39	
	Recycling costs for WEEE	1.72	

	Brand management costs	1.43	
	Use energy costs	1.10	
	User taxation	1.06	
	Responsibility, risk & crisis management	1.06	

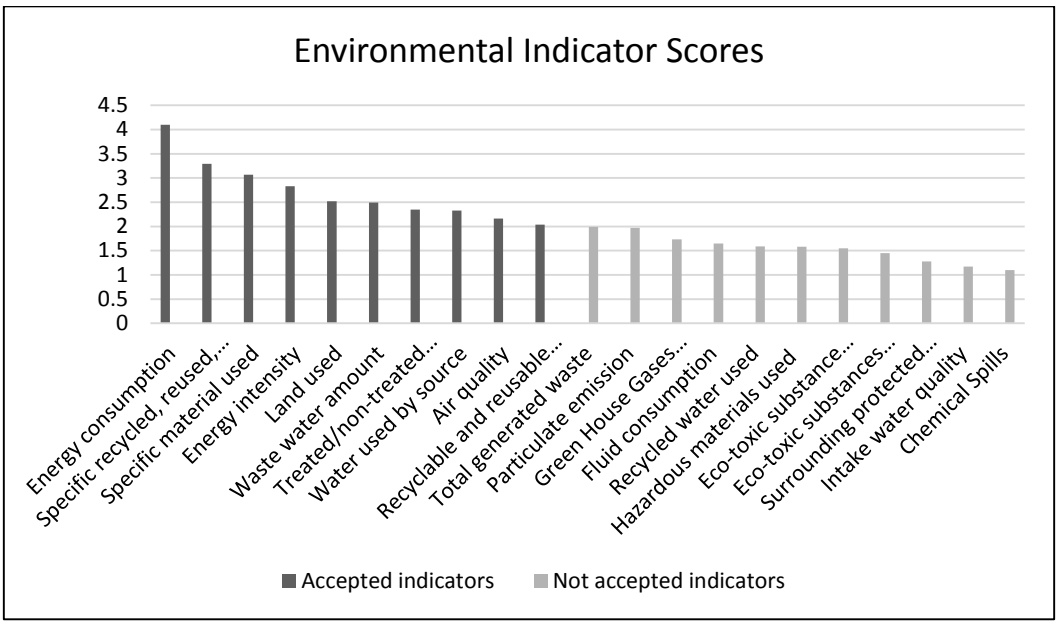

Figure 2.2: Environmental aspect industry survey scores.

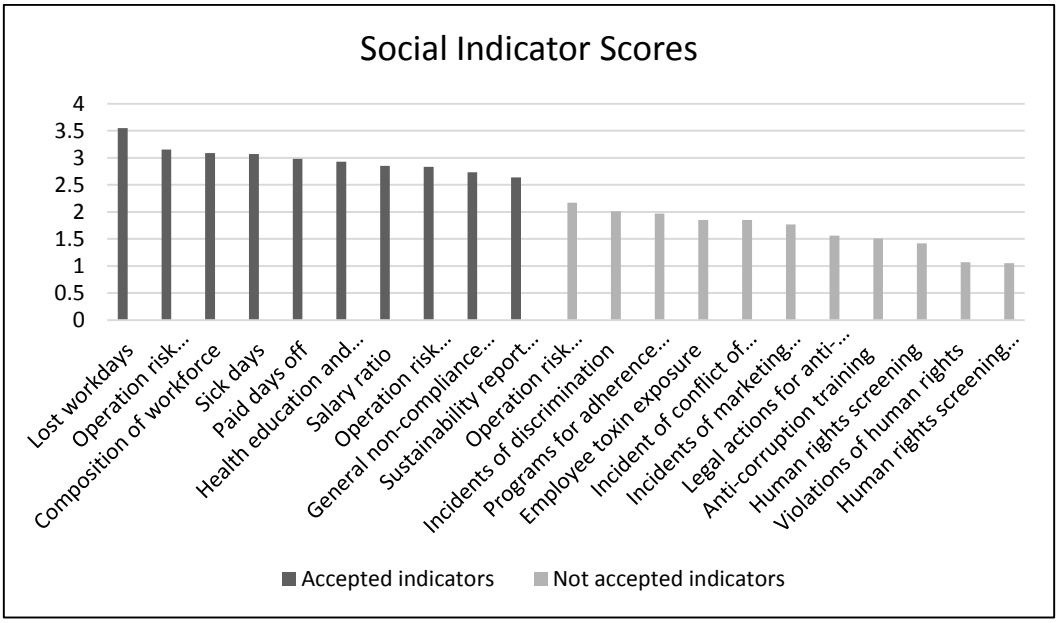

Figure 4.3: Social aspect industry survey scores.

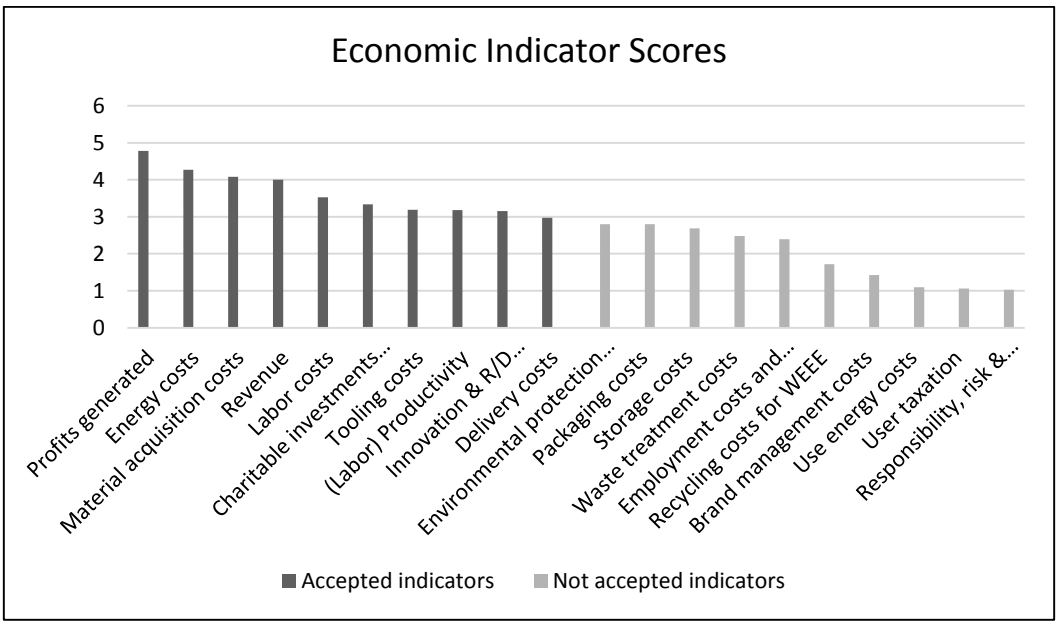

Figure 4.4: Economic aspect industry survey scores.

4.3.2 Discussion:

Expert survey discussion:

The reason why some of the experts did not send the completed survey may have to do with the time needed to complete the survey. It was noticed while speaking to the experts, that they generally held important positions in their organization. Therefore, made it difficult for them to take time to complete other tasks. Also, some fields where more willing than other fields to participate. The experts in the environmental field showed more interest in the topic of the research than the other fields, this maybe because it is common opinion that sustainability is more related to the environment than to the social and economic issues.

In the environmental aspect, the three highest scoring indicators were "Treated/non-treated waste water", "Eco-toxic substance effluent" and "Water used by source". All three are related to water. This reflects the importance of

water issues in Palestine (PWA 2013). Another reason for the emphases on water related indicators is that some of the government and both of the academic experts in this fields were specialized in water studies.

The three lowest scoring indicators in the environmental aspect were “Noise emissions”, “Acidification substances” and “after-sales servicing materials”. This shows that these are not priorities in Palestine in the opinion of the experts. Noise pollution effects has not been explored yet in Palestine according to the Environmental Quality Authority (EQA) (EQA 2010). However, one researcher who studied noise pollution in Nablus city, found that 58% of the locations measured had noise levels exceeding the allowed international standard (Ashqer, Zeid and Seh 2000). With regards to acidification substances, emission of acidic substances have been found to cause environmental problems in villages near industrial zones in settlements, as a byproduct of electroplating processes (ARIJ 2015).

The highest indicator scores in the social aspect were for “Operation risk assessment for child labor”, “Employee toxin exposure”, “Salary ratio”, “Composition of workforce”. These results are in line with characteristics of the Palestinian labor. Such as low female employment (Composition of workforce) (MAS 2014). The reason they are all related to the work force could be the academic, government and NGO experts were specialized in labor issues. The lowest two indictors were “Response to incidents of corruption” and “Paid bribes”. In conclusion, the experts do not consider corruption issues are relevant in the privet sector.

The four indicators that scored the highest by the economic experts are “Profits generated”, “Labor costs”, “Labor Productivity” and “Use energy costs”. Profits generated is expected to score high, as it is an important factor for economic success. Moreover, they are all related to costs, which is also directly related to profit. Also, energy is considered one of the major challenges facing economic independence in Palestine (PIPA 2015). For this reason, energy costs was scored high by the experts. The lowest indicator score was “Renewable energies and energy efficiency investments”. This is in contradiction with the “Energy cost” indicator that got a high score. This could be due to the importance of the rest of the indicators.

Enterprise survey discussion:

Having too many indicators in each survey discourages the participants to complete the survey. However, the method used to score the criteria was used in order to minimize the survey time. Unlike other methods such as AHP that would have needed each indicator to be compared with each other indicator.

The majority of the companies visited are small scale family owned businesses, with traditional management systems. Typically the management is very resistant in sharing information about their businesses.

“Energy consumption”, “Specific recycled, reused, repurposed or remanufactured material” and “Specific material used” received the highest scores from the enterprises. From conducting the survey, it was found that in the plastic industry, energy consumption is very high, this is due to the heating stage in the production

process. Concern regarding this high consumption is evident in the score. The second and third highest indicators are both related to the material used in the production, this is because plastic production is simple with not too many sub process that may have impacts on the environment. In addition. These indicators achieved high scores because they are relatively easy to understand and easy to measure through bills. The lowest scoring environmental indicators by the enterprises are, “Surrounding protected lands”, “Intake water quality” and “Chemical Spills”. In the case of plastic industry, there are no pollutants or emissions to the surrounding area. So, have surrounding protected lands is not a priority. The water that enters the production process is only used for cooling which does not need any specific qualities. Chemical spills are also not a concern to the enterprises because for the production methods in the surveyed factories do not use chemicals during production.

In the social aspect, “Lost workdays”, “Operation risk assessment for child labor” and “Composition of workforce” received the highest scores. As stated earlier, the companies surveyed were family businesses with traditional management. This type of business is dependent on a good relationship between the management and the work force. For this reason, any injuries that lead to lost days of work is of great concern to the companies. Child labor is also a concern to the enterprises most likely because of the strict labor laws in Palestine that restrict child labor. The lowest scoring indicators are, “Human rights screening”, “Violations of human rights”, “Human rights screening for suppliers and

contractors". From these results, it is apparent that human rights issues are not of an importance in Palestine.

"Profits generated", "Energy costs" and "Material acquisition costs" had the highest scores in the economic aspect. Profit is the main objective for the enterprise and this is probably the reason why it received a high score. Also, as mentioned above, the plastic industry consumes large amounts of energy, which contributes greatly to its costs. Material costs is another important factor for the economic aspect. The product costs is mostly due to the cost of the material, in the case of the plastic sector. "Use energy costs", "User taxation" and "Responsibility, risk & crisis management" are lowest scoring economic indicators.

In some indicators there were significant differences in the scores given to the "Relevance" criteria and the other criteria. This caused some indicators to get high scores while not being relevant in the industry. However, this does not reduce their importance in being an important indicator for Palestine as scored by the experts. Examples of indicators that had low relevance scores with high scores of the other criteria: "Waste water amount", "Treated/non-treated waste water", "Lost workdays", "Operation risk assessment for child labor" and "Operation risk assessment for force compulsory labor". On the other hand, other indicators had high scores of relevance relative to the other indicators. However, the relevance of the indicator to the industry was given a higher weight in order to give the indicator an overall higher score. Examples of indicators having significantly higher relevance to the industry than the other criteria are: "Energy

consumption", "Energy intensity", "Revenue", "Material acquisition costs" and "Delivery costs". Despite the survey effort to choose indicators that are easy to measure, understand, available data, and lower resources needed for measurement, the indicator "Air quality", which is an indicator of the quality of air in the area surrounding the factory, was chosen despite the need of sophisticated equipment to measure the value of the indicator.

4.4. Stage 3: Tool Development

4.4.1 Indicator details:

A symbol, description, unit of measurement, and calculation method for all the indicators that were selected in stage 2 was documented. The indicator details are shown in Appendix D.

4.4.2 Weights:

The list of indicators weight were calculated using equation (3.1). The results are shown in tables 4.10, 4.11 and 4.12. As an example the weight calculation for the energy consumption is shown as follows: $w_i = \frac{s_i}{\sum_1^n s_i} = \frac{3.9+4.5}{64} \approx 0.13$

Table 4.10: Environmental indicator weights.

Symbol	Indicator	Weight
$I_{EN,1}$	Energy consumption	0.13
$I_{EN,2}$	Specific recycled, reused, repurposed or remanufactured material	0.12
$I_{EN,3}$	Specific material used	0.10
$I_{EN,4}$	Energy intensity	0.12
$I_{EN,5}$	Land used	0.08
$I_{EN,6}$	Waste water amount	0.09
$I_{EN,7}$	Treated/non-treated waste water	0.09
$I_{EN,8}$	Water used by source	0.10
$I_{EN,9}$	Air quality	0.08

$I_{EN,10}$	Recyclable and reusable materials used by contracted service providers	0.09
Total		1

Table 4.11: Social indicator weights.

Symbol	Indicator	Weight
$I_{SO,1}$	Lost workdays	0.11
$I_{SO,2}$	Operation risk assessment for child labor	0.08
$I_{SO,3}$	Composition of workforce	0.08
$I_{SO,4}$	Sick days	0.11
$I_{SO,5}$	Paid days off	0.12
$I_{SO,6}$	Health education and wellness programs	0.11
$I_{SO,7}$	Salary ratio	0.12
$I_{SO,8}$	Operation risk assessment for force compulsory labor	0.08
$I_{SO,9}$	General non-compliance fines for products	0.11
$I_{SO,10}$	Sustainability report publishing	0.08
Total		1

Table 4.12: Economic indicator weights.

Symbol	Indicator	Weight
$I_{EC,1}$	Profits generated	0.13
$I_{EC,2}$	Energy costs	0.11
$I_{EC,3}$	Material acquisition costs	0.12
$I_{EC,4}$	Revenue	0.12
$I_{EC,5}$	Labor costs	0.11
$I_{EC,6}$	Charitable investments and community development	0.06
$I_{EC,7}$	Tooling costs	0.08
$I_{EC,8}$	(Labor) Productivity	0.10
$I_{EC,9}$	Innovation & R/D investments	0.07
$I_{EC,10}$	Delivery costs	0.10
Total		1

4.4.3 Software:

The software was developed in order to reduce the time needed to complete the assessment process, simplify the calculations, store the data for later use, compare scores annually or with other companies and visually display the results.

To complete the assessment the following steps must be followed:

1. In screen 1 (Figure 4.5), click on “new assessment”.
2. In screen 2 (Figure 4.6):
    a. Select “new company if this the first assessment for this company”.
    b. Enter the name of the company.
    c. Enter the year of the assessment.
    d. Choose the industry the company works in, however, the current version of the software only supports the plastic industry.
    e. Select the type of assessment method that will be used.
    f. Click “assess” to continue the assessment process.
3. In screen 3, 4 and 5 (Figures (4.7, 4.8 and 4.9)), fill in all the necessary data for each aspect and then click “assess” to continue to the results.
4. Screen 6 (Figure 4.10) shows the results of the assessment depending on the method of assessment. It shows the composite score and the score of each aspect separately for each year or company. In the case shown in the figure, the company in 2018 had a score of 0.906, which is higher than the score of 2017. This shows that the company improved its sustainability in 2018, with respect to 2017. Also, the individual scores of each aspect is shown separately to compare the improvement in each aspect. On this screen you can:
    a. Go back to screen 1 by clicking on “home”.
    b. Go back to screen 3, 4 and 5 to modify the data.
    c. View detailed results by clicking on “Details”.

d. Save the results to use in the future click “Save Results”.

5. If the “Details” button from screen 6 is clicked, the detailed score comparison for each indicator can be viewed for each aspect (Figure 4.11). When the score of the indicator is higher in one year that indicates that there was an improvement in that year compared to the other year. By clicking on “graphs” in the same screen, a spider diagram is shown to visually compare the results of all the aspects or each aspect separately (Figure 4.12).

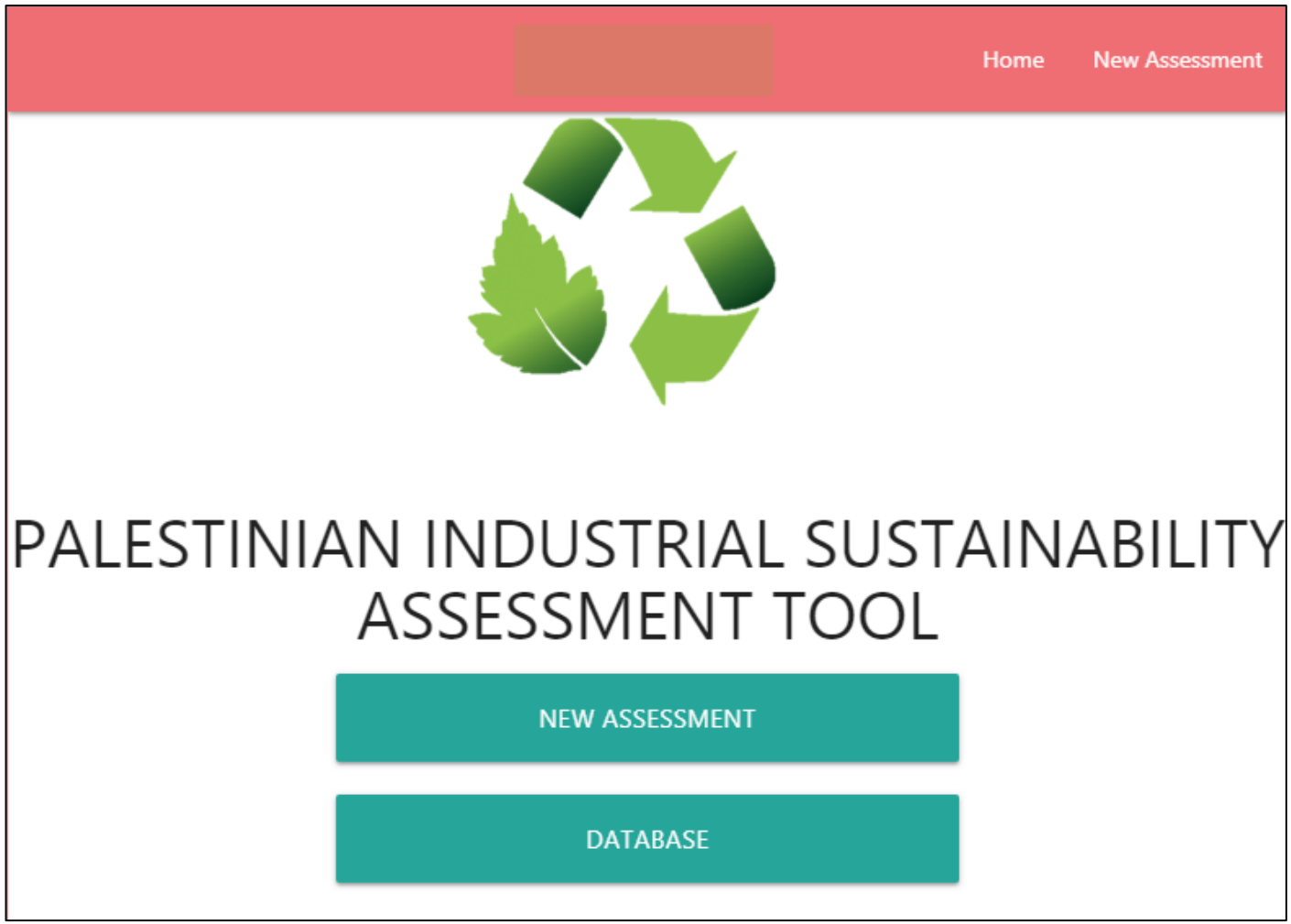

Figure 4.5: Software screen 1: Home page.

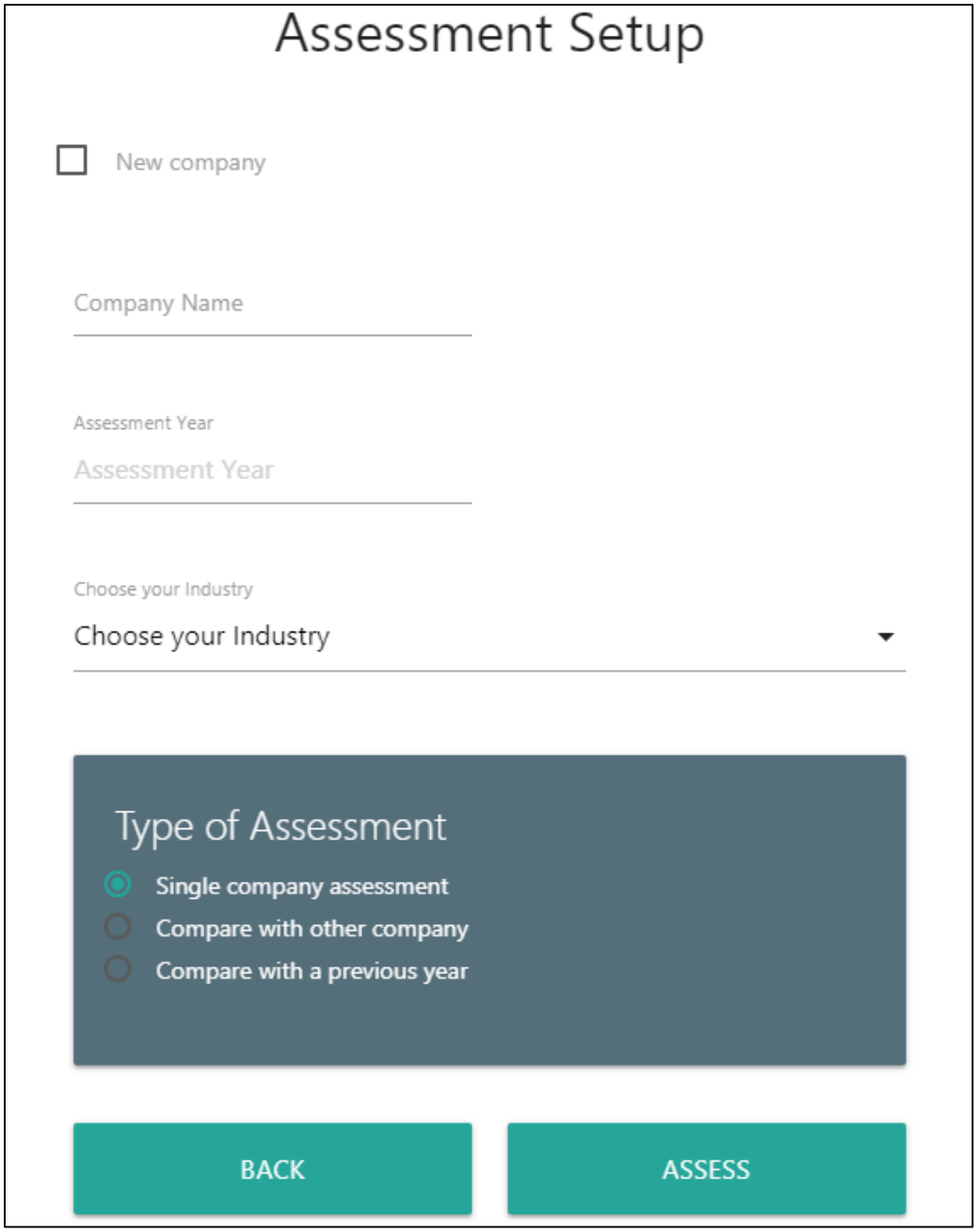

Figure 4.6: Software screen 2: Assessment setup.

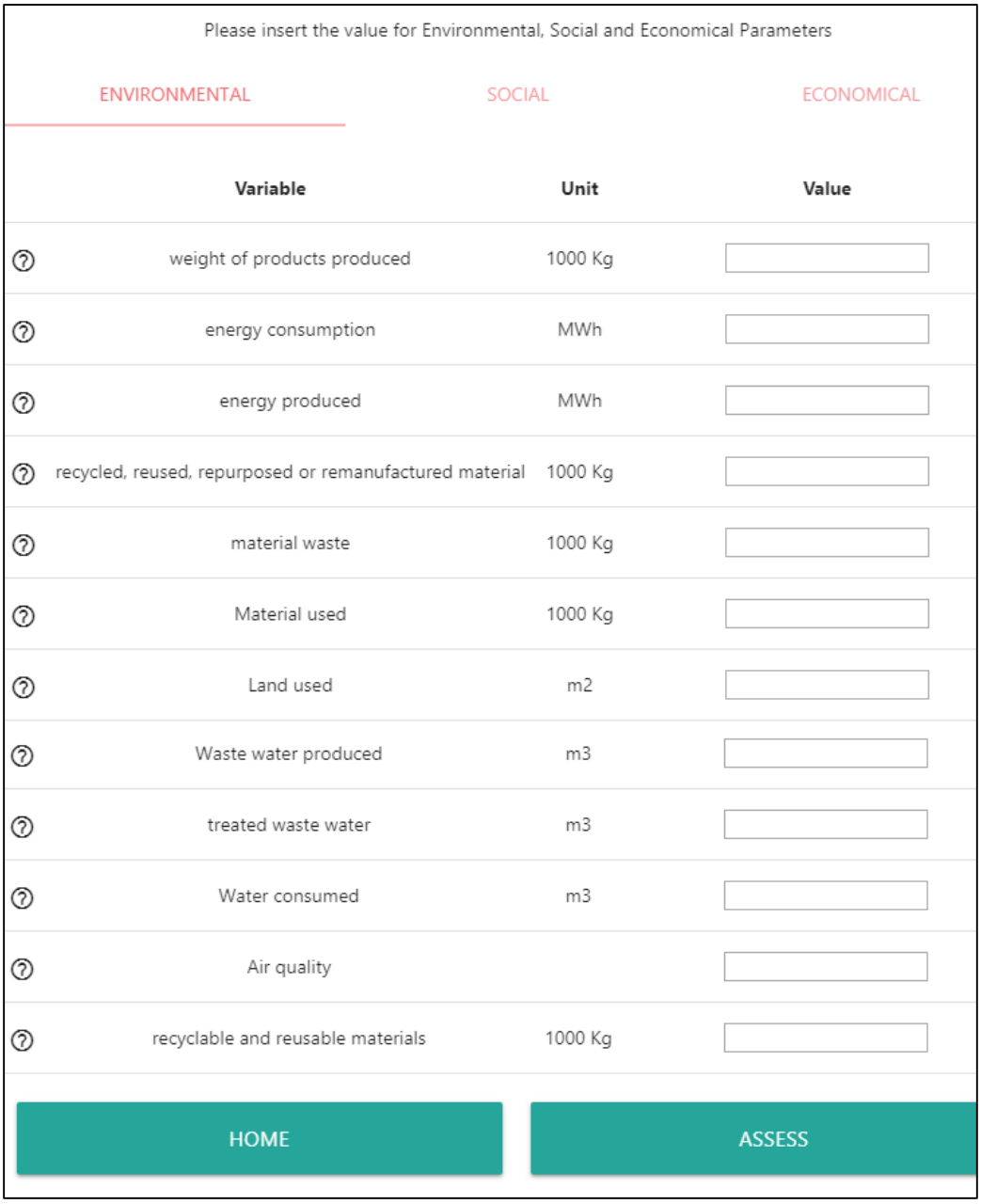

Figure 4.7: Software screen 3: Environmental data input.

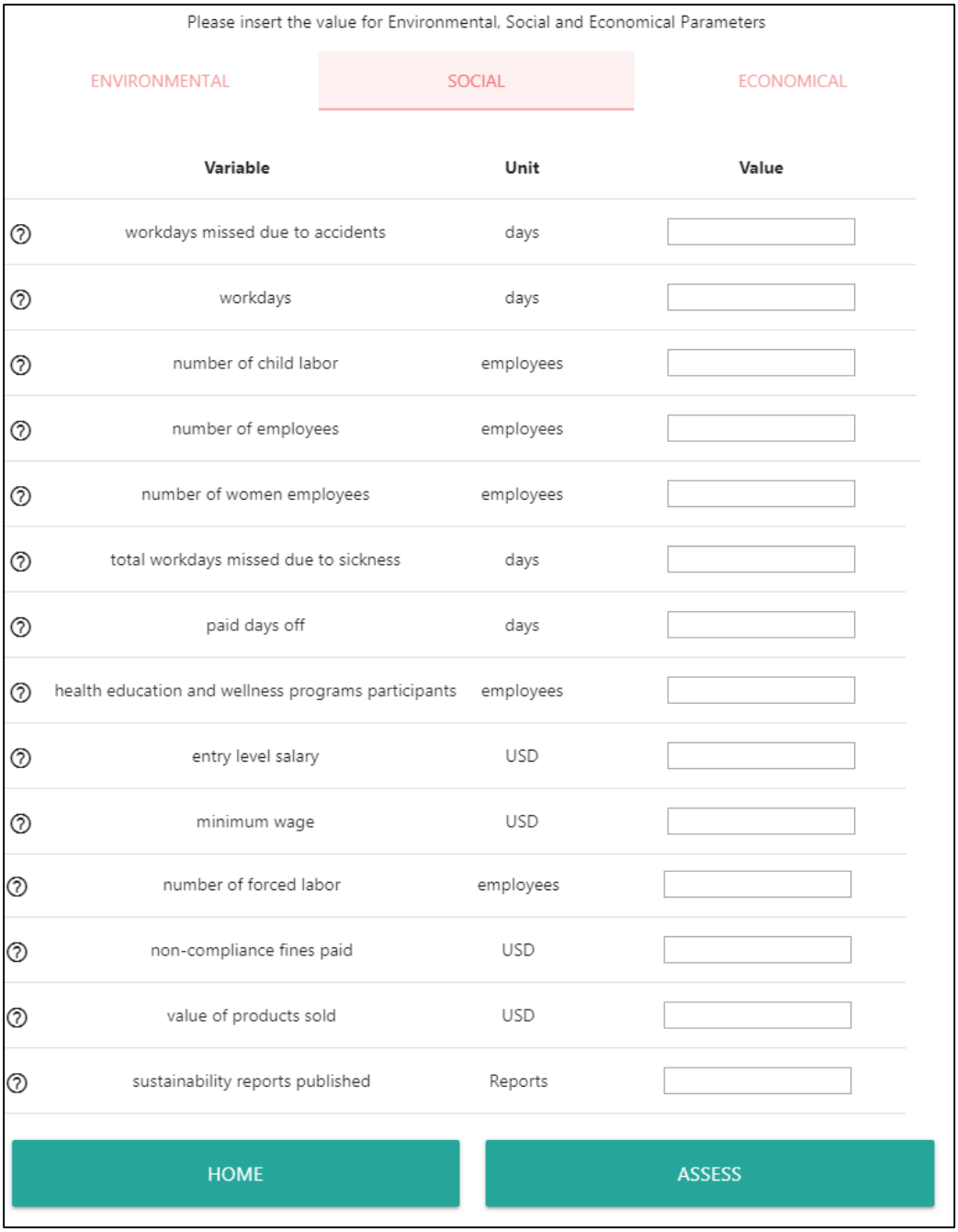

Figure 4.8: Software screen 4: Social data input.

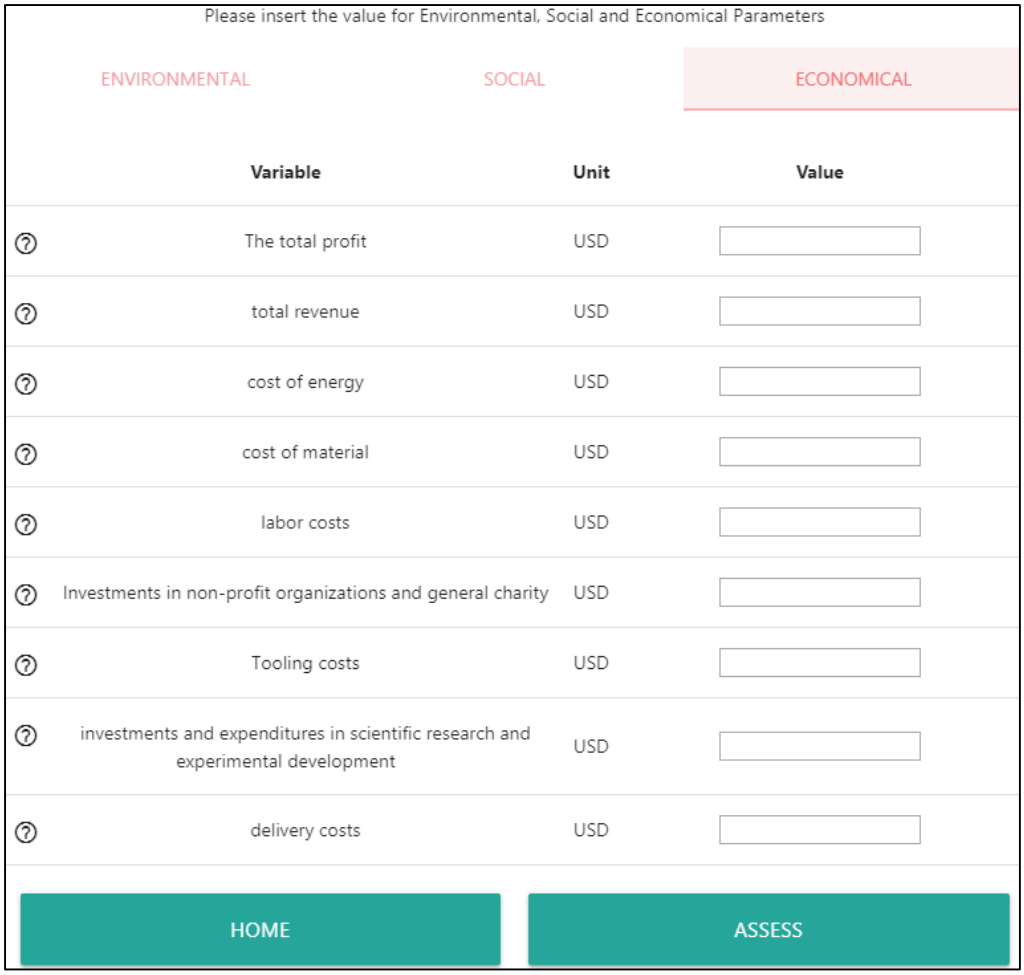

Figure 4.9: Software screen 5: Economic data input.

Figure 4.10: Software screen 6: Sustainability assessment results.

Figure 4.11: Software screen 7: Detailed sustainability assessment results.

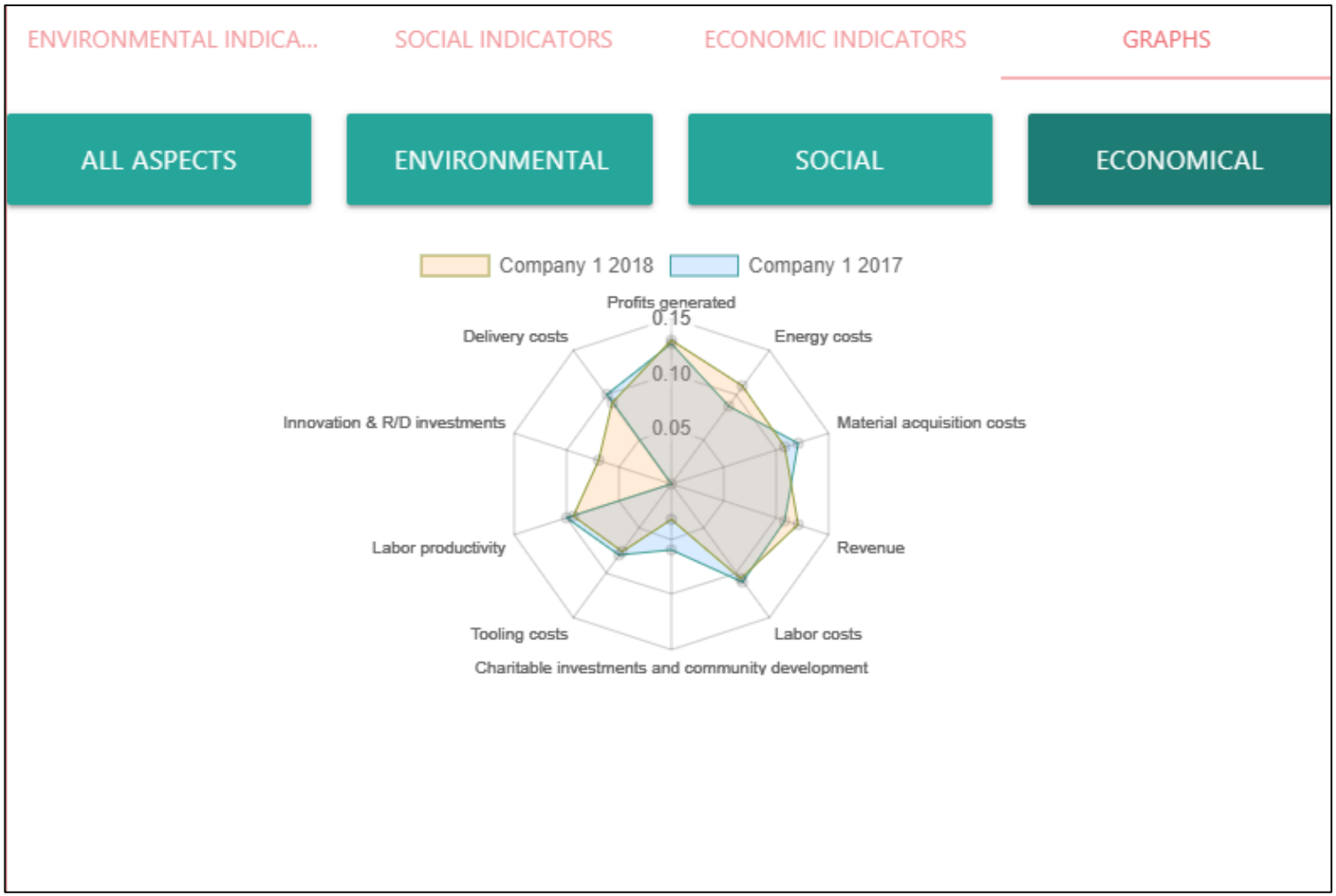

Figure 4.12: Software screen 8: Graphic sustainability assessment results.

4.5. Stage 4: Tool Testing

The tool was tested on a plastic manufacturer located in Beitonia city. The annual comparison method was used on the years 2018 and 2017 of the company. The results of the questionnaire are shown in Table 4.12.

Table 4.13: Tool testing questionnaire results.

Part 1: General Questions		
Question		**Answer**
1	How long did it take to finish the assessment?	60 minutes
2	I was encouraged to use the tool.	Neutral
3	The results of the assessment will affect the practices in the factory to improve sustainability.	Agree
4	I would be willing to voluntarily use this software to assess the sustainability of the factory.	Agree
5	It would take me significantly less time to finish the assessment next time I use the software.	Strongly agree
6	What input data was difficult to obtain, measure or calculate?	a. Data: Weight of products produced. Explanation: There are many different products and types of materials which complicate the tracking of this data. b. Data: Recycled, reused, repurposed or remanufactured materials. Explanation: This data is not documented.
7	What input data were you least willing to provide because of privacy issues?	Data: Profit and revenue. Explanation: This data is considered sensitive data.
8	What method of assessment do you think will be most useful for the factory? Explain.	Method: Annual comparison. Explanation: Can help

		track improvements.
Part 2: Software usability		
Question		**Answer**
1	Overall the software was easy and simple to use.	Agree
2	The additional help information provided on screen and user manual was sufficient.	Neutral
3	The interface was clear and organized.	Agree
4	General suggestions to improve the software	• Add Arabic language. • Give suggestions on how to improve the score based on the results.

The time taken to complete the assessment was only 60 minutes. However, the short time could indicate the participant did not take too much care in providing accurate data, which, could affect the credibility of the results.

The answer to if the participant was encouraged to participate in the survey was neutral. This could be due to multiple reasons. The reasons in the view of the researcher are as follows:

- The participant does not have too much free time and considers the time taken to participate in research project as a waste of their time.
- The participant is uncomfortable releasing financial information that is needed for the assessment.
- The participant is not fully aware of the benefits of improving the sustainability of their company.

The participant answered “Agree” to the question if the results of the assessment will affect the practices in the factory to improve sustainability. This shows that

the tool could be useful in guiding the manufacturers to improve their sustainability.

The participant answered “Strongly agree” to the question if it would take me significantly less time to finish the assessment next time I use the software. This result is expected. The time taken to complete the assessment the next time the tool is used could be because the participant is more familiar with the tool and they might improve their method to retrieve the necessary data.

Regarding the data that is difficult to obtain, measure or calculate, the “weight of products produced” was chosen by the participant. In addition to, “recycled, reused, repurposed or remanufactured materials”. It was explained that there are many different products and types of materials which complicate the tracking of this data and the data is not documented. Both cases could be resolved for future assessments by integrating the assessment tool into other data entry practices such as accounting and inventory to have the data readily available.

Profit and revenue was chosen as the data that participant was least willing to provide because of privacy issues. This is expected because for privet companies, this data is an indicator of the economic performance that they don’t want their competitors to know. Also, the owner of the company would not want other people to know how much money they make. To avoid the unwillingness to release this data, the users of the tool should be reassured that the input data for the assessment would not be released and only the final results would be released.

The participant chose the annual comparison to be the most useful method to use the tool and explained that it can help track improvements. This could be because the user of the tool does not think the result of other companies would be relevant to its practices. However, if the same question was directed to researchers that aim to improve the sustainability of a specific manufacturing sector, the company comparison method could be favored.

The answers to the questions regarding the usability of the software were generally positive. However, more opinions of participants should be gathered to get more in-depth results.

The general suggestions to improve the software include adding the Arabic language to the software. This is very important for the tool to be suitable for all the local plastic manufacturers. The second suggestion was to “give suggestions on how to improve the score based on the results”. This could be very useful to guide the manufacturers to improve their sustainability. This can be implemented by preparing a list of suggestions on how to improve each indicator and on the results screen, a list of suggestions will show on the screen based on which indicators got the lowest scores. Another solution could be to provide the manufacturers with guide book on how to improve their score for each indicator.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The use of a sustainability assessment tool is key to improving the sustainability of manufacturers. There has been a large amount of research dedicated to developing tools to assess sustainability. However, most of these attempts developed tools to be implemented in large companies and in developed countries, which is inconsistent with how the Palestinian economy and society are structured. For this reason, this research aimed to develop a tool that takes into consideration the different factors that affect the sustainability of Palestinian manufacturers. The plastic industry was used as a case study.

The selection process of the indicators that will be used in the assessment is highly subjective in most research. For this reason, a comprehensive list of indicators was selected and then filtered using experts' opinions and local plastic manufacturers. The final tool consists of 10 indicators for each aspect of sustainability. From the expert survey, the water related indicators, injury rates and profits where the most important indicators in the economic, social and economic aspects respectively. From the enterprise survey, energy consumption was regarded as the most important environmental indicator. With respect to the social aspect, lost work days because of injury was the most important. As in the

expert survey, profit was the most important economic indicator for the enterprises.

Developing a software application provides a number of advantages not present in other assessment tools. The software reduces the time needed to complete the assessment, calculates the final sustainability score, provides visuals to compare results and stores the data to be retrieved at any time for further assessment.

After developing the software, the tool was tested in a local manufacturer in order to reveal any problems in the software and to compare the advantages and disadvantages of the tool. It was found that there were not any major problems in the software. The participant in the testing suggested to add the Arabic language into the software and to integrate information on how to improve the sustainability score into the software.

Going further from this a number of recommendations were formulated with suggestions for further research.

5.2. Recommendations

Based on the results of this research and the literature review related to this field the bellow recommendations are given. The recommendations include improvements regarding the developed tool, future directions of research and recommendation of implementing the tool. The recommendation are as follows:

1. The list of indicators could be better generalized by increasing the sample size of the expert and industry survey.

2. More Case studies should be conducted to validate the applicability of the tool. This should include the applicability of the indicators to confirm they could be easily understood by the industry and the also easily measurable. Moreover, the case studies should test the usability of the software and recommend areas of improvement.
3. A similar research should be conducted on other manufacturing sectors in addition to other commercial sectors.
4. A database of indicator values should be made to take advantage of different normalization methods. This could give the tool more flexibility by using the database to normalize values of individual factories.
5. Explore the use of AHP to determine the weights of the indicators.
6. Implementation recommendations:
    - The tool could be used by companies to track their progress towards their sustainability goals.
    - The tool could be used by government and NGOs to assess the sustainability of the plastic sector. This assessment could be used to guide the implementations of sustainable manufacturing related policies.
    - It could be used to give certifications of sustainability or sustainability awards by the Palestine Standards Institution.

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APPENDICES

Appendix A: Expert Surveys

Appendix A.1: Environmental expert Survey (English)

Master Program of Sustainable Engineering in Production

Dear Participant:

My name is Tariq Talhami and I am a graduate student in the program Sustainable Engineering in Production, a joint program between Birziet and An-Najah. For my thesis, I am developing a tool to assess the sustainability of local plastic manufacturers. Because you are an expert in one or more fields of that the assessment covers, I am inviting you to participate in this research study by completing the attached surveys.

The following questionnaire will require approximately 15 minutes to complete. If you choose to participate in this project, please answer all questions as honestly as possible and return the completed questionnaires promptly to this same Email.

Thank you for taking the time to assist me in my educational endeavors. The data collected will provide useful information regarding selecting suitable indicators for sustainability. If you require additional information or have questions, please contact me at the number listed below.

Sincerely,

Tariq Talhami

0592041094

Tariq.talhami@gmail.com

Part 1: General Information about the Expert

Name		
Telephone No.		
E-mail address		
Name of Organization		
Position at Organization		
Type of organization		**Government**
		NGO
		Academic institution
Field of work of organization (for NGO only)		

Part 2: Indicator Assessment

Please judge the following indicators according to how important they are as sustainability assessment indicators for Palestinian industries. **(5: Very important, 1: Very unimportant)**

Category A: Emissions

	Name	Definition	Score
1	Waste water amount	Amount of waste water discharged by an organization or process specified by category (i.e. eco-toxic, hazardous, treated, non-treated, reused, non eco-toxic, etc.)	
2	Treated/non-treated waste water	Proportion of waste water discharged by an organization or process that is treated, in order to reduce pollutants before being discharged to the environment, by level of treatment (primary, secondary or tertiary)	
3	Total generated waste	Amount of waste generated by an organization, process, or product specified by category (i.e. eco-toxic, disposable, recyclable, reusable, etc.)	
4	Reusable, Recyclable and Remanufacturable waste produced	Amount of waste that is reusable, recyclable and remanufacturable in the production process for an organization or process	

Category B: Pollution

	Name	Definition	Score
1	Hazardous materials used	Amount of hazardous materials used by an organization or process in the production of a product. Includes regulated materials, hazardous, radioactive, heavy metals, toxic chemical, etc. Includes: Lead (Pb), Mercury (Hg), Hexavalent Chromium (Cr6+), Cadmium (Cd), Polybrominated biphenyl flame retardants (PBB), Polybrominated diphenyl ether flame retardants (PBDE),	
2	Eco-toxic substance effluent	Amount of hazardous wastes in water effluent discharged by organization or process. Includes: regulated materials, hazardous, radioactive, heavy metals, toxic chemicals, etc.	
3	Chemical Spills	Total number and volume of significant spills at an organization's facility	
4	Eco-toxic substances emission	Specific eco-toxic substances emitted by an organization's facility, process, and/or product. Includes: persistent organic pollutants (POPs), heavy metals, radiation, and other pollutants	
5	Green House Gases emissions	GHGs emitted by an organization's facility, process, and/or product. Includes:CO2, CH4, N2O, CFCs, NOx, SOx, etc.	
6	Noise emission	Noise and vibrations emitted from an organization's facility, process, and/or product	
7	Acidification substances	Emissions of specific acidifying substances from an organization's facility or process	
8	Air quality	Air quality of within and in surrounding areas of an organization's facility including smog, visibility, odor, GHG concentration, pollutant concentration, etc.	
9	Particulate emission	Emissions of small particles by an organization's facility, process, and/or product	

Category C: Resource Consumption Indicators

	Name	Definition	Score
1	Specific material used	Amount and type of materials used by an organization, process, and/or product	
2	Material intensity	Ratio of the amount of materials needed for an organization, process, or product to the amount of materials used by an organization, process, or product	
3	Specific recycled, reused, repurposed or remanufactured material	Amount and type of recycled, reused, repurposed or remanufactured materials used by an organization, process, and/or product	
4	Fluid consumption	Amount of auxiliary fluids used by an organization or process including: cleaners, lubricants, oils, coolants, etc.	
5	Recyclable and reusable materials used by contracted service providers	Amount of recyclable and reusable materials used by contracted service providers	
6	Reclaimed packaging	Generation, disposal, and/or recycling of packaging waste for a product	
7	After-sales servicing materials	Quantity of materials used during after-sales servicing of products	
8	Energy consumption	Amount of energy consumed by an organization, process, or product. Energy is specified by source and type	
9	Energy intensity	Ratio of the energy used by an organization or process to the energy available for an organization or process	
10	Renewable energy consumption	Amount of energy consumed by an organization, process, or product that is categorized by renewable sources (i.e. hydropower, wind, solar, tide and wave, biomass, etc.)	
11	Renewable energy generated	Amount of energy generated by an organization that is classified as renewable (i.e. hydropower, wind, solar, tide and wave, biomass, etc.)	
12	Energy efficiency	Ratio of the actual energy consumed by an organization, process, or product to the theoretical energy needed for the organization, process, or product	
13	Water used by source	Total water used by an organization, process, or product categorized by type/source	

14	Recycled water used	Waste water that is treated and reused within an organization or a manufacturing process	
15	Intake water quality	Amount of contaminants and nutrients within intake water supply and groundwater. Includes coli-form bacteria, nutrients, pollutants, oxygen, phosphorus, suspended solids	
16	Land used	Land used by an organization's facility categorized by fertile and non-fertile areas	
17	Land quality	Waste effects on land quality indicated by surface integrity, soil nutrients and contaminants, non-fertile land, salanized areas, etc.	
18	Surrounding protected lands	Areas protected surrounding facility and/or rehabilitated in surrounding areas of an facility	

Thank you for your participation

Appendix A.2: Social Expert Survey (English)

Master Program of Sustainable Engineering in Production

Dear Participant:

My name is Tariq Talhami and I am a graduate student in the program Sustainable Engineering in Production, a joint program between Birziet and An-Najah. For my thesis, I am developing a tool to assess the sustainability of local plastic manufacturers. Because you are an expert in one or more fields of that the assessment covers, I am inviting you to participate in this research study by completing the attached surveys.

The following questionnaire will require approximately 20 minutes to complete. If you choose to participate in this project, please answer all questions as honestly as possible and return the completed questionnaires promptly to this same Email.

Thank you for taking the time to assist me in my educational endeavors. The data collected will provide useful information regarding selecting suitable indicators for sustainability. If you require additional information or have questions, please contact me at the number listed below.

Sincerely,

Tariq Talhami

0592041094

Tariq.talhami@gmail.com

Part 1: General Information about the Expert

Name		
Telephone No.		
E-mail address		
Name of Organization		
Position at Organization		
Type of organization		**Government**
		NGO
		Academic institution
Field of work of organization (for NGO only)		

Part 2: Indicator Assessment

Please judge the following indicators according to how important they are as sustainability assessment indicators for Palestinian industries. **(5: Very important, 1: Very unimportant)**

Category A: Employee Indicators

	Name	Definition	Score
1	Injury rate	Accidents requiring first aid	
2	Lost workdays	Workdays missed due to accidents and sickness	
3	Health education and wellness programs	Employee participation in on-site health education/wellness programs promoted by an organization	
4	Sick days	Ratio of sick days to work days	
5	Health index of on-site food (cafeteria)	Health index of on-site food	
6	Paid days off	Paid days off	
7	Employee toxin exposure	Employee exposed to specific toxins and the affects of these exposures-days away due to exposure to toxins	
8	Safety measures adopted	Number of safety measures adopted, safety/fail-safe equipment installed, and improvements in safety performance from these measures	
9	Injury rate	Injury rate categorized on injury type, such as puncture, laceration, or strain	
10	Line stops due to safety concerns	Line stops due to safety concerns	

11	Representation in joint management-worker health and safety committees	Employees represented in formal joint management–worker health and safety committees that help monitor and advise on occupational health and safety programs	
12	Health and safety agreements	Health and safety topics covered in formal agreements with trade unions	
13	Diffusion of work-related illness	Spread of work-related illness	
14	OSHA reported events	OSHA reported events categorized by process and/or product being manufactured	
15	Average hours of training	Average hours of training per year per employee by employee category	
16	Skills management programs	Indicate the implementation of your company's formalized skill mapping and developing process for: Executive/Top management, Middle/General management, First line management/Supervisor, Specialists groups, Other employees	
17	Employee performance and career development review	Employees receiving regular performance and career development reviews categorized by employee type	
18	Employee Training in Sustainability	Employees trained in basic sustainability concepts and/or current sustainability initiatives	
19	Job satisfaction	Satisfaction level of your employees	

Category B: Customer Indicators

	Name	Definition	Score
1	Life cycle assessment for health and safety impacts	Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and significant products and services categories subject to such procedures	
2	Incidents of non-compliance with voluntary codes	Incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes	

3	Product quality assurance and management	Incidents of product recalls and customer complaints, and resolutions met from these incidents	
4	Customer satisfaction assessment	Practices related to customer satisfaction, including results of surveys measuring customer satisfaction	
5	Customer complaints	Customer complaints received concerning a product or service for an organization	
6	Product and service information required by procedures	Product and service information required by procedures, and significant products and services subject to such information requirements	

Category C: Community Indicators

	Name	Definition	Score
1	Legal actions for anti-competitive behavior	Legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes	
2	Composition of governance bodies	Composition of governance bodies and breakdown of employees per category according to gender, age group, minority group membership, locality, and other indicators	
3	Salary ratio	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation and range of basic wage of men to women by employee category	
4	Composition of workforce	Composition of workforce and breakdown of employees per category according to gender, age group, minority group membership, locality, and other indicators	
5	Employee turnover	Rate of employee turnover by age group, gender, and region	
6	Operation risk assessment for child labor	Operations identified as having significant risk for incidents of child labor, and measures taken to contribute to the elimination of child labor	
7	Operation risk assessment for force compulsory labor	Operations identified as having significant risk for incidents of forced or compulsory labor, and measures to contribute to the elimination of forced or compulsory labor	
8	Employees covered by collective	Employees covered by collective bargaining agreements	

	bargaining		
9	Operation change notice period	Minimum notice period(s) regarding operational changes, including whether it is specified in collective agreements	
10	Operation risk assessment for freedom of association and collective bargaining	Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights	
11	Human rights screening	Significant investment agreements that include human rights clauses or that have undergone human rights screening and participation in developed human rights declarations (UN Universal Declaration of Human Rights, ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, OECD Guidelines for Multinational Enterprises, etc.)	
12	Human rights screening for suppliers and contractors	Significant suppliers and contractors that have undergone screening on human rights and actions taken	
13	Human rights training	Employee training on policies and procedures concerning aspects of human rights that are relevant to operations	
14	Incidents of discrimination	Incidents of discrimination and actions taken	
15	Anti-corruption training	Employees trained in organization's anti-corruption policies and procedures categorized by type	
16	Response to incidents of corruption	Actions taken in response to incidents of corruption	
17	Paid bribes	Employees having been asked or having complied with expectation by government officials or other outside officials to pay a bribe for his or her services.	
18	Incident of conflict of interests	Conflicts of interests or ethical dilemmas for an organization and its reporting, auditing, and operating agencies	
19	General non-compliance fines for products	Significant fines for non-compliance with laws and regulations concerning the provision and use of products and services	
20	Incidents of	Incidents of non-compliance with	

	marketing communications or product non-compliance	regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship or product and service information and labeling, by type of outcomes.	
21	Programs for adherence to laws	Programs for adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship	
22	Violations of human rights	Incidents of violations involving rights of indigenous people and actions taken	
23	Sustainability report publishing	Public reporting of common sustainability assessments and level of reporting of those assessments (i.e. GRI, WSPI, etc.)	

Thank you for your participation

Appendix A.3: Economic Expert Survey (English)

Master Program of Sustainable Engineering in Production

Dear Participant:

My name is Tariq Talhami and I am a graduate student in the program Sustainable Engineering in Production, a joint program between Birziet and An-Najah. For my thesis, I am developing a tool to assess the sustainability of local plastic manufacturers. Because you are an expert in one or more fields of that the assessment covers, I am inviting you to participate in this research study by completing the attached surveys.

The following questionnaire will require approximately 10 minutes to complete. If you choose to participate in this project, please answer all questions as honestly as possible and return the completed questionnaires promptly to this same Email.

Thank you for taking the time to assist me in my educational endeavors. The data collected will provide useful information regarding selecting suitable indicators for sustainability. If you require additional information or have questions, please contact me at the number listed below.

Sincerely,

Tariq Talhami

0592041094

Tariq.talhami@gmail.com

Part 1: General Information about the Expert

Name		
Telephone No.		
E-mail address		
Name of Organization		
Position at Organization		
Type of organization		**Government**
		NGO
		Academic institution
Field of work of organization (for NGO only)		

Part 2: Indicator Assessment

Please judge the following indicators according to how important they are as sustainability assessment indicators for Palestinian industries. **(5: Very important, 1: Very unimportant)**

Category A: Profit Indicators

	Name	Definition	Score
1	Revenue	Revenue attributable to manufacturing a product	
2	Profits generated	Total net profits for an organization or product	

Category B: Manufacturing Cost Indicators

	Name	Definition	Score
1	Material acquisition costs	Costs for acquiring materials used within the manufacturing process for a product or an organization	
2	Energy costs	Cost for energy used in the production process for an organization or a product	
3	Tooling costs	Costs for tooling including fixtures and jigs used during the manufacturing process for an organization or product	
4	Labor costs	Costs of labor (specified by indirect and direct) used during the manufacturing process for an organization or product	
5	Waste treatment costs	Costs for waste treatment processes (including separation and disposal of	

		hazardous materials, wastewater treatment, etc.) used during the manufacturing process for an organization or a product	
6	Packaging costs	Costs for packaging process (including materials and reclaimation)of a product or total packaging cost for an organization	
7	Delivery costs	Costs for transportation of product to customer including fuel costs, labor costs, and equipment costs	
8	Storage costs	Costs for storage of product for an organization	
9	Brand management costs	Investments and expenditures in advertising, marketing, and branding of a product or technology	
10	Responsibility, risk & crisis management	Cost associated with managing employee responsibilities in reporting or assessing risks and crisis programs for an organization	
11	Employment costs and employee benefits	Costs and benefits afforded an organization in hiring and retaining personnel	
12	Environmental protection expenditures	Expenditures in maintaining environmentally protected areas, ecosystems, and/or habitats. Includes: expenditures for air emission, water effluent treatments, solid wastes, and carbon credit or certified emission reductions (CERs) issued by Clean Development Mechanism (CDM)	
13	Use energy costs	Cost for energy used during the use-phase of a product. Includes fuel costs, electricity costs, etc.	
14	User taxation	Costs of taxes accrued for a product during its use-phase life	
15	Recycling costs for WEEE	Cost to recycle a product or costs associated with recycling for an organization	
16	(Labor) Productivity	Output for a given process per unit labor required. Labor required can account for value-added activities, as well as, non-value added activities.	

Category C: Investment Indicators

	Name	Definition	Score
1	Innovation & R/D investments	Investments and expenditures in scientific research and experimental development (R&D) for future innovative products and technologies	
2	Charitable investments and community development	Investments in non-profit organizations and general charity organizations for an organization	
3	Renewable energies and energy efficiency investments	Investment in renewable energy and energy efficiency improvements specifically applied to an organization's operations	

Thank you for your participation

Appendix B: Industry Survey

برنامج هندسة الإستدامة في الانتاج

تحية طيبة و بعد،

أنا طارق تلحمي ، طالب ماجستير في برنامج هندسة الإستدامة في الإنتاج المشترك بين جامعة بيرزيت و جامعة النجاح الوطنية، أقوم بإعداد رسالتي البحثية بعنوان "تطوير اداة تقييم إستدامة المنشآت الصناعية البلاستيكية في فلسطين". حيث أن قياس مؤشرات الاستدامة ستساعد على تحسين إستدامة منشأت الصناعية مما يؤثر بشكل إيجابي على البيئة و المجتمع و المنشأة نفسها، و يزيد أيضا من القدرة على المنافسة في الأسواق المحلية و العالمية.

الإستبيان التالي يحتاج الى ثلاثين دقيقة لإكماله ، يرجى إتمامه بشكل كامل و بدقة.

شكرا لمشاركتم في إتمام الاستبيان ، مع العلم بأن المعلومات التي تقومون بتوفيرها ستستخدم فقط لأهداف تعليمية و تعتبر جزء اساسي من الرسالة ، فشكرا لكم على جهودكم ووقتكم للإجابة على الإستبيان.

مع الشكر و فائق التقدير

م. طارق تلحمي
0592041094
tariq.talhami@gmail.com

الجزء الاول: معلومات عامة عن المنشأة

اسم المنشأة		
العنوان		
معلومات التواصل	الهاتف	
	البريد الاكتروني	
مجال العمل		
عدد سنوات عمل المنشأة		
عدد الموظفين الدائمين		

الجزء الثاني: معلومات عامة عن معبيء الإستبيان

الإسم		
المنصب		
عدد سنوات العمل في المنشأة		
معلومات التواصل	الهاتف	
	البريد الالكتروني	

الجزء الثالث: تقييم قابلية تطبيق المؤشر

يكون هذا الجزء من ثلاثة أقسام (مؤشرات بيئية و إجتماعية و إقتصادية) ، يرجى تقييم المؤشرات حسب المعايير بعلامة من 1 إلى 5.

(1 = لا أوافق بشدة ، 2 = لا أوافق ، 3 = محايد ، 4 = أوافق ، 5 = أوافق بشدة)

أ) المؤشرات البيئية:

الرقم	المؤشر	المؤشر له صلة كبيرة بمجال عمل الشركة	يلزم وقت قليل للقياس المؤشر	يلزم موارد قليلة لقياس المؤشر	البيانات المتعلقة بالمؤشر متوفرة بسهولة	فهم المؤشر سهل لغير المتخصصين
	مثال	**3**	**2**	**5**	**2**	**4**
1	كمية مياه الصرف					
2	مياه الصرف الصحي المعالجة / غير المعالجة					
3	مجموع النفايات					
4	المواد الخطرة المستخدمة					
5	المواد السامة بيئيا المتسربة					
6	تسرب المواد الكيميائية					
7	المواد السامة بيئيا المنبعثة					
8	انبعاثات غازات الاحتباس الحراري					
9	جودة الهواء					
10	انبعاث الجسيمات					
11	المواد المحددة المستخدمة					
12	المواد المعاد تدويرها /استخدامها / توجيهها/ تصنيعها					
13	استهلاك السوائل					
14	المواد القابلة لإعادة التدوير ولإعادة الاستخدام المستخدمة من مزودو الخدمة المتعاقدون					
15	استهلاك الطاقة					
16	كثافة استخدام الطاقة					
17	المياه المستخدمة حسب المصدر					
18	المياه المعاد تدويرها المستخدمة					

19	جودة المياه المدخلة					
20	الأرض المستخدمة					
21	الاراضي المجاوية المحمية					

ب) المؤشرات الإجتماعية:

الرقم	المؤشر	المؤشر له صلة كبيرة بمجال عمل الشركة	يلزم وقت قليل للقياس المؤشر	يلزم موارد قليلة لقياس المؤشر	البيانات المتعلقة بالمؤشر متوفرة بسهولة	يسهل على غير المختصون فهم المؤشر
	مثال	**3**	**2**	**5**	**2**	**4**
1	معدل الإصابات					
2	برامج التثقيف الصحي					
3	عدد الأيام المرضية					
4	ايام الإجازات المدفوعة					
5	تعرض الموظف لسموم					
6	الإجراءات القانونية للسلوك المناهض للمنافسة					
7	نسبة الراتب					
8	تركيبة القوى العاملة					
9	تقييم مخاطر التشغيل لعمالة الأطفال					
10	تقييم مخاطر التشغيل للقوة العاملة الإجبارية					
11	فحص حقوق الإنسان					
12	فحص حقوق الإنسان للموردين والمقاولين					
13	حوادث التمييز					
14	تدريب لمكافحة الفساد					

15	عدد حوادث تضارب المصالح					
16	غرامات عدم الامتثال العام للمنتجات					
17	غرامات عدم الامتثال العام للمنتجات					
18	حوادث الاتصالات التسويقية أو عدم الامتثال للمنتجات					
19	برامج للالتزام بالقوانين					
20	انتهاكات حقوق الإنسان					
21	نشر تقرير الاستدامة					

ج) المؤشرات الإقتصادية:

الرقم	المؤشر	المؤشر له صلة كبيرة بمجال عمل الشركة	يلزم وقت قليل للقياس المؤشر	يلزم موارد قليلة لقياس المؤشر	البيانات المتعلقة بالمؤشر متوفرة بسهولة	يسهل على غير المختصون فهم المؤشر
	مثال	**3**	**2**	**5**	**2**	**4**
1	الايرادات					
2	الربح					
3	تكاليف شراء المواد					
4	تكاليف الطاقة					
5	تكاليف الأدوات					
6	تكاليف العمالة					
7	تكاليف معالجة النفايات					
8	تكاليف التغليف					
9	تكاليف النقل					
10	تكاليف التخزين					

11	تكاليف إدارة العلامة التجارية					
12	المخاطر وإدارة الأزمات					
13	تكاليف التوظيف					
14	نفقات الحماية البيئية					
15	تكاليف الطاقة عند الاستخدام					
16	ضريبة المستخدم					
17	تكاليف إعادة تدوير المنتج					
18	انتاجية العامل					
19	استثمارات الابتكار و البحث و التطوير					
20	الاستثمارات الخيرية وتنمية المجتمع					

تعريفات المؤشرات

ت) المؤشرات البيئية:

	اسم المؤشر	التعريف
1	كمية مياه الصرف	كمية مياه الصرف التي تصرفها منظمة أو عملية محددة حسب الفئة (أي السمية البيئية أو الخطرة أو المعالجة أو غير المعالجة أو المعاد استخدامها أو غير السامة البيئية أو غير ذلك)
2	مياه الصرف الصحي المعالجة / غير المعالجة	نسبة مياه الصرف التي تصرفها منظمة أو عملية تتم معالجتها ، من أجل تقليل الملوثات قبل تصريفها في البيئة.
3	مجموع النفايات	كمية النفايات الناتجة عن منظمة أو عملية أو منتج محدد حسب الفئة (أي السمية البيئية ، أو القابل للتصرف ، أو القابل لإعادة التدوير ، أو إعادة الاستخدام ، إلخ.)
4	المواد الخطرة المستخدمة	كمية المواد الخطرة التي تستخدمها منظمة أو عملية في إنتاج منتج ما. يشمل المواد الخاضعة للرقابة ، والخطرة ، والمشعة ، والمعادن الثقيلة ، والمواد الكيميائية السامة ، الخ. يشمل: الرصاص (Pb) ، الزئبق (Hg)، Hexavalent Chromium (Cr6 +) ، الكادميوم (Cd) ، مثبطات اللهب ثنائية الفينيل متعددة البروم (PBB) ، مثبطات اللهب ثنائي الفينيل متعدد البروم ثنائي الفينيل (PBDE).
5	المواد السامة بيئيا المتسربة	كمية النفايات الخطرة في مياه الصرف التي يتم تصريفها المنظمة أو العملية. يشمل: المواد الخاضعة للرقابة ، المواد الخطرة ، المشعة ، المعادن الثقيلة ، المواد الكيميائية السامة ، إلخ.
6	تسرب المواد الكيميائية	عدد و كمية التسربات للمواد الكيميائية.
7	المواد السامة بيئيا المنبعثة	مواد سامة بيئية محددة تنبعث من منشأة أو عملية و / أو منتج تابع لمنظمة ما. يشمل: الملوثات العضوية الثابتة (POPs) ، والمعادن الثقيلة ، والإشعاع ، والملوثات الأخرى
8	انبعاثات غازات الاحتباس الحراري	غازات الاحتباس الحراري المنبعثة و تشمل: CO2 CH4 N2O CFCs NOx Sox الخ.
9	جودة الهواء	جودة الهواء داخل المناطق المحيطة بالمنشأة وفي المناطق المحيطة بها ، بما في ذلك الضباب الدخاني ، والرؤية ، والرائحة ، وتركيز غازات الدفيئة ، وتركيز الملوثات ، إلخ.
10	انبعاث الجسيمات	انبعاثات الجسيمات الصغيرة من المنشأة أو العمليات.
11	المواد المحددة المستخدمة	كمية ونوع المواد المستخدمة من قبل منظمة أو عملية أو منتج.
12	المواد المعاد تدويرها /استخدامها / توجيهها/ تصنيعها	كمية ونوع المواد المعاد تدويرها أو المعاد استخدامها أو المعاد توجيهها أو المعاد تصنيعها والتي تستخدمها منظمة أو عملية أو منتج.
13	استهلاك السوائل	كمية السوائل الإضافية التي تستخدمها منظمة أو عملية بما في ذلك: المنظفات ، ومواد التشحيم ، والزيوت ، والمبردات ، إلخ.
14	المواد القابلة لإعادة التدوير ولإعادة الاستخدام المستخدمة من مزودو الخدمة	كمية المواد القابلة لإعادة التدوير والقابلة لإعادة الاستخدام التي يستخدمها مقدمو الخدمات المتعاقدون.

	المتعاقدون	
15	استهلاك الطاقة	كمية الطاقة المستهلكة من قبل منظمة أو عملية أو منتج. يتم تحديد الطاقة حسب المصدر والنوع.
16	كثافة استخدام الطاقة	نسبة الطاقة المستخدمة من قبل منظمة أو عملية إلى الطاقة المتاحة لمنظمة أو عملية.
17	المياه المستخدمة حسب المصدر	كمية الطاقة التي تستهلكها منظمة أو عملية أو منتج تصنفه مصادر متجددة (مثل الطاقة الكهرومائية ، الرياح ، الطاقة الشمسية ، المد والجزر ، الكتلة الحيوية ، إلخ.)
18	المياه المعاد تدويرها المستخدمة	مياه عادمة يتم معالجتها وإعادة استخدامها داخل منظمة أو عملية تصنيع.
19	جودة المياه المدخلة	كمية الملوثات داخل إمدادات المياه. يشمل البكتيريا القولونية ، والعناصر الغذائية ، والملوثات ، والأكسجين ، والفوسفور ، والمواد الصلبة المعلقة.
20	الأرض المستخدمة	الأرض المستخدمة من قبل منشأة مصنفة حسب المناطق الخصبة وغير الخصبة.
21	الاراضي المجاوية المحمية	المناطق المحمية المحيطة أو التي أعيد تأهيلها في المناطق المحيطة بالمنشأة.

ث) المؤشرات الإجتماعية:

	اسم المؤشر	**التعريف**
1	معدل الإصابات	الحوادث التي تتطلب الإسعافات الأولية
2	برامج التثقيف الصحي	مشاركة الموظف في برامج التثقيف الصحي التي تروج لها المنظمة
3	ايام مرضية	نسبة أيام المرض إلى أيام العمل
4	اجازات مدفوعة	اجازات مدفوعة
5	تعرض الموظف لسموم	تعرض الموظف لسموم محددة و اثار هذه السموم
6	الإجراءات القانونية للسلوك المناهض للمنافسة	الإجراءات القانونية للسلوك المناهض للمنافسة وممارسات مناهضة الثقة وممارسات الاحتكار ونتائجها
7	نسبة الراتب	نسب الأجور القياسية لمستوى المدخل مقارنة بالأجور المحلية الدنيا في المواقع المهمة للتشغيل ومدى الأجر الأساسي للرجال بالنسبة للمرأة حسب فئة الموظف
8	تركيبة القوى العاملة	تكوين القوى العاملة وتفكك الموظفين لكل فئة وفقًا لنوع الجنس والفئة العمرية وعضوية مجموعة الأقلية والمحلية والمؤشرات الأخرى
9	تقييم مخاطر التشغيل لعمالة الأطفال	العمليات التي تم تحديدها على أنها تنطوي على مخاطر كبيرة لحوادث عمل الأطفال ، والتدابير المتخذة للمساهمة في القضاء على عمل الأطفال
10	تقييم مخاطر التشغيل للقوة العاملة الإجبارية	العمليات التي تم تحديدها على أنها تنطوي على مخاطر كبيرة لحوادث العمل القسري أو الإجباري ، وتدابير للمساهمة في القضاء على العمالة القسرية أو الإجبارية
11	تقييم المخاطر من	العمليات التي تم تحديدها والتي قد يكون فيها الحق في ممارسة حرية

	أجل حرية تكوين الجمعيات والمفاوضة الجماعية	تكوين الجمعيات والمفاوضة الجماعية عرضة لخطر كبير ، والإجراءات المتخذة لدعم هذه الحقوق.
12	فحص حقوق الإنسان	اتفاقيات استثمار كبيرة تشمل بنود حقوق الإنسان أو خضعت لفحص حقوق الإنسان والمشاركة في إعلانات حقوق الإنسان المتقدمة (إعلان الأمم المتحدة العالمي لحقوق الإنسان ، إعلان مبادئ ثلاثي الأطراف لمنظمة العمل الدولية بشأن الشركات متعددة الجنسيات والسياسة الاجتماعية ، المبادئ التوجيهية لمنظمة التعاون والتنمية في الميدان الاقتصادي للشركات متعددة الجنسيات ، إلخ.)
13	فحص حقوق الإنسان للموردين والمقاولين	كبار الموردين والمقاولين الذين خضعوا لفحص حقوق الإنسان والإجراءات المتخذة
14	حوادث التمييز	حوادث التمييز والإجراءات المتخذة
15	تدريب لمكافحة الفساد	التدريب على سياسات وإجراءات مكافحة الفساد في المؤسسة المصنفة حسب النوع
16	عدد حوادث تضارب المصالح	تضارب المصالح أو المعضلات الأخلاقية لمنظمة ما ووكالات إعداد التقارير والتدقيق والوكالات
17	غرامات عدم الامتثال العام للمنتجات	غرامات كبيرة لعدم الامتثال للقوانين واللوائح المتعلقة بتوفير واستخدام المنتجات والخدمات
18	حوادث الاتصالات التسويقية أو عدم الامتثال للمنتجات	حوادث عدم الامتثال للأنظمة والقواعد الطوعية المتعلقة بالاتصالات التسويقية ، بما في ذلك الإعلان والترويج والرعاية ، أو معلومات عن المنتجات والخدمات ووضع العلامات ، حسب نوع النتائج.
19	برامج للالتزام بالقوانين	برامج للالتزام بالقوانين والمعايير والقواعد الطوعية المتعلقة بالاتصالات التسويقية ، بما في ذلك الإعلانات والترويج والرعاية
20	انتهاكات حقوق الإنسان	حوادث الانتهاكات التي تنطوي على حقوق السكان الأصليين والإجراءات المتخذة
21	نشر تقرير الاستدامة	الإبلاغ العام عن تقييمات الاستدامة المشتركة ومستوى الإبلاغ عن تلك التقييمات (GRI، WSPI ، إلخ.)

ح) المؤشرات الإقتصادية:

	اسم المؤشر	**التعريف**
1	الايرادات	الإيرادات المنسوبة إلى تصنيع منتج
2	الربح	إجمالي صافي الأرباح لمؤسسة أو منتج
3	تكاليف شراء المواد	تكاليف الحصول على المواد المستخدمة في عملية التصنيع لمنتج أو منظمة
4	تكاليف الطاقة	تكلفة الطاقة المستخدمة في عملية الإنتاج لمؤسسة أو منتج
5	تكاليف الأدوات	تكاليف الأدوات المستخدمة أثناء عملية التصنيع لمؤسسة أو منتج
6	تكاليف العمالة	تكاليف العمالة (بطريقة مباشرة و غير مباشرة) المستخدمة أثناء عملية التصنيع لمنظمة أو منتج
7	تكاليف معالجة النفايات	عمليات معالجة النفايات (بما في ذلك فصل المواد الخطرة والتخلص منها ومعالجة مياه الصرف الصحي ، إلخ) المستخدمة أثناء عملية التصنيع لمنظمة أو منتج
8	تكاليف التغليف	تكاليف عملية التعبئة والتغليف (بما في ذلك المواد واستخلاصها) من المنتج أو التكلفة الإجمالية للتغليف للمنظمة
9	تكاليف النقل	تكاليف نقل المنتجات إلى الزبون بما في ذلك تكاليف الوقود وتكاليف

		العمالة وتكاليف المعدات
10	تكاليف التخزين	تكاليف تخزين المنتج للمؤسسة
11	تكاليف إدارة العلامة التجارية	الاستثمارات والنفقات في مجال الإعلان والتسويق والعلامة التجارية لمنتج أو تقنية
12	المخاطر وإدارة الأزمات	التكلفة المرتبطة بإدارة مسؤوليات الموظف في الإبلاغ عن المخاطر أو برامج الأزمات أو تقييمها للمنظمة
13	تكاليف التوظيف	تكاليف توظيف و إعادة تدريب الموظفين الجدد
14	نفقات الحماية البيئية	لنفقات في صيانة المناطق المحمية بيئيًا والنظم الإيكولوجية و الموائل. تشمل: نفقات انبعاث الهواء ، ومعالجة مياه الصرف ، والنفايات الصلبة.
15	تكاليف الطاقة عند الاستخدام	تكلفة الطاقة أثناء مرحلة استخدام المنتج. يشمل تكاليف الوقود وتكاليف الكهرباء ، إلخ.
16	ضريبة المستخدم	تكاليف الضرائب المتراكمة لمنتج ما خلال فترة الاستخدام
17	تكاليف إعادة تدوير المنتج	تكاليف إعادة تدوير المنتج
18	انتاجية العامل	الانتاج لعملية معينة لكل وحدة عمل المطلوبة. يمكن أن يكون العمل العملية ذات القيمة المضافة ، بالإضافة إلى الأنشطة التي لا تضيف قيمة.
19	استثمارات الابتكار و البحث و التطوير	الاستثمارات والنفقات في البحث العلمي والتطوير التجريبي (R & D) للمنتجات والتقنيات المبتكرة في المستقبل
20	الاستثمارات الخيرية وتنمية المجتمع	الاستثمارات في المنظمات غير الربحية والمنظمات الخيرية العامة لمنظمة

Appendix C: preliminary List of Indicators

Part A: Environmental Stewardship

Emission indicators:

#	Name	Definition	Unit
1	Waste water amount	Amount of waste water discharged by an organization or process specified by category (i.e. eco-toxic, hazardous, treated, non-treated, reused, non eco-toxic, etc.)	Volume of total waste water discharged by an organization or process categorized by type
2	Treated/non-treated waste water	Proportion of waste water discharged by an organization or process that is treated, in order to reduce pollutants before being discharged to the environment, by level of treatment (primary, secondary or tertiary)	Volume or percent of waste water discharged by an organization or process that is treated categorized by level of treatment (primary, secondary, or tertiary)
3	Total generated waste	Amount of waste generated by an organization, process, or product specified by category (i.e. eco-toxic, disposable, recyclable, reusable, etc.)	Kilograms of waste produced by an organization, process, or product categorized by type
4	Reusable, Recyclable and Remanufacturable waste produced	Amount of waste that is reusable, recyclable and remanufacturable in the production process for an organization or process	Kilograms or percent of waste produced by an organization or process that is reusable, recyclable and remanufacturable categorized by type

Pollution indicators:

#	Name	Definition	Unit
1	Hazardous materials used	Amount of hazardous materials used by an organization or process in the production of a product. Includes regulated materials, hazardous, radioactive, heavy metals, toxic chemical, etc. Includes: Lead (Pb), Mercury (Hg), Hexavalent Chromium (Cr6+), Cadmium (Cd), Polybrominated biphenyl flame retardants (PBB), Polybrominated diphenyl ether flame retardants	Kilograms or percent of waste produced by an organization, process, and/or product that is a regulated toxic/hazardous material categorized by type

		(PBDE),	
2	Eco-toxic substance effluent	Amount of hazardous wastes in water effluent discharged by organization or process. Includes: regulated materials, hazardous, radioactive, heavy metals, toxic chemicals, etc.	Volume or percent of waste water discharged by an organization or process containing toxic/hazardous materials categorized by type
3	Chemical Spills	Total number and volume of significant spills at an organization's facility	Number and volume of significant spills at an organization's facility
4	Eco-toxic substances emission	Specific eco-toxic substances emitted by an organization's facility, process, and/or product. Includes: persistent organic pollutants (POPs), heavy metals, radiation, and other pollutants	Kilograms or percent of eco-toxic substances emitted categorized by type for an organization's facility, process, or product
5	Green House Gases emissions	GHGs emitted by an organization's facility, process, and/or product. Includes: CO2, CH4, N2O, CFCs, NOx, SOx, etc.	Kilograms or percent of GHGs emitted categorized by type for an organization's facility, process, or product
6	Noise emission	Noise and vibrations emitted from an organization's facility, process, and/or product	Decibels of noise emission from an organizations facility, process, and/or product
7	Acidification substances	Emissions of specific acidifying substances from an organization's facility or process	Weight of or percent of acidifying substances emitted from an organizations facility per organization, process, product
8	Air quality	Air quality of within and in surrounding areas of an organization's facility including smog, visibility, odor, GHG concentration, pollutant concentration, etc.	Values for given air quality indicators including smog, visibility, odor, GHG concentration, pollutant concentration
9	Particulate emission	Emissions of small particles by an organization's facility, process, and/or product	Kilograms of fine particulates in emitted air from an organization's facility, process, or product

Resource Consumption Indicators:

#	Name	Definition	Unit
1	Specific material used	Amount and type of materials used by an organization, process, and/or product	Kilograms and percent of specific materials used by an organization, process, or product categorized by type
2	Material intensity	Ratio of the amount of materials	Ratio of the amount of materials

		needed for an organization, process, or product to the amount of materials used by an organization, process, or product	needed for an organization, process, or product to the amount of materials used by an organization, process, or product
3	Specific recycled, reused, repurposed or remanufactured material	Amount and type of recycled, reused, repurposed or remanufactured materials used by an organization, process, and/or product	Kilograms and percent of specific recycled, reused, repurposed or remanufactured materials used by an organization, process, or product categorized by type
4	Fluid consumption	Amount of auxiliary fluids used by an organization or process including: cleaners, lubricants, oils, coolants, etc.	Volume or dollar amount of auxiliary fluids used by an organization or process
5	Recyclable and reusable materials used by contracted service providers	Amount of recyclable and reusable materials used by contracted service providers	Kilograms or percent of materials used by a contracted service provider that are reused and/or recycled
6	Reclaimed packaging	Generation, disposal, and/or recycling of packaging waste for a product	Kilograms or percent of packaging materials that are reclaimed and recycled
7	After-sales servicing materials	Quantity of materials used during after-sales servicing of products	Kilograms or dollar amount of materials used for after-sales servicing of products per product
8	Energy consumption	Amount of energy consumed by an organization, process, or product. Energy is specified by source and type	Energy measure or dollar amount of consumed energy directly attributable to the manufacturing process and/or product use categorized by type
9	Energy intensity	Ratio of the energy used by an organization or process to the energy available for an organization or process	Ratio of the energy used by an organization or process to the energy available for an organization or process
10	Renewable energy consumption	Amount of energy consumed by an organization, process, or product that is categorized by renewable sources (i.e. hydropower, wind, solar, tide and wave, biomass, etc.)	Energy measure or dollar amount of consumed energy that is renewable categorized by type/source
11	Renewable energy generated	Amount of energy generated by an organization that is classified as renewable (i.e. hydropower, wind, solar, tide and wave, biomass, etc.)	Amount of energy generated in energy measure or dollar amount by an organization that is renewable categorized by type/source
12	Energy efficiency	Ratio of the actual energy	Ratio of the actual energy

		consumed by an organization, process, or product to the theoretical energy needed for the organization, process, or product	consumed by an organization, process, or product to the theoretical energy needed for the organization, process, or product
13	Water used by source	Total water used by an organization, process, or product categorized by type/source	Volume and percent of water used by an organization, process, or process categorized by type/source
14	Recycled water used	Waste water that is treated and reused within an organization or a manufacturing process	Volume or percent of water recycled and used, specified by level of treatment (primary, secondary or tertiary)
15	Intake water quality	Amount of contaminants and nutrients within intake water supply and groundwater. Includes coli-form bacteria, nutrients, pollutants, oxygen, phosphorus, suspended solids	Proportion of contaminants/nutrients per liter of intake water at a given point of time. Values of common water quality indicators for intake water
16	Land used	Land used by an organization's facility categorized by fertile and non-fertile areas	Square feet of an organizations facility categorized by fertile and non-fertile areas
17	Land quality	Waste effects on land quality indicated by surface integrity, soil nutrients and contaminants, non-fertile land, salanized areas, etc.	Values for given land quality indicators of surrounding lands of an organization's facility including surface integrity, soil nutrients and contaminants, non-fertile land, salanized land areas, etc.
18	Surrounding protected lands	Areas protected surrounding facility and/or rehabilitated in surrounding areas of an facility	Land area of protected lands surrounding an organization's facility

Part B: Economic Growth

Profit Indicators:

#	Name	Definition	Unit
1	Revenue	Revenue attributable to manufacturing a product	Dollar amount
2	Profits generated	Total net profits for an organization or product	Dollar value of profits generated by an organization or product

Manufacturing cost indicators:

#	Name	Definition	Unit
1	Material acquisition costs	Costs for acquiring materials used within the manufacturing process for a product or an organization	Dollar amount for acquiring materials used within the manufacturing process for a product or an organization
2	Energy costs	Cost for energy used in the production process for an organization or a product	Dollar amount for energy used in the production process for an organization or a product
3	Tooling costs	Costs for tooling including fixtures and jigs used during the manufacturing process for an organization or product	Dollar amount for tooling including fixtures and jigs used during the manufacturing process for an organization or product
4	Labor costs	Costs of labor (specified by indirect and direct) used during the manufacturing process for an organization or product	Dollar amount of labor (specified by indirect and direct) used during the manufacturing process for an 6organization or product
5	Waste treatment costs	Costs for waste treatment processes (including separation and disposal of hazardous materials, wastewater treatment, etc.) used during the manufacturing process for an organization or a product	Dollar amount of waste treatment processes (including separation and disposal of hazardous materials, wastewater treatment, etc.) used during the manufacturing process for an organization or a product
6	Packaging costs	Costs for packaging process (including materials and reclaimation)of a product or total packaging cost for an organization	Dollar amount for packaging process (including materials and reclaimation) of a product or total packaging cost for an organization
7	Delivery costs	Costs for transportation of product to customer including fuel costs, labor costs, and equipment costs	Dollar amount for transportation of product to customer including fuel costs, labor costs, and equipment costs
8	Storage costs	Costs for storage of product for an organization	Dollar amount for storage of product per product or total for an organization
9	Brand management costs	Investments and expenditures in advertising, marketing, and branding of a product or technology	Dollar amount or percent of investments in marketing and advertising per an organization or product
10	Responsibility, risk & crisis management	Cost associated with managing employee responsibilities in reporting or assessing risks and crisis programs for an organization	Dollar amount for managing employee responsibilities in reporting or assessing risks and crisis programs for an organization
11	Employment costs and employee	Costs and benefits afforded an organization in hiring and	Dollar amount afforded to an organization for hiring and

	benefits	retaining personnel	retaining employees
12	Environmental protection expenditures	Expenditures in maintaining environmentally protected areas, ecosystems, and/or habitats. Includes: expenditures for air emission, water effluent treatments, solid wastes, and carbon credit or certified emission reductions (CERs) issued by Clean Development Mechanism (CDM)	Dollar amount or percent of expenditures for maintaining environmental protection goals per an organization
13	Cost of energy in use phase	Cost for energy used during the use-phase of a product. Includes fuel costs, electricity costs, etc.	Dollar amount for energy used during the use-phase of a product per product
14	User taxation	Costs of taxes accrued for a product during its use-phase life	Dollar amount of taxes accrued for a product during its use-phase life
15	Recycling costs for WEEE	Cost to recycle a product or costs associated with recycling for an organization	Dollar value of recycling costs for a product or dollar value of total recycling costs for an organization
16	(Labor) Productivity	Output for a given process per unit labor required. Labor required can account for value-added activities, as well as, non-value added activities.	Ratio value of actual labors hours to planned labor hours for in performing an operation or manufacturing a product

Investment indicators:

#	Name	Definition	Unit
1	Innovation & R/D investments	Investments and expenditures in scientific research and experimental development (R&D) for future innovative products and technologies	Dollar amount or percent of R&D funds for the development of innovative technologies per product or per organization
2	Charitable investments and community development	Investments in non-profit organizations and general charity organizations for an organization	Dollar amount of investments in non-profit organizations and general charity organizations for an organization and community development
3	Renewable energies and energy efficiency investments	Investment in renewable energy and energy efficiency improvements specifically applied to an organization's operations	Dollar amount or percent of investments for renewable energies, emission reductions, clean development and energy efficiency improvements per an organization

Part C: Social Well-being

Employee indicators:

#	Name	Definition	Unit
1	Injury rate	Accidents requiring first aid	Number or percent of accidents requiring first aid
2	Lost workdays	Workdays missed due to accidents and sickness	Number or percent of workdays missed due to accidents
3	Health education and wellness programs	Employee participation in on-site health education/wellness programs promoted by an organization	Number or percent of employee participation in on-site health education/wellness programs promoted by an organization
4	Sick days	Ratio of sick days to work days	Ratio of sick days to work days
5	Health index of on-site food (cafeteria)	Health index of on-site food	Health index of on-site food
6	Paid days off	Paid days off	Number of paid days off per facility or per employee
7	Employee toxin exposure	Employee exposed to specific toxins and the affects of these exposures-days away due to exposure to toxins	Number of employees or percent of employees exposed to specific toxins, and the number of days away due to exposure to these toxins
8	Safety measures adopted	Number of safety measures adopted, safety/fail-safe equipment installed, and improvements in safety performance from these measures	Number or percent of safety measures adopted, safety/fail-safe equipment installed, and estimated reductions in dollar amount from abating accidents from these measures
9	Injury rate	Injury rate categorized on injury type, such as puncture, laceration, or strain	Injury rate based on injury type, such as puncture, laceration, or strain
10	Line stops due to safety concerns	Line stops due to safety concerns	Number or percent of line stops due to safety concerns
11	Representation in joint management-worker health and safety committees	Employees represented in formal joint management–worker health and safety committees that help monitor and advise on occupational health and safety programs	Number or percent of employees represented in formal joint management–worker health and safety committees that help monitor and advise on occupational health and safety programs
12	Health and safety agreements	Health and safety topics covered in formal agreements with trade unions	Qualitative
13	Diffusion of	Spread of work-related illness	Increase/decrease in number of

	work-related illness		employees affected by work-related illness once the illness is identified and controlled
14	OSHA reported events	OSHA reported events categorized by process and/or product being manufactured	Number of reported OSHA events categorized by process and/or product being manufactured
15	Average hours of training	Average hours of training per year per employee by employee category	Training per year per employee by employee category
16	Skills management programs	Indicate the implementation of your company's formalized skill mapping and developing process for: Executive/Top management, Middle/General management, First line management/Supervisor, Specialists groups, Other employees	Number of programs for skills management and lifelong learning that supports the continued employability of employees and assist them in managing career endings, and number or percent of employees participating in these programs
17	Employee performance and career development review	Employees receiving regular performance and career development reviews categorized by employee type	Number or percent of employees receiving regular performance and career development reviews categorized by employee type
18	Employee Training in Sustainability	Employees trained in basic sustainability concepts and/or current sustainability initiatives	Percentage of employees trained in basic sustainability concepts and/or current sustainability initiatives
19	Job satisfaction	Satisfaction level of your employees	Satisfaction level of your employees based employee surveys and reviews, and number or percent of employees participating in surveys and assessments

Customer Indicators:

#	Name	Definition	Unit
1	Life cycle assessment for health and safety impacts	Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and significant products and services categories subject to such procedures	Number of life cycle stages in which health and safety impacts of products and services are assessed for improvement, and number or percent of significant products and services categories subject to such procedures
2	Incidents of non-compliance with	Incidents of non-compliance with regulations and voluntary codes	Number of incidents of non-compliance with regulations and

	voluntary codes	concerning health and safety impacts of products and services during their life cycle, by type of outcomes	voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes
3	Product quality assurance and management	Incidents of product recalls and customer complaints, and resolutions met from these incidents	Number of or dollar amount paid from incidents of product recalls and customer complaints, and number or percent of resolutions met from these incidents
4	Customer satisfaction assessment	Practices related to customer satisfaction, including results of surveys measuring customer satisfaction	Number and dollar amount investment practices related to customer satisfaction, including results of surveys measuring customer satisfaction
5	Customer complaints	Customer complaints received concerning a product or service for an organization	Number of customer complaints per year received concerning a product and/or service
6	Product and service information required by procedures	Product and service information required by procedures, and significant products and services subject to such information requirements	Type of product and service information required by procedures, and percentage of significant products and services subject to such information requirements

Community indicators:

#	Name	Definition	Unit
1	Legal actions for anti-competitive behavior	Legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes	Number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and dollar amount ensued by their outcomes
2	Composition of governance bodies	Composition of governance bodies and breakdown of employees per category according to gender, age group, minority group membership, locality, and other indicators	Number or percent of corporate governance body broken down by category gender, age group, minority group membership, locality, and other indicators
3	Salary ratio	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation and range of basic wage of men to women by employee category	Ratios of standard entry level wage compared to local minimum wage at significant locations of operation and range of basic wage of men to women by employee category
4	Composition of workforce	Composition of workforce and breakdown of employees per	Number or percent of workforce broken down by category gender,

		category according to gender, age group, minority group membership, locality, and other indicators	age group, minority group membership, locality, and other indicators
5	Employee turnover	Rate of employee turnover by age group, gender, and region	Total number and rate of employee turnover by age group, gender, and region
6	Operation risk assessment for child labor	Operations identified as having significant risk for incidents of child labor, and measures taken to contribute to the elimination of child labor	Number or percent of operations identified as having significant risk for incidents of child labor, and number of resolutions met to eliminate of child labor
7	Operation risk assessment for force compulsory labor	Operations identified as having significant risk for incidents of forced or compulsory labor, and measures to contribute to the elimination of forced or compulsory labor	Number or percent of operations identified as having significant risk for incidents of forced or compulsory labor, and number of resolutions met to eliminate forced or compulsory labor
8	Employees covered by collective bargaining	Employees covered by collective bargaining agreements	Number or percent of employees covered by collective bargaining agreements
9	Operation change notice period	Minimum notice period(s) regarding operational changes, including whether it is specified in collective agreements	Minimum notice period(s) regarding operational changes, including whether it is specified in collective agreements
10	Operation risk assessment for freedom of association and collective bargaining	Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights	Number or percent of operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and number of resolutions met to support these rights
11	Human rights screening	Significant investment agreements that include human rights clauses or that have undergone human rights screening and participation in developed human rights declarations (UN Universal Declaration of Human Rights, ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, OECD Guidelines for Multinational Enterprises, etc.)	Number or percent of significant investment agreements that include human rights clauses or that have undergone human rights screening and number of developed human rights declarations (UN Universal Declaration of Human Rights, ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, OECD Guidelines for Multinational Enterprises, etc.)

			participated in by an organization
12	Human rights screening for suppliers and contractors	Significant suppliers and contractors that have undergone screening on human rights and actions taken	Number or percent of significant suppliers and contractors that have undergone screening on human rights and actions taken
13	Human rights training	Employee training on policies and procedures concerning aspects of human rights that are relevant to operations	Number or percent of employees trained on policies and procedures concerning aspects of human rights that are relevant to operations, and the number of hours for this training by employee
14	Incidents of discrimination	Incidents of discrimination and actions taken	Number of incidents of discrimination and number of resolutions met for these incidents
15	Anti-corruption training	Employees trained in organization's anti-corruption policies and procedures categorized by type	Number and percent of employees trained in organization's anti-corruption policies and procedures categorized by type
16	Response to incidents of corruption	Actions taken in response to incidents of corruption	Qualitative
17	Paid bribes	Employees having been asked or having complied with expectation by government officials or other outside officials to pay a bribe for his or her services.	Number of or percent of employees having been asked or having complied with expectation by government officials or other outside officials to pay a bribe for his or her services.
18	Incident of conflict of interests	Conflicts of interests or ethical dilemmas for an organization and its reporting, auditing, and operating agencies	Number of conflicts of interests or ethical dilemmas for an organization and its reporting, auditing, and operating agencies per period
19	General non-compliance fines for products	Significant fines for non-compliance with laws and regulations concerning the provision and use of products and services	Dollar amount of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services
20	Incidents of marketing communications or product non-compliance	Incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship or product and service information and labeling, by type	Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes

		of outcomes.	
21	Programs for adherence to laws	Programs for adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship	Number of programs and dollar amount invested for programs for the adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship
22	Violations of human rights	Incidents of violations involving rights of indigenous people and actions taken	Total number of incidents of violations involving rights of indigenous people and actions taken
23	Sustainability report publishing	Public reporting of common sustainability assessments and level of reporting of those assessments (i.e. GRI, WSPI, etc.)	Number of public sustainability assessments and reports published and percent of completion of those sustainability assessments

Appendix D: Indicator Details

Symbol	$I_{EN,1}$	**Name**	Energy consumption	**Goal**	Decrease
Definition	The ratio of net energy consumed by a factory to the number of production units produced.				
Calculation	$I_{EN,1} = \frac{\sum_{t=1}^{T} E_t^{Total} - E_t^{Produced}}{\sum_{t=1}^{T} P_t^{Total}}$ [MWh/Ton] (D.1) Where, E_t^{Total}: The total energy consumption for a factory summed up over a period T measured in MWh. $E_t^{Produced}$: The total energy produced in a factory summed up over a period T T measured in MWh. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,2}$	**Name**	Specific recycled, reused, repurposed or remanufactured material	**Goal**	Increase
Definition	The ratio of the total recycled, reused, repurposed or remanufactured material to total material waste produced in a factory.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} M_t^{Total,R}}{\sum_{t=1}^{T} MW_t^{Total}} \times 100$ [%] (D.2) Where, $M_t^{Total,R}$: The total recycled, reused, repurposed or remanufactured material in a factory summed up over a period T measured in tons. MW_t^{Total} : The total material waste produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,3}$	**Name**	Specific material used	**Goal**	Decrease
Definition	The ratio of the total used material to the total products produced in a factory.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} M_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}} \times 100$ [%] (D.3) Where, M_t^{Total}: The total used material in a factory summed up over a period T measured in tons. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,4}$	**Name**	Energy Intensity	**Goal**	Decrease
Definition	The ratio of energy consumed by a factory to the number of production units produced.				
Calculation	$I_{EN,1} = \frac{\sum_{t=1}^{T} E_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [MWh/ton] (D.4) Where, E_t^{Total}: The total energy consumption for a factory summed up over a period T measured in MWh. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,5}$	**Name**	Land use	**Goal**	Decrease
Definition	The ratio of land used by an organization's facility to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} L_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [m^2/ton] (D.5) Where, L_t^{Total}: The total used land by a factory summed up over a period T measured in m^2. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,6}$	**Name**	Waste water amount	**Goal**	Decrease
Definition	The ratio of waste water discharged by a factory to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} WW_t^{Total}}{\sum_{t=1}^{T} P_t^{Total,produced}} \times 100$ [%] (D.6) Where, L_t^{Total}: The total used water by a factory from all sources summed up over a period T measured in m^3. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,7}$	**Name**	Treated/non-treated waste water	**Goal**	Increase
Definition	Proportion of waste water discharged by a factory that is treated, in order to reduce pollutants before being discharged to the environment to the total amount of waste water produced by the factory.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} TWW_t^{Total}}{\sum_{t=1}^{T} WW_t^{Total}} \times 100$ [%] (D.7) Where, TWW_t^{Total}: The total treated waste water produced by a factory summed up over a period T measured in m^3.				

	WW_t^{Total} : The total waste water produced by a factory summed up over a period T measured in m³.

Symbol	$I_{EN,8}$	**Name**	Water used	**Goal**	Decrease
Definition	The ration of water used by a factory to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} W_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [m³/Ton] (D.8) Where, W_t^{Total}: The total water consumed by a factory summed up over a period T measured in m³. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EN,9}$	**Name**	Air quality	**Goal**	Increase
Definition	Air quality of within and in surrounding areas of an organization's facility including smog, visibility, odor, GHG concentration, pollutant concentration, etc.				
Calculation	Use Air Quality Index (AQI)				

Symbol	$I_{EN,10}$	**Name**	Recyclable and reusable materials used by contracted service providers	**Goal**	Increase
Definition	The ratio of recyclable and reusable materials used by contracted service providers to the total amount of materials used by the factory.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} R_t^{Total}}{\sum_{t=1}^{T} M_t^{Total}} \times 100$ [%] (D.10) Where, R_t^{Total}: The total recyclable and reusable materials used by contracted service providers over a period T measured in Tons. M_t^{Total} : The weight of materials used by a factory summed up over a period T measured in tons.				

Symbol	$I_{SO,1}$	**Name**	Lost workdays	**Goal**	Decrease
Definition	Ratio of workdays missed due to accidents to total number of work days.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} LD_t^{Total}}{\sum_{t=1}^{T} WD_t^{Total}} \times 100$ [%] (D.11) Where, LD_t^{Total}: The total workdays missed due to accidents over a period T measured in days. WD_t^{Total} : The total workdays over a period T measured in days.				

Symbol	$I_{SO,2}$	**Name**	Child labor	**Goal**	Decrease
Definition	Number of incidents of child labor employment per number of employees.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} CE_t^{Total}}{\sum_{t=1}^{T} EM_t^{Total}} \times 100$ [%] (D.12) Where, CE_t^{Total}: The total number of child labor employment in a period T. EM_t^{Total} : The total number of employees in a period T.				

Symbol	$I_{SO,3}$	**Name**	Composition of workforce	**Goal**	Increase
Definition	Composition of workforce and breakdown of employees according to gender				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} WE_t^{Total}}{\sum_{t=1}^{T} EM_t^{Total}} \times 100$ [%] (D.13) Where, WE_t^{Total}: The total number of women employees in a period T. EM_t^{Total} : The total number of employees in a period T.				

Symbol	$I_{SO,4}$	**Name**	Sick days	**Goal**	Decrease
Definition	Ratio of sick days to total number of work days.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} SD_t^{Total}}{\sum_{t=1}^{T} WD_t^{Total}} \times 100$ [%] (D.14) Where, SD_t^{Total}: The total workdays missed due to sickness over a period T measured in days. WD_t^{Total} : The total workdays over a period T measured in days.				

Symbol	$I_{SO,5}$	**Name**	Paid days off	**Goal**	Increase
Definition	Number of paid days off per employee.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} PD_t^{Total}}{\sum_{t=1}^{T} EM_t^{Total}}$ [days/employee] (D.15) Where, PD_t^{Total}: The total paid days off over a period T measured in days. EM_t^{Total} : The total number of employees in a period T.				

Symbol	$I_{SO,6}$	**Name**	Health education and wellness programs	**Goal**	Increase
Definition	Employee participation health education/wellness programs.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} HE_t^{Total}}{\sum_{t=1}^{T} EM_t^{Total}} \times 100$ [%] (D.16) Where, HE_t^{Total}: The total number of employees that participated in health education and wellness programs over a period T measured in employees.				

	E_t^{Total} : The total number of employees in a period T.

Symbol	$I_{SO,7}$	**Name**	Salary ratio	**Goal**	Increase
Definition	Range of ratios of standard entry level wage compared to local minimum wage.				
Calculation	$I_{EN,2} = \frac{S_p}{BS} \times 100$ [%] (D.17) Where, S_p: The salary given to an entry level employee measured in USD. BS: The Basic standard minimum wage measured in USD.				

Symbol	$I_{SO,8}$	**Name**	Force compulsory labor	**Goal**	Decrease
Definition	Incidents of forced or compulsory labor per number of employees.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} FE_t^{Total}}{\sum_{t=1}^{T} EM_t^{Total}} \times 100$ [%] (D.18) Where, CE_t^{Total}: The total number of forced labor employment a period T. E_t^{Total} : The total number of employees in a period T.				

Symbol	$I_{SO,9}$	**Name**	General non-compliance fines for products	**Goal**	Decrease
Definition	The ration of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services to the value of products sold.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} F_t^{Total}}{\sum_{t=1}^{T} S_t^{Total}} \times 100$ [%] (D.19) Where, F_t^{Total}: The value of non-compliance fines paid over a period T measured in USD. S_t^{Total} : The value of products sold over a period T measured in USD.				

Symbol	$I_{SO,10}$	**Name**	Sustainability report publishing	**Goal**	Increase
Definition	Public reporting of common sustainability assessments.				
Calculation	$I_{EN,2} = \sum_t^T SR$ [Number] (D.20) Where, SR : The number of public sustainability reports published over a period T.				

Symbol	$I_{EC,1}$	**Name**	Profits generated	**Goal**	Increase
Definition	Ratio of total net profits for a factory to the total revenue gained.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} PR_t^{Total}}{\sum_{t=1}^{T} R_t^{Total}} \times 100$ [%] (D.21)				

	Where, PR_t^{Total}: The total profit gain by the factory over a period T measured in USD. R_t^{Total} : The total revenue gain by the factory over a period T measured in USD.

Symbol	$I_{EC,2}$	**Name**	Energy costs	**Goal**	Decrease
Definition	The ratio of the cost of energy used in the production process to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} CE_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [\$/Ton] (D.22) Where, P_t^{Total}: The total cost of energy used by the company over a period T. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EC,3}$	**Name**	Material acquisition costs	**Goal**	Decrease
Definition	The ratio of the cost of materials used in the production process to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} CM_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [\$/Ton] (D.23) Where, P_t^{Total}: The total cost of material used by the company over a period T. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EC,4}$	**Name**	Revenue	**Goal**	Increase
Definition	The ratio of the revenue gained by the factory to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} R_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [\$/Ton] (D.24) Where, R_t^{Total} : The total revenue gain by the company over a period T. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EC,5}$	**Name**	Labor costs	**Goal**	Decrease
Definition	The ratio of the labor costs to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} LC_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [\$/Ton] (D.25) Where,				

	LC_t^{Total} : The total labor costs in a factory over a period T. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.

Symbol	$I_{EC,6}$	**Name**	Charitable investments and community development	**Goal**	Increase
Definition	The ratio of investments in non-profit organizations and general charity organizations to the profit gained by the factory.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} CI_t^{Total}}{\sum_{t=1}^{T} PR_t^{Total}} \times 100$ [%] (D.26) Where, R_t^{Total} : Investments in non-profit organizations and general charity by the company over a period T. PR_t^{Total}: The total profit gain by the factory over a period T.				

Symbol	$I_{EC,7}$	**Name**	Tooling costs	**Goal**	Decrease
Definition	Ratio of tooling costs including fixtures and jigs used during the manufacturing process in a factory to the number of production units produced.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} TC_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$ [$/Ton] (D.27) Where, TC_t^{Total} : The total toolsing costs the company pays over a period T. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Symbol	$I_{EC,8}$	**Name**	Labor productivity	**Goal**	Increase
Definition	Output for a given process per unit labor required. Labor required can account for value-added activities, as well as, non-value added activities.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} P_t^{Total}}{\sum_{t=1}^{T} EM_t^{Total}}$ [Ton/Employee] (D.28) Where, P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons. E_t^{Total} : The total number of employees in a period T.				

Symbol	$I_{EC,9}$	**Name**	Innovation & R/D investments	**Goal**	Increase
Definition	Ratio of investments and expenditures in scientific research and experimental development (R&D) for future innovative products and technologies to the total profit gained by the factory.				
Calculation	$I_{EN,2} = \frac{\sum_{t=1}^{T} RD_t^{Total}}{\sum_{t=1}^{T} PR_t^{Total}} \times 100$ [%] (D.29)				

	Where, RD_t^{Total} : The total investments and expenditures in scientific research and experimental development summed up over a period T measured in USD. PR_t^{Total}: The total profit gain by the factory over a period T.

Symbol	$I_{EC,10}$	**Name**	Delivery costs	**Goal**	Decrease
Definition	Ratio of transportation cost of products including fuel costs, labor costs, and equipment costs to the number of production units produced.				
Calculation	$$I_{EN,2} = \frac{\sum_{t=1}^{T} DC_t^{Total}}{\sum_{t=1}^{T} P_t^{Total}}$$ [\$/Ton] (D.30) Where, TC_t^{Total} : The total delivery costs the company pays over a period T. P_t^{Total} : The total weight of products produced in a factory summed up over a period T measured in tons.				

Appendix E: Tool testing Survey

Sustainability Assessment Software Testing Questionnaire

After completing the assessment of you factory using the software please complete the following questionnaire.

Part 1: General Questions.

1. How long did it take to finish the assessment?

_____ Minutes.

2. I was encouraged to use the tool.

◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

3. The results of the assessment will affect the practices in the factory to improve sustainability.

◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

4. I would be willing to voluntarily use this software to assess the sustainability of the factory.

◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

5. It would take me significantly less time to finish the assessment next time I use the software.

◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

6. What input data was difficult to obtain, measure or calculate?
   a. Data: _____

      Explain:

      _____

   b. Data: _____

Explain:
_____

c. Data: _____

Explain:
_____

d. Data: _____

Explain:
_____

7. What input data were you least willing to provide because of privacy issues?
   a. Data: _____

      Explain:
      _____

   b. Data: _____

      Explain:
      _____

   c. Data: _____

      Explain:
      _____

   d. Data: _____

      Explain:
      _____

8. What method of assessment do you think will be most useful for the factory?

   ◯ Single factory assessment.
   ◯ Annual comparison assessment.
   ◯ Factory comparison assessment.

   Explain:
   _____

Part 2: Software usability.

1. Overall the software was easy and simple to use.

   ◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

2. The additional help information provided on screen and user manual was sufficient.

   ◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

3. The interface was clear and organized.

   ◯ Strongly agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly disagree

4. General suggestions to improve the software:

   - _____
   - _____
   - _____
   - _____

Thank you for your participation.